The Salt Industry in Europe at the Threshold to the Industrial Era (1780-1880)

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Until far beyond the mid-18th century, the salt industry in western and central Europe was characterised by the traditional evaporating salterns. However, whereas the salt could be won without the use of additional energy in the marine salterns on the Mediterranean and Atlantic coasts, the question of energy consumption ranked increasingly high in the evaporating salterns [1]. In the 18th century, and in some cases still earlier, efforts were made to reduce the energy input - primarily wood as well as coal - in particular by constructing complex graduation systems and developing multistage open pan systems. In the first half of the 19th century - and partially earlier in England - the breakthrough was finally achieved by applying new techniques in various fields: 1. deep-well drilling enabled saturated brine to be collected, 2. utilization of the steam engine allowed shafts to be sunk down into the rock salt zone, and - at a later date - 3. the evaporating technique in vacuum evaporators reduced the energy consumption in addition. From about the mid-19th century, the situation of the salt industry was also improved in that railways were increasingly available for transport purposes. On the basis of these developments, it is shown that the production process in the salt industry underwent a fundamental change in the early years of industrialisation. In addition, the staggered implementation of innovations at various production locations is analysed and - with reference to the production figures, for example - the scale of the transformation process is illustrated.

1. UTILISATION OF THE STEAM ENGINE

The steam engine was first utilised in the salt industry in the very homeland of that invention, in the important salt winning region of Cheshire in central England, with its production locations of Nantwich, Northwich and Middlewich. To the south of Northwich, in the Winsford area, a steam engine ordered from Boulton and Watt was installed in 1779 on the premises of Messrs. Salmon and Penlington. Henry Holland describes the situation: „... nor can I pass silently over the capital and new-erected salt-works built upon the banks of the navigable canal at Thurlwood in Cheshire, the property of Messrs. Salmon and Penlington. In an adjoining valley they have fixed a fire engine, constructed by Messrs. Boulton and Watt, which in the waste of three hundredweights of coals, (value ninepens) does in twelve hours throw up to the height of a hundred yards, not less than twenty-four thousand gallons of brine; which is received in a very large reservoir and from thence conveyed in the pans". Only ten years later a further steam engine was ordered from Boulton and Watt, this time by John Gilbert for his salt-works at Northwich, where he planned to pump rock salt and water out of his shaft. Holland reported in 1808 that the further utilisation of steam engines was quick to follow: „Others soon followed suit, for windmills had their disadvantages". Evidence of the use of further steam engines dates from 1796, when Thomas Marshall, a Northwich salt mine owner, ordered a steam engine, a drawing of which is still preserved (Fig. 1). The title of the drawing is: „General View of the Engine", and it shows a double-action steam engine with rotary movement and the typical parallelogram. The cartwright beam was in the timber version characteristic of its time. From the 1808 standpoint, Holland concludes for the early phase of steam engine application that the brine was pumped with steam engines in almost all newly established salt-works [2, pp. 3-4].

