Jean-Marie Welter

Copper and Copper-Alloy Sheets for Musical Brass Instruments, Made in the Kingdom of Saxony

The Kingdom of Saxony, more specifically its southern part, the Vogtland, used to be one of the biggest manufacturers of brass instruments in the world. As brass sheets are the most important basic material for manufacturing such instruments, their procurement was a major concern to the makers.[1] *The aim of the present article is to provide an overview of the possibilities on offer to them in those days. Unfortunately, no commercial archives have survived that might allow us to get insights into the demand side. The little information found in contemporaneous publications about the musical instrument industry in the Vogtland only lets us locate some suppliers. Nevertheless, it appears worthwhile to give a broader view of the manufacturers of semi-finished copper products, both in the Kingdom of Saxony and in the other states in nineteenth-century Germany. We shall also describe certain major innovations that were introduced in the copper industry at the end of the eighteenth century and at the beginning of the nineteenth that proved profitable for brass instrument makers. To begin, we shall offer some facts about the Kingdom of Saxony and its musical brass-instrument industry in the Vogtland.*

The political and economic background

The Kingdom of Saxony was home to the ruling family of the Wettiner (the name derives from the castle of Wettin near Halle in central Germany). Although some members of the family played an important political role in the Holy Roman Empire during the Middle Ages, the history of modern Saxony only really starts in the fifteenth century. This family, whose territories included the Margraviate of Meissen, was granted the Duchy and Electorate of Saxony. In 1485, the family divided up its possessions: the younger branch (the Albertiner) kept the Duchy/Electorate and its capital Dresden, whereas the elder branch (the Ernestiner) obtained the territories west of Meissen and Leipzig. During the ensuing centuries, the Albertiner succeeded in strengthening the influence of Saxony, even becoming the Kings of Poland in the eighteenth century under the reign of the Prince Electors Frederick August I, the famous August the Strong (1670–1733) and his son Frederick August II (1696–1763). Squeezed between Prussia and Austria, Saxony derived its importance not so much from military strength, but from its cultural aura and from economic assets such as its rich silver mines. Saxony converted to

We hereby acknowledge the help of the Musikinstrumenten-Museum (Markneukirchen), Bergarchiv (Freiberg) and Archivverbund Bautzen (Bautzen) in retrieving relevant documents. Our thanks are also due to the Wieland-Werke and to the Freiherren von Beck-Peccoz for providing information about the history of their companies. [Editor's note: Further thanks go to Enrico Weller, who kindly helped to edit this text after the passing away of Jean-Marie Welter in 2022.]

1 See Hachenberg 1990.

Lutheranism in the sixteenth century, which entailed a major upheaval that proved of crucial importance for the emergence of the musical instrument industry.

In 1806, after the conquest of Germany by the French armies, Napoleon elevated the Electorate of Saxony to a Kingdom, just as he did with Bavaria, Württemberg and Westphalia. But unlike the Kings of Bavaria and Württemberg, the Saxon King Frederick August I (1750–1827) remained an ally of Napoleon during the battle of Leipzig. The consequence was that Saxony had to cede its northern, highly agrarian regions to Prussia. Although this was painful, it had the advantage that during the following century conservative landowners had little opportunity to hinder the process of industrialisation in the Kingdom. In the Austro-Prussian War of 1866, Saxony was an Austrian ally. After their defeat at the Battle of Königgrätz, Saxony was controlled more and more by Prussia, and it was integrated in the German Empire in 1871. In November 1918, at the end of World War I (WWI), Frederick August III (1865–1932) abdicated, and the Kingdom became the 'Free State' of Saxony, which it still is today.

During the nineteenth century, Saxony joined the Ruhr region as one of the most industrialised parts of Germany.[2] The roots for this had already been laid by the old Electors, who had promoted the development of the mining industry in the Erzgebirge, a range of mountains rich in ores (mainly silver, lead and tin) along the border with Bohemia. They also encouraged the downstream production of porcelain and cobalt-based blue colours.[3]

The Electors' economic policies were founded in mercantilism, however, and they exerted strong control over these proto-industrial activities. For example, the export of copper and copper-alloy scrap was carefully regimented, as was the import of semi-finished products, and they were also heavily taxed. In contrast, exporting finished goods was promoted. This explains the importance of trade fairs. The best known of these was that of Leipzig, which during the eighteenth century became the 'marketplace of all Europe'. New, smaller manufacturing sectors also developed as a consequence of seasonal mining activity. When the miners were out of work, they started to make knitted wares and toys. Such developments were favoured by the fact that they took place mainly in the countryside and were thus beyond the control of the guild system. This system was abolished in Saxony as late as 1861, though the Kingdom's economy had begun a process of liberalisation already at the beginning of the century under the influence of the French. Saxony was also one of the founding members of the German Customs Union in 1834. This helped Saxon industry to undergo a boom and opened up sectors such as heavy machinery and textiles that were heavily export-oriented.[4] The monetary system in Germany was then unified in 1871 when the German Empire was created. The new currency was the mark, and all local currencies had to be converted; the thaler that had been used up to now was set at the equivalent of three marks.

The making of brass musical instruments in the Vogtland

Another manufacturing activity that began in Saxony in the mid-seventeenth century was musical instrument-making.[5] Its origins were not related to mining, but to the fact that Saxony was a Protestant state. After the Thirty Years' War, the Bohemian rulers in the surrounding regions enforced the Catholic Counter-Reformation. This also had an impact on Kraslice, a city already famous for its production of musical instruments. Many Protestant instrument makers sup-

2 See Karlsch/Schäfer 2006.
3 See Hermann 2016; Hermann 2015; Hammer 2004; Arnold et al. 1978.
4 See Schäfer/Töpel 2014.
5 See e.g. Weller 2004; Dullat 2010.

posedly refused to abandon their Protestant faith and preferred to go into exile across the border into the neighbouring Saxon region of the Vogtland. They settled in around 1650 in the small towns of Markneukirchen, Klingenthal and Adorf, and began making string instruments. These three towns formed what would later be known as the *Musikwinkel* (the 'music corner').

Just a century later, the first brass instruments were produced in Saxony. Isaak Eschenbach, who had learned his trade with Gottlieb Krone in Leipzig, is credited with having initiated this new business in around 1755. It rapidly gained in importance and in 1795 the brass instrument makers (the so-called *Waldhornmacher*, the French horn makers) incorporated a guild. The little information that we have suggests that their activities underwent considerable developments during the nineteenth century. In the Vogtland, the centre of brass instrument production was Markneukirchen (until 1858 known solely as Neukirchen). The expansion of the musical instrument business is reflected in the rise in the local population. During the years following the Napoleonic period, some 1,600 people lived in Markneukirchen.[6] The population thereafter increased continuously, numbering 9,500 inhabitants on the eve of WWI.[7] The yearly turnover of musical instruments fabricated in Markneukirchen was worth around 250,000 thalers in the years 1872/1873. The procurement of the raw materials – metals and wood – represented the largest proportion of this sum, being worth 140,000 thalers. Salaries accounted for 105,000 thalers.[8] The importance of musical instrument production is illustrated not least by the 22,800 bells that were manufactured annually in Markneukirchen, 10% of which were directly exported. A further figure relates to the yearly consumption of metal sheets: in 1795 this was around one ton, whereas 63 tons of brass and 13 tons of nickel silver were needed in 1876. For assembling the instruments by brazing, 700 cords of good-quality wood were needed (approximately 2,300 m^3).[9] The brass instrument industry in the Vogtland was notable in that it relied first of all on highly specialised craftsmen working in their own workshops, with just one or two aids. The practice of specialisation went so far as to mean that some workshops only made parts of instruments – such as the bells, valves or mouthpieces. Some workshops also produced metallic parts (keys) for woodwind instruments. Only a few factory-based companies existed. Here, we have to mention Schuster & Co. in Markneukirchen, which started its activities in 1861. Half a century later, this company claimed to be the largest musical instrument manufactory in Germany. In contrast to craftsmen, factories had a much larger portfolio. They produced both string and wind instruments, and were commercially more independent. At the beginning of the 1870s, solely 105 workmen were active in the factories in Markneukirchen. In the shops, the workforce consisted of 144 master craftsmen working with 127 assistants and 45 apprentices.[10] Furthermore, an unknown number of female workers was employed for polishing the brass instruments. The commercial activity of the shops was in the hands of merchants using a putting-out system. Thanks to their networks, they achieved a high export rate. They were also responsible for the procurement of the raw materials. One consequence of this system was that the income of the craftsmen remained very low, which led to emigration and a loss of know-how. The profits remained with the merchants, and some of their mansions have survived as a testament to their wealth. One of the best-known of these is the Paulus-Schlössel ('small castle of Paulus'), which today houses the Museum of Musical Instruments in Markneukirchen.

6 Bein 1884, Tab. 1.
7 Wild 1960, p. 11.
8 Berthold/Fürstenau 1876, p. 30.
9 Ibid., pp. 28–30.
10 Ibid., p. 27.

Fig. 1 Paulus-Schlössel in Markneukirchen (© Musikinstrumenten-Museum Markneukirchen/Frank Fickelscherer-Faßl).

Who were the customers for these brass instruments? The most important ones were the military bands,[11] who were keen to source the highest quality instruments, both in terms of sound and design. At this time, the number of regiments was increasing, as was the number of players in a band. A further reason for high demand among military bands was the relatively short shelf life of their instruments, which were typically replaced every five years. Band leaders also argued for the need to improve the quality of their bands, and it is likely that a certain amount of corruption was involved. Church bands, like the brass bands of the Salvation Army or the *Posaunenchöre* (literally 'trombone choirs') that were mostly affiliated to the Protestant Church, were also important customers. Further clients were the orchestras of opera houses and concert halls, along with street bands and itinerant bands – and, last but not least, the many conservatories and amateur performers who made music in their family circle or in band associations. An important number of instruments was exported, and the *Musikwinkel* became a major player for providing musical instruments to the rest of the world. It is said that in around 1900, some 50% of the worldwide production of musical instruments and parts originated in the Vogtland. As has already been mentioned above, 'technology transfer' also occurred through emigration, mainly to the Americas. The importance of business relations with the USA led to the opening of a consular agency in Markneukirchen in 1893, which lasted until 1916.

In around 1900, the price of brass musical instruments varied between a few marks for simple post horns and hunting horns to more than one hundred marks for high-quality helicons and bombardons. To satisfy the demands of the various categories of customer, instrument makers produced different quality brands. The best and most expensive were produced for military bands. Their quality relied on forging mechanical and supporting parts from higher gauge wire rather than casting them, on using a lot of nickel silver for reinforcements, tub-

11 See e.g. Nex 2019, p. 254.

ing and ornamentation, and on assembling parts by hard brazing. Instruments that were of high quality but much cheaper were also manufactured for soloists. In 1845, Georg & August Klemm sold a chromatic F horn with "the most recent mechanics" for 38 thalers and its case for 6 thalers (114 and 18 marks respectively). M. Schuster jun. asked 13 thalers for a chromatic trumpet and 24 thalers for a clarinet made of brass (39 and 72 marks respectively). Both manufacturers had their shops in Markneukirchen.[12] At the end of the nineteenth century, a long G or F trumpet of military quality would cost 60 marks, one of solo quality 35 marks.[13] As another example, the factory Schuster & Co. offered four brands – *Artist*, *Extra*, *Solist* and *Courant* – with descending prices. In ca 1893, they asked for 45, 42, 36 and 33 marks respectively for a "Quart-Bass-Zug-Posaune in F" in these four categories. The price also depended to some extent on the materials used for making the instrument. If the same instruments were made with red brass or nickel silver instead of yellow brass, the prices increased to 57, 54 and 48 marks for the three higher categories. *Courant* brand trombones were produced only with yellow brass.[14]

New metallurgical technologies relevant to brass musical instruments

The years 1780–1840 were a period of path-breaking innovations in the copper industry. They did not so much concern the production of copper, but mainly sheet production, alloys and alloying practices, and surface enhancement technologies.[15] New processes in mining, smelting and electrolytic refining emerged only at the end of the nineteenth century and greatly improved the purity of copper. In comparison to the copper production routes of the nineteenth century (predominantly based on sulphide ores), it was now possible to eliminate minor elements like lead, silver, arsenic, antimony, bismuth, iron, nickel, etc. almost completely. However, we should note that purer copper had already been available during the second half of the eighteenth century, when copper was shipped to Europe from the Lake Superior region in North America.

In England, large sheets of copper started to be rolled instead of hammered as early as 1760.[16] Rolling mills were installed in France on the very eve of the 1789 Revolution. Rolling brass was a somewhat more demanding process and only came into use at the end of the Napoleonic era. In Saxony and the rest of Germany, rolling mills appeared in around 1800. Even if the homogeneity of sheet thickness was still not optimal, rolling sheets instead of hammering them allowed for much better control of their thickness. The main flat semi-finished products of the mills were rectangular plates and sheets. During the nineteenth century, rolling mills predominantly used waterpower in combination with fly wheels. Occasionally, steam engines were installed. The first rolling mills driven by electric motors were built during the first decade of the twentieth century. The continuous rolling of long strips and foils also started in around 1900 with the appearance of electrically actuated coilers.

In Silesia and Belgium, the years 1800–1810 saw the beginnings of the industrial production of metallic zinc in Europe.[17] One consequence of this was a change in brass making. It was now possible to co-melt copper and zinc, instead of reducing zinc oxide-rich ores (calamine) with charcoal in a crucible in the presence of copper pieces or granules. The zinc vapour generated reacted with copper to form brass. By the middle of the nineteenth century, this so-called

12 *SGA* 1845, pp. 79f.
13 Kaden 1898.
14 Schuster & Co. 1893, p. 97.
15 Bischoff 1865; Neumann 1904.
16 Welter 2017.
17 Welter 2016; Garçon 1999.

calamine or cementation process had almost completely disappeared in Europe. Co-melting copper and zinc allowed for much greater flexibility and reproducibility in alloying practices. It was also cheaper. In 1818, the Saxon brass mill of Niederauerbach (see below) made a comparative profitability calculation. The costs for producing 100 cwt of brass ingots were 3,476 and 3,208 thalers for the calamine and zinc processes respectively. It is interesting to note that brass now began to become cheaper than copper: for 100 cwt of copper, the mill had to pay 3,650 thalers (including transportation).

At about the same time, metallurgists were learning to extract metallic nickel, an element that had been identified in around 1750 by Alex Fredrik Cronstedt (1722–1765).[18] This led to the production of a new brass alloy – nickel silver. Alloying brass with nickel increases the mechanical strength of the material. It also shifts the colour from yellow to greyish white. This evolution started during the eighteenth century with the import of *paktong* from China ('white copper' in Chinese, but also called *pakfong* in Europe). It was a casting alloy; for production reasons, the alloy had high amounts of zinc and nickel and was thus too brittle for wroughting. By reducing the zinc content to 25% and the nickel content to 20% in 1823, the Saxon chemist Ernst August Gleitner (1783–1852) was able to develop a more ductile alloy that could be hammered and rolled. He marketed it as *Argentan*. Gleitner extracted the nickel from the slag that was a by-product of smelting cobalt-containing ores in the Erzgebirge. To produce sheets, he acquired parts of an old iron hammer located in Aue, the Auerhammer.[19] His business flourished. In 1852, Gleitner's son-in-law Franz Adolph Lange (1815–1898) became the head of the company and continued its expansion. Nickel silver became a popular alloy known under a large number of names all over the world. Within less than 15 years, musical instruments in the Vogtland were being made with *Argentan*. The metallurgical trend was to still reduce the content of nickel in order to increase ductility without losing too much mechanical resistance and while maintaining the silver-like colour. Many companies started producing this alloy. Their aim was mainly to serve the market for tableware and cutlery. Another German company that we should mention here was that of the Henninger brothers, which they established in Berlin in 1824 after having developed a nickel silver alloy similar to that of Gleitner. They called it *Neusilber* (i.e. 'new silver'), a name that is still used in Germany to designate nickel silver.

The prices of these metals accurately reflect the evolution of the mining and processing methods for the ores, both in terms of availability and productivity. Table 1 gives an overview of the prices asked in Germany for copper, zinc and nickel during the second half of the nineteenth century. The price of zinc remained fairly constant, but the price of copper and nickel decreased until the 1880s and then stabilised until WWI.

The discovery in 1800 of the copper-zinc battery as a source of electrical current by Alessandro Volta (1745–1827) led five years later to the invention of gold electroplating by Luigi Valentino Brugnatelli (1761–1818).[20] This opened up new possibilities for colouring and preserving the surfaces of objects made, for example, of copper, brass and nickel silver. The industrial breakthrough came in 1840, when the cousins George Richards (1801–1865) and Henry Elkington (1810–1852) developed cyanide solutions for silver and gold electroplating. At the same time, recipes appeared for electroplating objects with copper and nickel. Electroplating became even more accessible in 1872 with the development of the direct current dynamo by Zénobe Gramme (1826–1901). The old gilding techniques, like fragile leaf gilding or fire gilding with

18 Auer et al. 2001; Grant 2015.
19 See Hermann 2015; and Auerhammer 1973.
20 Jelinek/Lausmann 2014.

	Copper			Zinc		Nickel
	Mansfeld	Engl. & USA brands Berlin	Chilean bars London	good quality Silesia	ordinary brand London	99%
1846–1850	172					
1851–1855	209			39		
1856–1860		234		49	44	
1861–1865		202		40	39	
1866–1870		164		43	41	
1871–1875		181		48	46	2235
1876–1880		148	131	41	39	1138
1881–1885		132	114	33	29	1075
1886–1890		119	107	40	36	763
1891–1895		111	88		37	769

Table 1 Evolution of the prices asked in Germany for various brands of copper, zinc and nickel during the years 1846 to 1895, in marks/100 kg, compiled from Rössing 1901, p. 159.

the noxious mercury-gold amalgam, were increasingly abandoned. Nevertheless, it took many years to find the right electrolytes for plating with more complex metals. Thus it was not until 1924 that George J. Sargent (1885–1965) found ways of depositing chromium. In around 1930, Max Schlötter (1878–1946) developed galvanic baths for brilliant coatings of tin, nickel and silver. Although none of the basic electroplating techniques was invented in Saxony, it was a Saxon chemist, Georg Ernst Langbein (1849–1909), who played an important role in the diffusion of the new technology and established a factory in Leipzig in 1881. He was one of the first entrepreneurs – besides Wilhelm Pfanhauser (1843–1923) in Vienna, with whom he later collaborated – to offer electroplating workshops a whole package of chemicals, equipment and know-how.