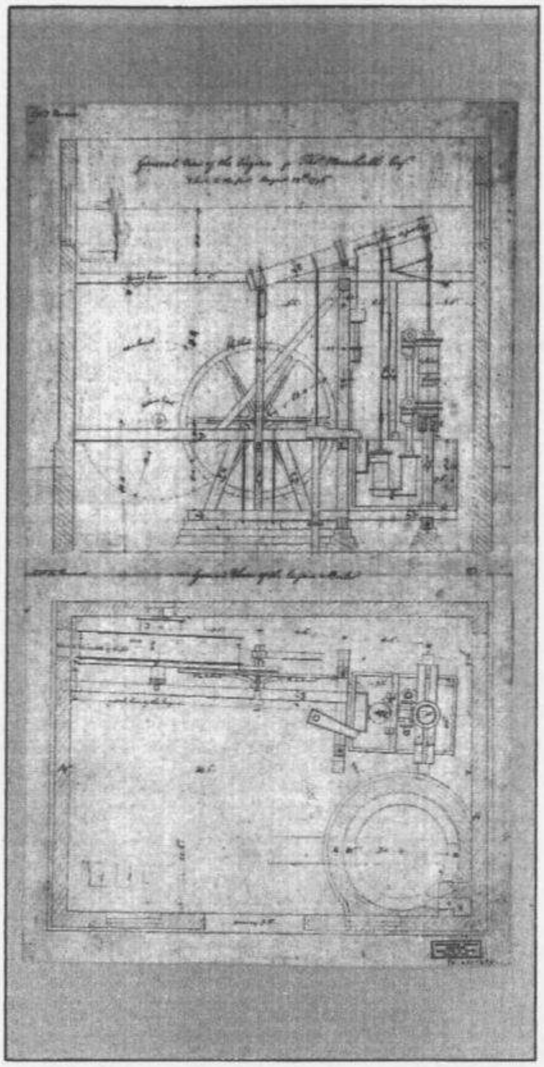

Figure 1. Boulton and Watt engine at Thomas Marshall's mine [2].

In Germany, a steam engine was first used in connection with salt production at the Schönebeck saltern. On 12th December 1792, the new machine was put into service above brine shaft III, albeit with unexpected starting problems: persons unknown had crammed the machine full of wood shavings in order to sabotage the new technology. Although those responsible were never identified, the background to this operation to thwart the new technology is certainly that the steam engine made the old pumping technique with horse-whims superfluous, so that 15 labourers with their 109 horses were redundant. The new steam engine, which worked at a rate of 10 to 16 strokes per minute, was originally wood-fired but later driven with coal from Saxony. It was in use until 1828 [3,4,5].

Steam engines asserted themselves increasingly in the following years and are documented at numerous salterns. The first steam engine to be used in a saltern in western Germany, for example, was installed at Unna in 1799. However, a special focal point for application of the new technology ultimately evolved in the rock salt mining industry, where this pumping technique proved to be indispensable in pumping out water penetrating during shaft-sinking operations [6,7].

2. DEEP-WELL DRILLING AND SHAFT SINKING

2.1 Deep-well drilling technique

Whereas the search for new brine springs in the late 16th century was based on the well-digging technique, restricting depths to a few meters [8,9], there are increasing reports by the mid-18th century of deep-well drilling, with drilling depths of 71.6 meters – for instance at Cannstatt - being achieved after 1772. The technique used is recorded by one of the pioneers of the saltern drilling technique, Karl Christian von Langsdorf (1757 – 1834). With this technique, the man operating the drilling bit always turned it by a small angle on the upward movement of the drill rod assembly so that the cuneiform or cruciform cutting edge always struck a different place on the downward movement, thus loosening the rock. The man operating the long lever or walking beam – though in most cases more than one labourer was occupied here – moved the drill rod assembly continuously upwards through the force exerted by him, but then let it drop down again immediately. The rock crushed on the bottom of the well bore by the drilling bit was removed from the well bore at appropriate intervals with bailing tools [10].

Initial improvements were made to the simple drilling technique by the distinguished saltern specialist Carl Christian Friedrich von Glenck (1779 – 1845), who secured the well bore at Wimpfen, which he drove down to a depth of 142 meters into the saliniferous rock in only 298 days, starting on 19th January 1818, with well casing to prevent it from collapsing. Further fundamental innovations in drilling technology were then achieved by Glenck's pupil, Carl Gotthelf Kind (1801 – 1873). The drilling technique with the walking beam was replaced by Kind from 1827 onwards with a tread-wheel. The outcome was that, instead of the workers having to raise the drill rod assembly by force, the beam stroke was generated by the rotary movement of the tread-wheel. The wheels used by Kind had a diameter of five and a width of three meters. About five men at a time ran inside the wheel and outside on the top of the mill. Kind considered the main advantage of drilling with a tread-wheel to be that the drill falls freely, whereas the weight of the drill had to draw up the heavy beam in the case of walking beam drilling. One drawback of the tread-wheel was the extreme noise made when the heaver struck down onto the laminated spring block limiting the fall of the rod assembly [11].