Saxon manufacturers of copper, brass and nickel silver semi-finished products

The hammering of copper and brass sheets and the drawing of wire had already started in Saxony during the sixteenth century. Two such plants deserve a mention here – Grünthal and Niederauerbach, which formed the backbone of metallurgical copper activities in Saxony until the beginning of the twentieth century. It was extremely advantageous for these two plants that the Prince Electors awarded them a monopoly for their business when they set out on their activities.

Grünthal's origins lay in a technology – the liquation process – that had been developed during the fifteenth century with the aim of extracting silver from silver-bearing copper.[21] This technology was rapidly taken up in Saxony. Liquation plants began treating black copper (i.e. unrefined copper) from the Erzgebirge, but worked more and more with copper from Bohemia and Upper Hungary. These plants had short lifetimes. The real breakthrough came about in 1537 when Hans Leonhardt, a master miner ('Bergmeister') from Annaberg, set up a new liquation plant in Grünthal next to Olbernhau.[22] This plant was ideally located in the Erzgebirge, next to the Bohemian border in an area rich in wood and waterpower from the river Flöha.

21 Suhling 1976.

22 Kasper 1993; Morgenstern 2010.

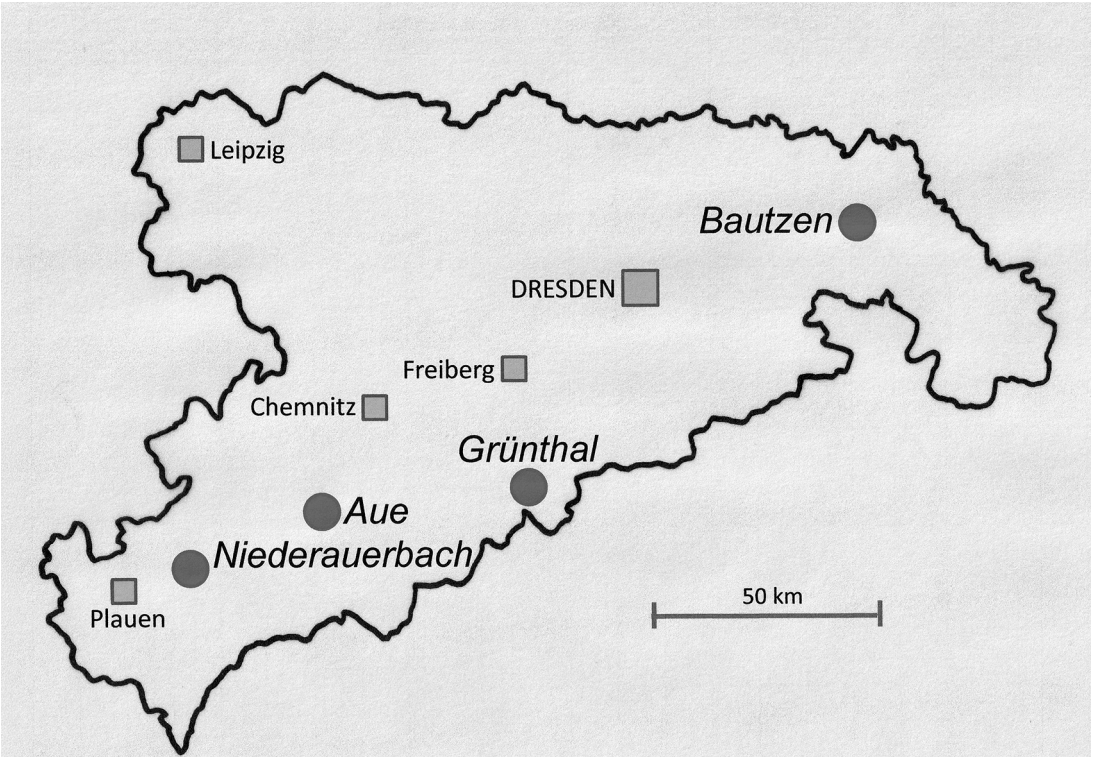

Fig. 2 Saxon manufacturers of copper, brass & nickel silver semi-finished products.

This plant worked well during the following three decades, but it was overshadowed by ownership conflicts between Leonhardt, his partners and successors and even the Prince Elector. In 1567, the plant was acquired by the Saxon state. It was expanded during the seventeenth century. A shop for refining the de-silvered copper was installed, as well as a hammer mill for the production of copper sheets for boiler makers and roofers. Decrees gave the plant a monopoly for liquating copper and, to a large extent, for producing copper sheets. It accordingly enjoyed prosperity over the course of the years. Serious problems appeared at the beginning of the nineteenth century, however. The liquation of copper started to be wound down in the years 1846/1847 and was completely given up in 1853. As the final operation of the liquation process consisted of refining the de-silvered copper to make it forgeable (Garkupfer), refining impure copper was now subjected to intense development. Sheet rolling was introduced with a considerable delay when compared to competitors: the first rolling mill was only commissioned in 1850, a second one in 1858. During the ensuing years, two further rolling mills were installed. The business flourished again and Grünthal produced some 5% of the copper sheets made in the German Empire.

Of course, new competitors appeared, also in Saxony near Grünthal. First there was a plant owned by the Tietzen/Reinhardt family in Bautzen.[23] At the end of the eighteenth century, Christian Gotthelf Tietzen (1747–1816) purchased a small local craft shop where a few workers produced copper sheets with a hydraulic hammer driven by the waters of the river Spree. Such shops existed in various cities including Bautzen. At Tietzen's death, his two sons continued the plant until 1837. In that year, Tietzen's son-in-law (in old German: 'Eidam') Johann Georg Reinhardt (1788–1841), who had already entered the business in 1820, became the sole owner and renamed the company "C. G. Tietzens Eidam". A first rolling mill was installed short-

23 Marquardt 2015.

ly thereafter, and in 1845 a second was commissioned. Reinhardt and his descendants rapidly turned the shop into a large, globally active factory producing copper sheets and wires. It saw its glory years during the second half of the nineteenth century and the beginning of the twentieth. One success of Tietzens Eidam was to break the monopoly of Grünthal for the production of copper roofing sheets. Nevertheless, after WWI the company slid into insolvency and was closed in 1928. The buildings of the plant were recently transformed into condominiums.

In 1870, the Saxon parliament decided that the state should disengage from commercial enterprises. Consequently, after 300 years of state ownership, the Grünthal plant was offered up at auction in 1873. It was bought by Franz Adolph Lange, the owner of the Auerhammer. Lange was joined by his son in the business in 1885, and together they expanded it despite enduring difficult economic conditions and harsh competition. Grünthal was operated as a copper plant in parallel with the Auerhammer, where nickel silver, brass and bronze semi-finished products were manufactured. The situation deteriorated considerably during the 1920s. In 1931, the two companies were merged. Grünthal continued production until the end of WWII. Most of its equipment was then transferred to the Soviet Union. During the GDR era, steel strips were rolled on the remaining mills, though the Auerhammer continued producing copper products and also other metallurgical specialities for the electronic industry. Shortly after German reunification, both plants were closed. Grünthal became a museum that aims to preserve the old liquation and hammering technologies. At the Auerhammer, some minor activity was restarted more recently for rolling predominantly nickel-based alloys.

In Niederauerbach, brass production using the calamine process began during the years 1593–1601. It is now a part of Rodewisch, a town located on the river Göltzsch, some 30 km north of Markneukirchen.[24] The new plant was established on the premises of an iron hammer that had existed since the Middle Ages. In 1603, the Prince Elector Christian II (1583–1611) granted the mill the exclusive prerogative for producing brass in his territory. Import and transit taxes were only levied as of 1677, however, and this state of affairs continued until 1802. The first rolling mill was installed in 1812/1813, though it did not meet expectations and so a new, more powerful mill was commissioned in 1816. It took another 18 years before sheet hammering was abandoned. A further change involved replacing the discontinuous coarse wire drawing using a tong by continuous coiling on a slowly rotating drum. Also in 1816, brass began to be produced using metallic zinc instead of calamine. Notwithstanding those innovations, the production tools of the plant had fallen behind those of its competitors. Further handicaps were that the plant had no access to the railroad network that was developed in the mid-century and that the financial resources of the owning family were limited. Turnover thus diminished steadily, leading to its stepwise transformation into a stock company after 1860. This did not stop its decline, however, and in 1886 the company was wound up. Two years later, what remained of it was acquired by the Wellner family, who since 1854 had owned part of the Auerhammer for producing nickel silver for tableware manufacturing. The Wellners could not stop the decline of the brass mill, and the plant was finally closed in 1926 and the factory dismantled. Today, a supermarket exists on the site. All that remains of the factory are the base of a chimney and a memorial plaque showing the presentation of the 1603 decree granting the exclusive right to produce brass in Saxony.

24 Gericke 2008.

Fig. 3 Memorial plaque on the former site of the brass mill in Rodewisch (© J.-M. Welter).

Where did the Saxon brass musical instrument makers buy their semi-finished products?

In the previous chapter, we have shown that the Kingdom of Saxony had a functioning industry for manufacturing semi-finished products of copper and its alloys. They thus ought to have been the natural suppliers for the Vogtland brass instrument industry. As long as the mercantilist system was in effect, the instrument makers and the merchants bought brass sheets in Niederauerbach and copper sheets in Grünthal. But when the customs frontiers between Saxony and the other German states were abolished during the 1830s, manufacturers located outside Saxony became the major suppliers for semi-finished products of copper and copper alloys.[25] Niederauerbach continued to provide only higher gauge brass wire. The Grünthal plant and the Auerhammer still supplied copper and high-quality nickel silver sheets respectively. But the most important material for making brass instruments – brass sheets – was no longer purchased in Saxony. Thin, high-quality brass strips were acquired in southern Germany, predominantly in Augsburg, but also in Ulm. Thick sheets came from Westphalia and Berlin (which was also a source of low-quality nickel silver, possibly from the Henninger works). Goslar supplied the lead needed for bending tubes. It is unclear why the large historical copper and brass districts of Aachen/Stolberg and Nuremberg were apparently not considered as procurement centres.[26]

Nor do we know why Niederauerbach was no longer the supplier for brass sheets. It is possible that the plant did not produce the necessary quality, which was a situation that the Vogtland brass instrument makers had faced at the end of the previous century.[27] They had found that the brass sheets produced in the mill in nearby Bohemian Kraslice could be strained to a higher level without tearing than the sheets made in Niederauerbach. Brass production had been established in Kraslice in 1675/1676 by Count Johann Hartwig Nostitz-Rieneck (1610–1683) in order to take advantage of the copper mined near the town. Because Saxon import taxes were high, the instrument makers of Markneukirchen asked for a tax exemption. The government

25 Bein 1884.
26 Schleicher 1974; Hachenberg 2002.
27 Hachenberg 1998.

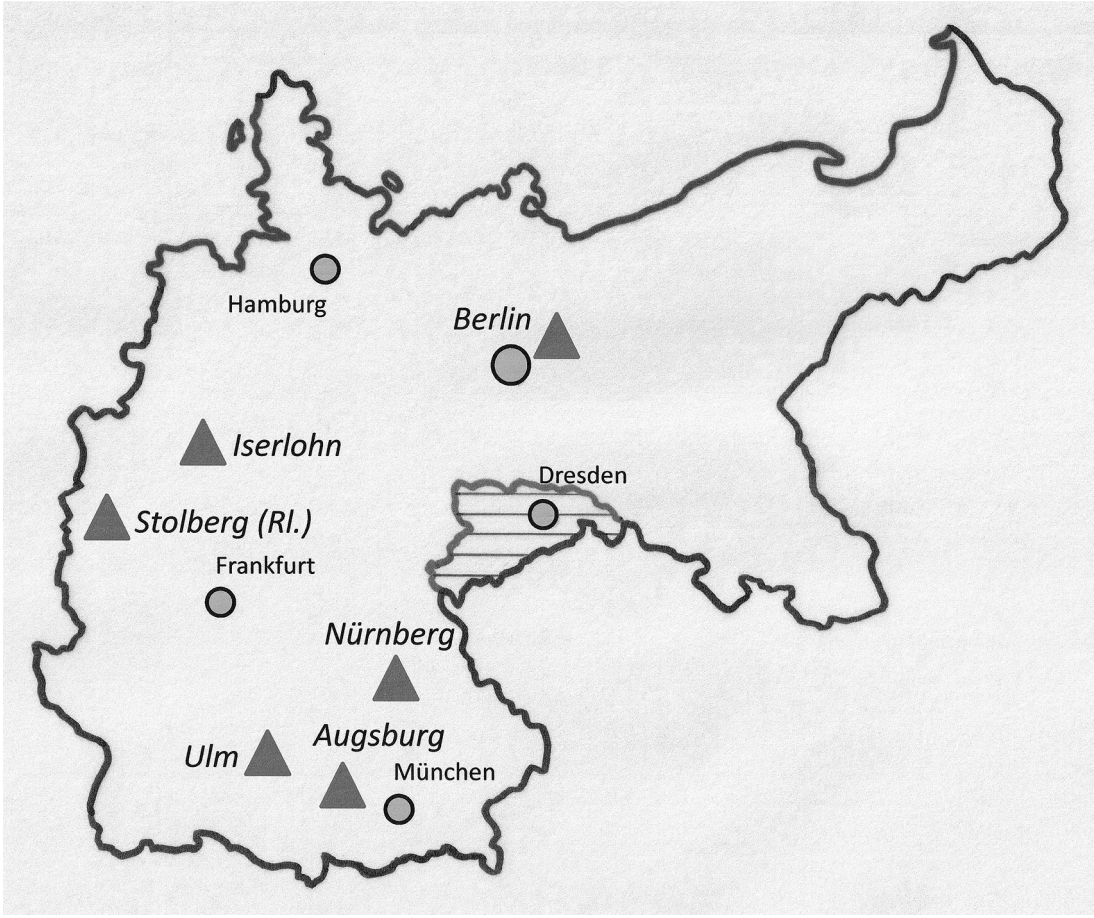

Fig. 4 Copper & copper alloy sheet manufacturers in the German Empire outside Saxony.

thereupon initiated an investigation. It turned out that the brass from Niederauerbach had a lower forming capacity due to a higher content of deleterious lead and sulphur. The higher impurity level resulted from the use of lower quality raw materials, which allowed for cost savings. Coal was substituted for charcoal to a large extent: it was half as expensive but had a higher sulphur content. Much of the calamine needed for the production of brass in Kraslice and Niederauerbach came from the territory around the Altenberg (Vieille Montagne) in the old duchy of Limbourg.[28] Whereas Kraslice also used calamine from the Tyrol, Niederauerbach imported large amounts of calamine from (southern) Poland.[29] It was cheaper but was much richer in lead. After years of negotiation between 1787 and 1795, the government agreed that the instrument makers could import one ton of brass sheets per year. Unfortunately, shortly after the agreement had been reached, the mill in Kraslice discontinued its production of high-quality brass sheets.

High-quality brass sheets were purchased by the Vogtland brass instrument makers during the nineteenth century from two companies established in Southern Germany. They can be easily identified because they were the sole ones in Augsburg and Ulm: Beck & Company and Wieland & Company respectively. We are less fortunate when it comes to identifying the individual brass mills of Westphalia and Berlin, where many were active.

28 Ladeuze et al. 1991.
29 Jars 1781, p. 101.

A short history of the two brass mills in southern Germany

The founders of these two companies were craftsmen whose initial trade was casting guns, bells and pipes. Shortly after metallic zinc became available and rolling mills were constructed, they saw the advantage of using these new technologies for producing brass semi-finished products. As we shall see, our two pioneers acquired rolling mills two to three decades before their Saxon competitors adopted the new technology.

The founder of the Wieland Company in Ulm (or the Wieland-Werke as it is known nowadays) was Philipp Jakob Wieland (1793–1873).[30] He was the son of a local inn and brewery owner, but his uncle, Thomas Frauenlob (1756–1822), was a metal caster. In 1805, he had acquired the city bell and gun foundry located in downtown Ulm. Wieland started his apprenticeship there as a foundry-man at the age of 14. After his three years of military service, Wieland left in 1816 to travel across Europe to improve his knowledge of casting copper and its alloys. He came back to Ulm in 1820 and took over the foundry from his uncle. Wieland soon saw the necessity of diversifying production with new products such as brass wires and sheets. The advantage of these products was that they were not subjected to guild regulations; their drawback was that Wieland needed waterpower to operate the drawing drums and rolling mills. In late 1823, he tried to lease an old water wheel on the river Kleine Blau outside the city wall. In 1827, after many clashes with the town council because of his machinery's water consumption and the possible impact on the city's water supply, he was given permission to install a rolling mill. Two years later, Wieland bought a sawmill where the Blau flows into the Danube and in 1831 transferred his brass mill to the new location. Throughout his life, Wieland kept the foundry and the rolling mill as two separate legal units. As for the brass alloys produced in the early 1830s, we know for sure of CuZn32 (grade 1), CuZn38 (grade 2, also for rods and wire) and CuZn31 (for rolled-in thin strips). During the subsequent years, Wieland's portfolio increased. New alloys had a higher zinc content of up to 43%, but also small amounts of tin of around 1%. He also produced tombak CuZn11Sn0.5. Trials to add lead in the 1% range were unsuccessful. Wieland's business flourished, and he continued looking for water wheels in the immediate vicinity of Ulm. In 1859, he acquired the Spital mill that was located just outside the city wall. This gave him enough space to transfer his foundry from downtown Ulm to the new premises in 1861. The success of his activities was not so much due to his brass semi-finished products, but rather to the fact that he used them to manufacture many metal articles that were needed in everyday life. Nevertheless, the waterpower available in and around Ulm was no longer sufficient. In 1864, Wieland bought a mill in Vöhringen that used the water of the river Iller as well as a lot 16 ha in size. Vöhringen is located some 17 km south of Ulm. This also had political consequences, because it meant that Wieland moved from the Kingdom of Württemberg to the Kingdom of Bavaria. He soon transferred his rolling activities to Vöhringen too, though it was not until 1891 that the slab foundry followed. Over the years, new buildings were constructed and new equipment was installed. In 1901, the company commissioned the first rolling mills for continuously rolling strips as well as installing the first extrusion press for profiles and tubes. These efforts made the Vöhringen factory one of the largest brass mills worldwide. To this day, its headquarters remain in Ulm.

Wieland supervised the technical and commercial activities of his company for over 50 years. He died in 1873, which was the first year of the long economic depression that hit Europe and the USA and whose impact was felt throughout the final decades of the nineteenth cen-

30 The following paragraphs are based on archival documents kindly provided by the Wieland Werke.

tury. Wieland's second wife, Mathilda, managed the company during that difficult period. In 1887, her eldest son Philipp (1863–1949) joined the company, and she retired in 1892. Philipp was now in charge of technical matters, while his younger brother Max was made responsible for the commercial and financial aspects of the company. Philipp was also active in politics, and from 1920 to 1928 was a left-liberal member of the Reichstag. His brother was more involved in the activities of the association of German brass mills (see below). In 1919, the company became a stock corporation. Over the next hundred years, the Wieland Werke expanded steadily through technical innovations, internal growth and world-wide acquisitions. Its technical innovations included its pioneering work to introduce the continuous casting of brass slabs and billets in 1936. Today, Wieland is one of the largest manufacturers of semi-finished copper and copper-alloy products in the world – if not the largest. The rolling activity that was the company's starting point still dominates the business. Wieland is thus the sole survivor of all the brass mills presented in this overview that were active in the nineteenth century as providers of copper-based products to the Vogtland musical brass instrument makers.

Unlike the success story of the Wieland Werke, Beck & Company took a different direction and no longer existed by the end of the nineteenth century. The differences in their fate might have been because the members of the Wieland family considered themselves primarily as industrialists, while the Beck family were predominantly merchants and investors who also became heavily involved in agricultural activities, as we shall see below.

The Augsburg brass mill was established by Ignaz Reiser (also Reisser, Reißer, 1774–1837) on the river Lech outside the Jakober town gate in 1817, thus not long after the fall of the Napoleonic Empire. He was a gun founder and had moved to Augsburg from Munich in 1806, following the transfer there of the royal field ordnance foundry. Augsburg had lost its status as an imperial free city in 1805 and was incorporated into the Kingdom of Bavaria. Reiser was the technical director of the foundry and introduced the casting of guns in sand moulds.[31] He is credited for having cast some 295 guns between 1801 and 1830. It seems that he then left the foundry, which was undergoing a major change involving plans to start casting heavy ordnance. Reiser was a versatile metallurgical man. Besides managing the brass mill and the bronze gun foundry, he also developed and produced flax crushers using cast iron in 1819.

By 1818, this brass mill had already gained a reputation for its rolled sheets made of brass, copper, semilor (a copper alloy with roughly 10% zinc and some tin), white copper and for roofing spiauter (zinc that has to be rolled at temperatures of circa 120°C). The brass sheets were known for their exceptional width. Interestingly, the plant in its early years was designated a "stretching work" (*Streckwerk*). Installing such a rolling mill required major financial resources. By 1827 the plant was already equipped with four rolling mills and a wire-drawing line.[32] Reiser's partner was Ignaz Ducrue (†1825), who became the joint owner of the mill together with the tobacco manufacturer Carl Schmid. Ducrue was a member of a wealthy Catholic family of merchants, bankers and landowners. His ancestors had arrived in Augsburg in around 1700 from the French side of the Duchy of Savoy and soon became very rich. They acquired a palace in Augsburg in 1750; Anton Graff (1736–1813) painted Bernard François Ducrue (1730–1796) in 1761, and Ducrue's wife Marie Anne Josèphe (*1739) in 1766, posing in expensive dresses.

The mill soon faced the problem of how to procure sufficient zinc. As the north-eastern Alps have many zinc ore deposits, Ducrue and Schmid secured a mine near Mittenwald in the Bavarian district of Werdenfels. In 1824 they also obtained a ten-year monopoly on operating

31 Anonymous 1826, col. 557.
32 Rudhart 1827, pp. 140f.

a zinc production plant in Hammersbach, east of Garmisch.[33] But the Bavarian mine was rapidly exhausted, and calamine had to be imported from the nearby Tyrol. In circa 1835, their plant was producing some 60 to 75 tons of metallic zinc.[34] Ducrue died in 1825; the following year, Joseph Anton Beck (1765–1833) stepped in as a new partner, becoming the sole owner of the mill in 1832 after Schmid left the company. Besides producing semi-finished products, the plant also manufactured iron wood screws according to the recently invented French method of pressing the blanks of the screwheads. Beck and Schmid had already obtained a ten-year privilege for producing such screws back in 1826. They nevertheless abandoned production because they needed the space to expand their core business.

The Beck family were also Catholic immigrants, though they came from the Italian side of the Savoy. Their origins lay in the valley of Gressoney at the foot of the Monte Rosa massif[35] and they came to Germany during the second half of the eighteenth century, earning their living as travelling traders. In 1785, the Beck brothers Johann Christoph (1759–1825) and Joseph Anton established a trading house in Augsburg together with the Castell family. This marked the beginning of the economic and social rise of the Becks. After the death of Joseph Anton Beck, his sons Joseph Anton Junior (1808–1882) and Carl (1812–1867) took over the company, which continued to bear the name of their father. The brothers also had other interests, especially Carl, so their mill continued to be managed by Ignaz Reiser, then after his death in 1837 by his son. Carl Beck diversified the family business by installing a machine factory outside Munich in 1841, and the most modern Bavarian paper mill of its time in 1843. Other acquisitions that Carl made in Munich included a brewery and a factory that made candles and soap. In terms of the family's future, their most important acquisitions were not these industrial assets, but the estates bought by the brothers early in the second half of the nineteenth century. In 1861, Joseph Anton acquired the estate of Kühbach, including a castle and a brewery. At the same time Carl acquired an estate in Au in the Hallertau, a region known for its outstanding hops. This was a logical step to cement the newly achieved social rank of the family. In 1840, the King of Bavaria ennobled the brothers as the hereditary Barons ("Freiherren") of Beck. It is interesting to note that this distinction was awarded not only for their entrepreneurial skills, but also for their charitable activities. In fact, their father (Joseph Anton Beck Senior) had already set up a health insurance fund for the workers of their brass mill in 1826. This was a novelty in Augsburg at the time (after several struggles with his workers, Wieland set up a similar fund in 1834). In 1842, the King of Sardinia conferred the title of Barons of Peccoz on the brothers, which is a French version of their original name. Since 1890, the family bears the title of Barons of Beck-Peccoz.

The Becks' brass mill developed very positively in the mid-nineteenth century.[36] Their reputation for high-quality products grew and was acknowledged by various gold and silver medals at industrial fairs.[37] The certificates that they were awarded provide us with some information about their products. We learn that their plant had immediately begun rolling brass plates and sheets to what at the time were extraordinary widths of 75 and 50 cm respectively. Wires were drawn to diameters as thin as human hairs. The high malleability of their brass products was always emphasised. These were made by selecting high-purity copper and zinc,

33 *RIB* 1824, col. 41.
34 Leuchs 1836, p. 712.
35 Beck-Peccoz 2012; Raab 2012.
36 See Wirth 1837, p. 162; Wirth 1846, p. 158; Anonymous 1834, paragraph "Messing- und Drahtfabrikate", pp. 407f.
37 Central-Industrie-Ausstellungs-Commission 1842, pp. 59f.

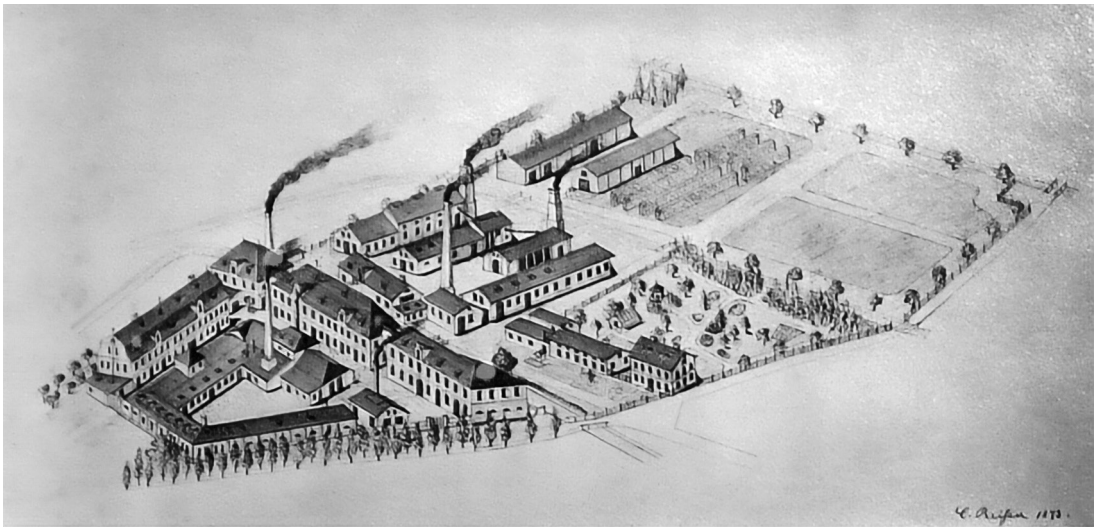

Fig. 5 Brass mill of Beck & Company, copperplate engraving by C. Reisen (1873) (© Freiherren von Beck-Peccoz).

which led to the virtual absence of lead (< 0.2%).[38] Copper imports from as far away as Sweden are documented for the years after 1840. The company was thus able to compete successfully with English brass products, and was even able to export its goods to France, despite its high import duties. This could explain why the brass instrument makers of the Vogtland preferred using sheets from the Becks' brass mill.

Their situation began to deteriorate during the 1870s, however. After the death of Joseph Anton Beck (Junior) in 1882, his son Carl Maximilian Anton (1832–1901) inherited the brass mill and the estate of Kühbach. He could not prevent the further decline of the plant, and in 1893 decided to sell it to the Wieland brothers. Philipp and Max Wieland wanted to get the plant afloat again and maintain its name, though it soon became apparent that it was an impossible task. In 1894, the workforce was laid off and the plant was closed. Some workers and equipment were transferred to Vöhringen. But even during the last years of its existence, the quality of products made by the brass mill was still high. After it closed, some customers even complained that Wieland was unable to match it.

The cartelisation of the German brass industry

Apart from the brass mills mentioned here in connection with the Vogtland brass instrument business, there were naturally other mills producing brass plates, strips and wires. Indeed, the industrialisation of the German states and their increase in prosperity – at least until the Franco-Prussian war – led to a strong demand for such products. In 1848, there were already eighteen brass mills in Germany, with thirty-three mills in operation just nine years later. This number remained almost constant until WWI. Developments such as the introduction of steam engines, then of electric motors in around 1900, provided for a considerable increase in productivity at the mills. The consequence was overproduction and a collapse in prices. The above-mentioned, long depression in the late nineteenth century was a disaster for the brass industry. Most brass mills were confident that eliminating price competition could ensure their survival, so they attempted to install price controls through forming associations and syndicates.[39]

38 Anonmous 1836, esp. p. 355.
39 See Jutzi 1925.

It was not just quality considerations that limited the choice of suppliers for brass instrument makers (and other trades), but also the difficulties involved in negotiating prices. Beck & Company and Wieland & Company, the two firms which supplied the best thin brass sheets to the Vogtland brass instrument industry, are suspected of having been the first to coordinate their prices during the 1870s. Their price lists were indeed almost identical. At the end of that decade, the brass mills from the western Prussian provinces, Westphalia and the Rhineland, set up the first association for their industry. Further mills rapidly joined. In 1881, the Association of German Brass Mills (Verein Deutscher Messingwerke) was incorporated with 19 members. During the subsequent decades, the number of its members increased, though with some fluctuations. By 1898, the Saxon mills of Grünthal, Rodewisch and Auerhammer had joined the Association. One major problem, which also depended on the general economic situation, was that the members more or less scrupulously followed the pricing and selling conditions agreed. Much of the Association's work was therefore devoted to ensuring that members kept to their covenants. In this context, the leading figure was Gustav Selve (1842–1909), the head of Basse & Selve in Altena (Westphalia).[40] His efforts culminated in 1907 with the constitution of a syndicate with 42 members (the Verband deutscher Messingwerke). Its largest member was Wieland & Company in Ulm, followed by the Westfälische Kupfer- und Messingwerke in Lüdenscheid. It is interesting to note that the three next-largest companies were located in Berlin. The syndicate's agreements did not only cover sheets and wires, but also brass rods and sheet coils. This was a consequence of the development of the hot extrusion press by George Alexander Dick (1837–1903) at the very end of the nineteenth century, and the production of motorised coiler systems for the rolling mills. This syndicate only survived until 1911, but its activities continued both before and after WWI in the form of a renewed association of brass mills.

Agreements were also sought by the copper mills, which also often functioned as brass mills. In 1887, a gentlemen's agreement was made among copper manufacturers who aimed to fix a minimum price for copper sheets. This led to the official incorporation of a syndicate in 1904.[41]

Price lists published by the brass associations in 1881 and 1907 allow us to follow their pricing policies for sheets. The unit quantity was 100 kg, a convention that is still followed today in Germany. Then the reference price was set for black, that is oxidised, brass sheets with a thickness of one mm. Brass (*Messing*) was defined as a copper-zinc alloy with zinc at 37.5% and 37% of the overall weight in 1881 and 1907 respectively. This content ensured that the sheets were free of hard β-phase inclusions. Tombak was the trade name for brass with a higher copper content. The different brands were identified by their colour, which depends on the copper/zinc ratio. In 1881, the reference price for brass was 165 marks. At a metal price of roughly 100 marks, fabricating costs accounted for 65 marks. A premium had to be paid for a higher copper content, thinner gauges and cleaner surfaces. Let us take as an example a 0.4 mm thick sheet of yellow tombak (CuZn28) with both sides finely polished. The surcharges were 5, 25 and 60 marks respectively. The brass instrument makers thus had to pay 255 marks/100 kg. The price increased by a further 15 marks when middle-red tombak (CuZn16,5) was needed. Prices remained fairly stable until WWI. A slight increase in fabricating costs was compensated for by a minor decrease in metal prices. In 1907, the same semi-finished products of yellow and middle-red tombak (now CuZn15) cost 242 and 257 marks for 100 kg respectively.

40 Stremmel 2009.

41 See Landsberg 1930.

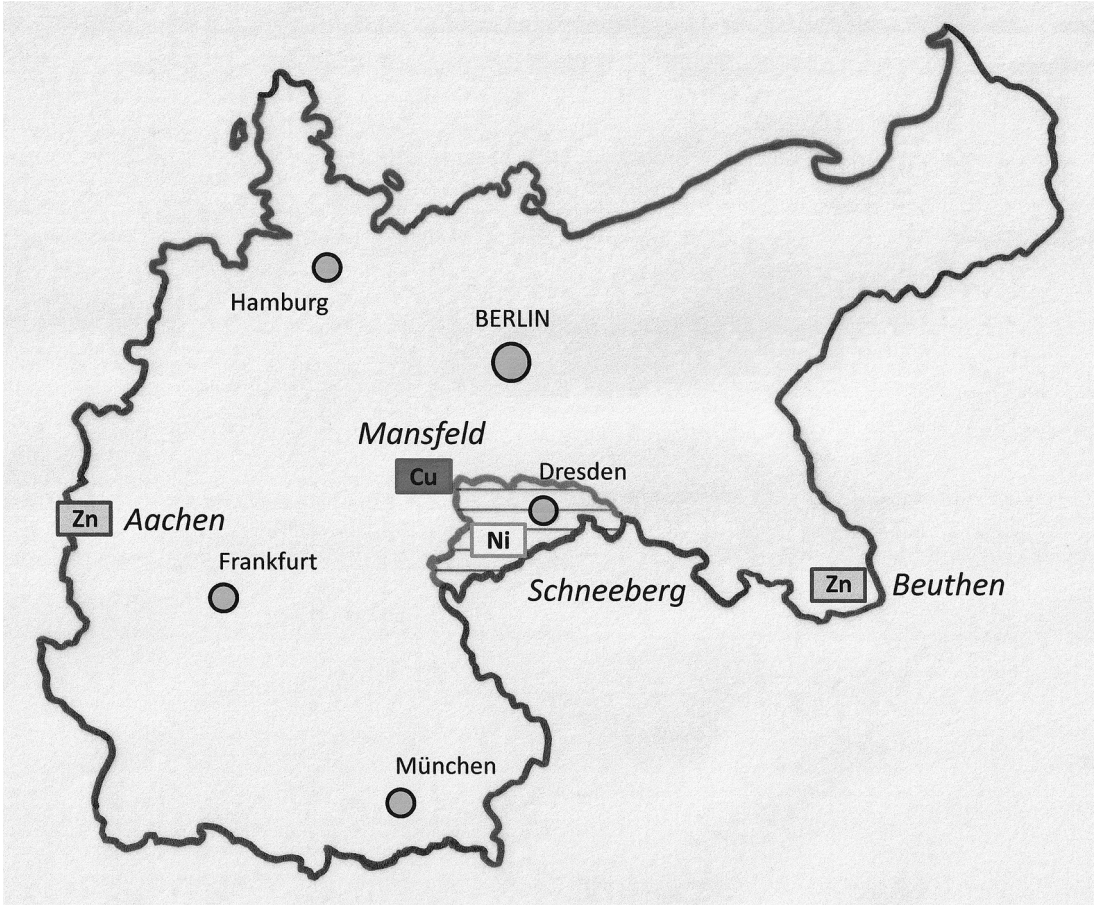

Fig. 6 German mining districts for copper, zinc and nickel ores.

Where did the copper, zinc and nickel come from?

Procuring raw materials, especially copper, posed a further problem to the brass mills. This concerned more the volume than the price. As we can see in Table 1, the prices for copper, zinc and nickel decreased during the second half of the nineteenth century and remained stable from the end of the century until WWI. One problem was import taxes, especially for copper, which had to be imported in large quantities. These taxes were a thorn in their flesh of the copper and brass mills.

Zinc was less of a problem. During the nineteenth century, Germany produced far more zinc than was needed to satisfy internal demand. In 1880, production and consumption were 99,600 t and 63,000 t respectively. By 1910, these figures had increased to 227,800 t and 184,500 t respectively. Germany remained the world's largest producer of metallic zinc until the last third of the nineteenth century, after which it was surpassed by the USA. One third of German zinc came from the ores mined in the Prussian provinces of the Rhineland and Westphalia, and two thirds from the deposits of Upper Silesia. The zinc ores of Upper Silesia are notable for being rich in cadmium, which could amount to as much as 1% of the zinc content. The high volatility of cadmium means that its concentration could reach 0.1% in metallic zinc obtained by the retort process. The presence of a few hundred ppm of cadmium in brass can be an indicator that Silesian zinc may have been used to produce the alloy. Cadmium has no longer been a major impurity in zinc brands since electrowinning began in the early twentieth century.

To some extent, Germany was also self-sufficient in nickel until the end of the nineteenth century because internal demand could be satisfied with the arsenic-rich nickel ores found predominantly in Saxony. However, demand for nickel increased considerably with the development of stainless steel and coinage, which led to large imports of Caledonian and Canadian nickel ores. From 1870 to 1889, the annual Prussian production of nickel was some 240 t, rising to 800 t in the subsequent decade.

For copper, the situation was completely different.[42] Some red metal always had to be imported,[43] but the situation worsened dramatically at the end of the nineteenth century. At the beginning of that century, most demand was covered by the copper obtained from the shale ores in the Prussian mines of Mansfeld and, to lesser extent, of nearby Sangerhausen (though that source decreased in importance during the nineteenth century). By the end of the century, the requirements of on-going industrialisation meant that Mansfeld was able to provide no more than 10% of the copper needed. Productivity had nevertheless improved greatly throughout the nineteenth century, especially during the decades after privatisation in 1852. The second half of the century saw an increase in annual output from less than 2,000 t to roughly 20,000 t, and this figure remained constant until the 1920s. However, we have to compare these figures with the amount of copper required in Germany. In 1902, consumption was already at 109,000 t and by 1912 it had increased to 253,000 t.[44] From 1903 onwards, the German Empire was the largest European consumer of copper, followed by Great Britain and France. Worldwide, it was second only to the USA. The most important consumers were the electrical industries and the brass mills. In 1900, the mills needed some 30,000 t of copper per annum. By 1913, that figure had more than doubled to 62,000 t. The mills also produced or refined some copper.

To satisfy demand, Germany had already started importing copper ores during the 1880s – mostly pyritic ones from the southern Iberian Peninsula – which resulted in some 23,000 t of copper by 1912. An important by-product obtained during the extraction of copper was sulphuric acid. Furthermore, black copper with a copper content between 94% and 99% was imported from Great Britain. By the end of the nineteenth century, more and more was being imported from the USA to be refined in Germany. Fire refining was the prevalent technique. Although the Norddeutsche Affinerie in Hamburg was one of the first companies to use electrolytic refining as early as 1875 (mainly to draw off silver and gold), this process did not become very popular in Germany. In around 1910, the annual output using this method was only a few thousand tons. The third most important import was electrolytic copper from the USA, a country which had strongly invested in this new technology. In 1912, American copper represented almost 90% of German copper imports, with most of it used in electrical applications. Refined copper also came from Australia (some 5%) and from countries like Japan, Great Britain and others, though with less than 1% each. Last but not least, recycled copper was also used. However, as might be expected in a boom, the share of recycled copper was rather low. It is estimated that recycled copper covered only 15 to 20% of demand. Procuring copper in the right quantities and at 'fair' prices was thus a major preoccupation of the brass mills, with import taxes on copper a major problem. They protested vehemently against these taxes, as in 1879, when 25 brass mills (together with the copper mills) wrote a petition to the imperial government asking for the abolition of these duties.

42 Reinhardt 1913.
43 Roelevink 2016.
44 Franke 1920.

For the fabrication of brass (and copper) semi-finished products, the purity of fire-refined copper was adequate. The brass mills bought their copper mainly from German copper producers. They used also most of the imported Australian and Japanese copper. Furthermore, they increasingly preferred electrolytic copper. The brass mills thus relied on many copper sources for manufacturing sheets and wires. Consequently, it is a hopeless task to try and make definitive statements about the origins of the copper used to make musical brass instruments. Only two situations allow us to formulate educated guesses. Very pure brass should be an indicator that electrolytic copper was used, either of American or, to a much lesser extent, of German origin. A high nickel content of around 0.4% points to shale copper, as was mined and processed in Mansfeld.

Conclusion

The production of musical brass instruments represented an important metalworking activity in the kingdom of Saxony. Because of the specificities of the trade, instrument makers were very demanding in terms of quality and price. The innovations made by the copper industry during the nineteenth century – primarily in the field of semi-finished products – were thus very beneficial to them. The instrument makers' requirements meant that they purchased their most important raw materials – brass strips and sheets – outside Saxony in Germany, using the advantages of the German Custom Union.

Bibliography

All weblinks in this article last accessed 28 May 2026.

Anonymous 1826 | Anonymous: Ueber die Industrie des Oberdonau-Kreises, in: *Kunst- und Gewerbe-Blatt* 12/4 (1826), cols. 542–544 and 557f.

Anonymous 1834 | Anonymous: Ueber die im November 1834 zu München gehaltene Industrieausstellung, in: *Polytechnisches Journal* 54 (1834), pp. 393–427.

Anonymous 1836 | Anonymous: Verbesserung in der Bereitung des Messings, in: *Oesterreichisches Wochenblatt für Industrie, Gewerbe, Handel und Hauswirthschaft* 2 (1836), pp. 341–343, 347f., 354–356.

Arnold et al. 1978 | Paul Arnold/Werner Quellmalz/Ulli Arnold: *Sächsisch-thüringische Bergbaugepräge,* Leipzig: Deutscher Verlag für Grundstoffindustrie 1978.

Auer et al. 2001 | Eberhard Auer/Siegfried Müller/Rainer Slotta: *250 Jahre Nickel. Vom "nickel" zum "EURO". Nickel als Münzmetall,* Bochum: Deutsches Bergbau-Museum 2001 (Veröffentlichungen aus dem Deutschen Bergbau-Museum Bochum, Vol. 95).

Auerhammer 1973 | *Neusilber – Grundlage der Entwicklung des VEB Halbzeugwerk Auerhammer im VEB Bergbau- und Hüttenkombinat "Albert Funk". Festschrift zum 150jährigen Jubiläum der Erfindung des Neusilbers,* ed. by VEB Halbzeugwerk Auerhammer, Aschersleben: Volksdruckerei 1973.

Beck-Peccoz 2012 | Umberto von Beck-Peccoz: *150 Jahre Familie von Beck-Peccoz in Kühbach, 1862–2012,* Kühbach: n.p. 2012.

Bein 1884 | Louis Bein: *Die Industrie des sächsischen Voigtlandes. Erster Teil. Die Musikinstrumenten-Industrie,* Leipzig: Duncker & Humblot 1884.

Berthold/Fürstenau 1876 | Theodor Berthold/Moritz Fürstenau: *Die Fabrikation musikalischer Instrumente und einzelner Bestandtheile derselben im Königl. Sächsischen Vogtlande,* Leipzig: Breitkopf & Härtel 1876.

Bischoff 1865 | Carl Bischoff: *Das Kupfer und seine Legierungen mit besonderer Berücksichtigung ihrer Anwendungen in Technik,* Berlin: Springer 1865.

Central-Industrie-Ausstellungs-Commission 1842 | *Amtlicher Bericht der allerhöchst angeordneten Königlich Bayerischen Central-Industrie-Ausstellungs-Commission über die im Jahre 1840 aus den acht Kreisen des Königreichs Bayern in Nürnberg stattgehabte Industrie-Ausstellung,* Nuremberg: Campe 1842.

Dullat 2010 | Günther Dullat: *Verzeichnis der Holz- und Metallblasinstrumentenmacher auf deutschsprachigem Gebiet von 1500 bis Mitte des 20. Jahrhunderts,* Tutzing: Schneider 2010.

Franke 1920 | Franz Werner Franke: *Abriß der neuesten Wirtschaftsgeschichte des Kupfers,* Munich/Leipzig: Duncker & Humblot 1920.

Garçon 1999 | Anne-Françoise Garçon: *Mine et métal, 1780–1880. Les non-ferreux et l'industrialisation,* Rennes: Presses universitaires 1999.

Gericke 2008 | Hans Otto Gericke: *Das privilegierte sächsische Messingwerk Niederauerbach i. Vogtl. Die Geschichte eines bedeutenden Hüttenwerkes von 1593 bis 1926,* Plauen-Jössnitz: Vogtland 2008.

Grant 2015 | Alistair Grant: A British History of German Silver. Part 1: The Discovery of Nickel and Development of Nickel Alloys, 1754–1823, in: *Journal of the Antique Metalware Society 23* (2015), pp. 58–79.

Hachenberg 1990 | Karl Hachenberg: Der Werkstoff Messing im mitteleuropäischen Instrumentenbau vom 16. bis Ende des 18. Jahrhunderts, in: *Instrumentenbau-Zeitschrift* 44/9 (1990), pp. 17–24.

Hachenberg 1998 | Karl Hachenberg: *Die Beschwerde der Markneukirchener Blechblasmusikinstrumentenmacher über die schlechte Qualität des Messings aus dem Messingwerk Rodewisch-Niederauerbach in Sachsen in den Jahren 1787–1795*, [manuscript], 1998, Musikinstrumenten-Museum, Markneukirchen, shelf mark I 0100.

Hachenberg 2002 | Karl F. Hachenberg: Nürnberger Musikinstrumente aus Messing, in: *Anzeiger des Germanischen Nationalmuseums* (2002), pp. 201–211.

Hammer 2004 | Peter Hammer: Das sächsische Blaufarbenwesen und der Handel mit Kobaltfarben – nach Unterlagen der Bücherei der Bergakademie Freiberg, in: *Scripta Geologica, Special Issue* 4 (2004), pp. 108–117.

Hermann 2015 | Robin Hermann: *Sächsisches Hüttenwesen. Schauplätze – Verfahren – Geschichte,* Chemnitz: Hermann 2015.

Hermann 2016 | Robin Hermann: *Sächsischer Erzbergbau. Bergstädte und Sachzeugen des Altbergbaus,* Chemnitz: Hermann [4]2016.

Jars 1781 | Antoine-Gabriel Jars: *Voyages métallurgiques. Tome troisième,* Paris: Didot 1781.

Jelinek/Lausmann 2014 | Thomas Walter Jelinek/Günther A. Lausmann: *Die Geschichte der Galvanotechnik,* Bad Saulgau: Leuze 2014.

Jutzi 1925 | Wilhelm Jutzi: *Fünfzig Jahre Verbandsbestrebungen in der deutschen Messingindustrie. Ein Stück Verbands-und Kartellgeschichte,* Cologne: Wirtschaftliche Vereinigung deutscher Messingwerke 1925.

Kaden 1898 | Heinrich Kaden: *Ueber die Beseitigung unreiner Töne der Messinginstrumente, Klarinette und Flöte,* Hannover: Lehne & Co 1898.

Karlsch/Schäfer 2006 | Rainer Karlsch/Michael Schäfer: *Wirtschaftsgeschichte Sachsens im Industriezeitalter,* Leipzig: Edition Leipzig 2006.

Kasper 1993 | Hanns-Heinz Kasper: *Von der Saigerhütte zum Kupferhammer Grünthal 1537–1873. Aus der 450-jährigen Geschichte eines metallurgischen Betriebes in Olbernhau-Grünthal,* Olbernhau-Grünthal: Saigerhüttenverein 1993.

Ladeuze et al. 1991 | France Ladeuze/Léon Dejonghe/Firmin Pauquet: La Vieille-Montagne, l'expoitation minière et la métallurgie du zinc ans l'ancien duché de Limbourg, in: *Bulletin trimestriel du Crédit communal* 178/4 (1991), pp. 15–30.

Landsberg 1930 | Heinrich Landsberg: *Die Gründung und Entwicklung des Kupferblech-Syndikats zu Kassel,* Frankfurt am Main: n.p. 1930.

Leuchs 1836 | Johann Carl Leuchs: *Allgemeines Waren-Lexikon. Zweite verbesserte Auflage. Zweiter Theil. N–Z,* Nuremberg: Leuchs & Comp. 1836.

Marquardt 2015 | Uta Marquardt: *Der Kupferhammer Bautzen – das älteste Bautzener Unternehmen* [Exhibition posters 2015], online, 2015, www.archivverbund-bautzen.de/fileadmin/media/archivverbund/Ausstellung-Kupferhammer.pdf.

Morgenstern 2010 | Rolf Morgenstern: *Chronik von Olbernhau zur 750 Jahrfeier,* Olbernhau: Stadtverwaltung Olbernhau 2010.

Neumann 1904 | Bernhard Neumann: *Die Metalle. Geschichte, Vorkommen und Gewinnung, nebst ausführlicher Produktions- und Preis-Statistik,* Halle a. S.: Knapp 1904.

Nex 2019 | Jenny Nex: Manufacture, in: *The Cambridge Encyclopedia of Brass Instruments,* ed. by Trevor Herbert, Arnold Myers and John Wallace, Cambridge: Cambridge University Press 2019, pp. 252–256.

Raab 2012 | Hubert Raab: Die Familie der Freiherren von Beck-Peccoz, in: *Kühbach. Kloster, Markt und Schlossgut*, ed. by Wilhelm Liebhart and Rudolf Wagner, Kühbach: Gemeinde Kühbach 2012, pp. 162–187.

Reinhardt 1913 | Ewald Reinhardt: *Die Kupferversorgung Deutschlands und die Entwicklung der deutschen Kupferbörsen,* Bonn: Marcus & Weber 1913.

RIB 1824 | *Regierungs- und Intelligenz-Blatt für das Königreich Baiern* 4 (1824).

Roelevink 2016 | Eva-Maria Roelevink: Deutschland und die bergbaulichen Rohstoff-Märkte für Steinkohle, Eisenerz, Kupfer und Kali von der Mitte des 19. Jahrhunderts bis 1930, in: *Geschichte des deutschen Bergbaus. Band 3: Motor der Industrialisierung. Deutsche Bergbaugeschichte im 19. und frühen 20. Jahrhundert,* ed. by Klaus Tenfelde and Toni Pierenkemper, Münster: Aschendorff 2016, pp. 17–43.

Rössing 1901 | Adelbert Rössing: *Geschichte der Metalle*, Berlin: Simion 1901.

Rudhart 1827 | Ignaz Rudhart: *Ueber den Zustand des Königreichs Bayern nach amtlichen Quellen,* Vol. 2: *Über die Gewerbe, den Handel und die Staatsverfassung des Königreichs Bayern,* Erlangen: Cotta, Palm & Enke 1827.

Schäfer/Töpel 2014 | *Sachsen und die Welt. Eine Exportregion im Vergleich 1750–2000,* ed. by Michael Schäfer and Veronique Töpel, Leipzig: Leipziger Universitätsverlag 2014 (Veröffentlichungen des sächsischen Wirtschaftsarchivs, Vol. 10).

Schleicher 1974 | Karl Schleicher: *Geschichte der Stolberger Messingindustrie,* Stolberg: Stolberger Metallwerke KG ^{2}1974

Schuster & Co. 1893 | *Preis-Liste der Musik-Instrumenten-Manufactur Schuster & Co. Markneukirchen Sachsen*, Markneukirchen: Schuster [ca 1893], http://digital.slub-dresden.de/id500425167.

SGA 1845 | Anonymous: *Katalog der Sächsischen Gewerbeausstellung zu Dresden 1845,* Dresden: Meinhold 1845.

Stremmel 2009 | Ralf Stremmel: Gustav Selve. Ein Grossindustrieller im Deutschen Kaiserreich, in: *Der Reidemeister* 180 (2009), pp. 1481–1486.

Suhling 1976 | Lothar Suhling: *Der Seigerhüttenprozess. Die Technologie des Kupferseigerns nach dem frühen metallurgischen Schrifttum,* Stuttgart: Riederer 1976.

Weller 2004 | Enrico Weller: *Der Blasinstrumentenbau im Vogtland von den Anfängen bis zum Beginn des 20. Jahrhunderts,* Horb am Neckar: Geiger 2004.

Welter 2016 | Jean-Marie Welter: The French Brass Industry during the 19th Century, in: *Romantic Brass. Französische Hornpraxis und historisch informierter Blechblasinstrumentenbau. Symposium 2*, ed. by Daniel Allenbach, Adrian v. Steiger and Martin Skamletz, Schliengen: Argus 2016 (Musikforschung der Hochschule der Künste Bern, Vol. 6), pp. 384–397.

Welter 2017 | Jean-Marie Welter: Du laminage à la coulée continue. Le regard de l'industriel, in: *Quatre mille ans d'histoire du cuivre. Fragments d'une suite de rebonds,* ed. by Michel Pernot, Bordeaux: Presses Universitaires de Bordeaux 2017, pp. 257–276.

Wild 1960 | Erich Wild: Ein Gang durch die Geschichte der Musikstadt Markneukirchen, in: *Festschrift für die "600-Jahr-Feier" der Musikstadt Markneukirchen,* Markneukirchen: Rat der Stadt 1960, pp. 4–16.

Wirth 1837 | Johann Christian Wirth: *Augsburg wie es ist! Beschreibung aller Merkwürdigkeiten der Stadt für Einheimische und Fremde,* Augsburg: Wirth 1837.

Wirth 1846 | Johann Christian Wirth: *Augsburg wie es ist! Beschreibung aller Merkwürdigkeiten dieser altberühmten Stadt mit Bezug auf Kunst, Handel, Fabriken, Gewerbe ec. Ein Hand- und Addreßbuch für Alle,* Augsburg: Wirth 1846.

Luxembourg citizen ***Jean-Marie Welter*** *(1944–2022) was a leading expert in the field of the history of copper and its industry. After studies in Paris (Ingenieur) and Munich (Dr. rer. nat.) he worked at the Kernforschungsanlage Jülich/Nuclear Research Center Jülich (Germany) and as a Director of the research center of the copper industry KME, France/R&D in Europe. He was a consultant to European and international professional associations of the copper industry and President of the Société française de métallurgie et de matériaux/French Association for Metallurgy and Materials.*