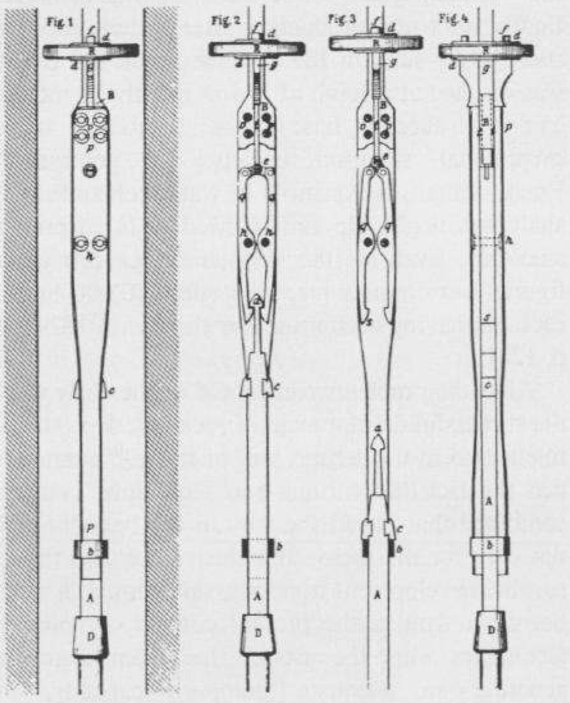

Figure 2. Free-fall system by Kind, dating from 1842 [12].

Another of Kind's inventions, the so-called „free-fall", was used from 1842 onwards (Fig. 2). This was a tie beam mechanism which automatically released the lower section of the drill rod assembly as it went down, so that the drill could fall completely freely. As the rod assembly rose, the tie beam closed, taking the drill with the gravity rod with it again. This technique now allowed the rod assembly to be made up of wooden rods instead of the previously used iron rods. The power required to lift the rod assembly was reduced in the water-filled drill holes whereas the efficiency at the cutting edge was increased, making for a substantial rise in drilling capacity [12].

Piasecki's map of innovative salterns in the German-speaking region identified and documented five centres in which technical innovations occurred in an exceptionally high density. These centres included Saxony, south-western Germany, Hesse, Westphalia and the area of the Alpine salterns. In south-western Germany, the innovations were confined to a brief period around 1600 [13]. Special interest was focused again on this region in the 19th century, which saw a number of significant innovations put into practice there. In the Heilbronn area, that of greatest importance to salt winning in the 19th century, the increase in the number of deep wells drilled and the use of steam engines from the late 18th century onwards is exceptionally well documented. The drilling technique combined with steam engines paved the way for industrialisation. This is illustrated by brief consideration of the development at the Wimpfen and Friedrichshall-Jagstfeld salterns.

The history of the Friedrichshall-Jagstfeld state saltern is of outstanding interest, on the one hand because it was here in 1816 that the first deep well aimed at developing a rock salt deposit was drilled, and on the other hand because work was started in 1817 on a salt mine. This work had to be stopped, however, because the steam engine ordered from England could not be delivered on time. For a second, now successful attempt in 1854 to sink a shaft with a diameter of 6.9 meters, two steam engines were available to pump out the water penetrating into the shaft.

Salt winning at Wimpfen started in 1752, when a notary by the name of Weigand came across salt water after some initial excavations and obtained permission from the town council to continue searching for brine. Operations at this saltern,

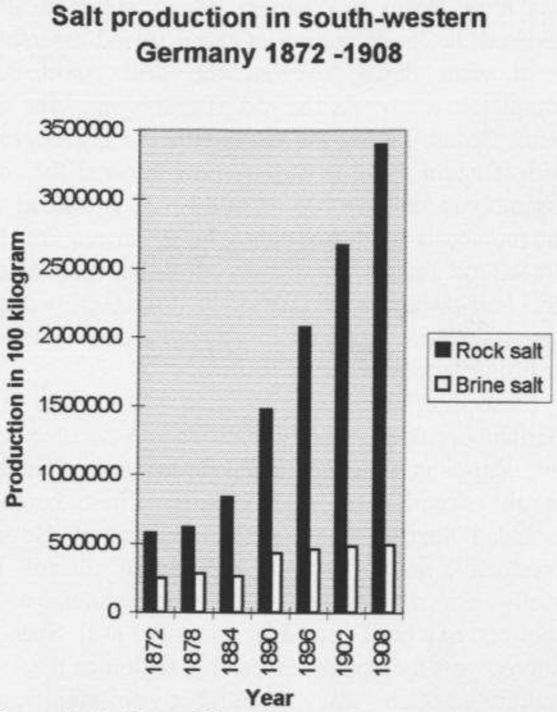

Figure 3. By Peter Piasecki

which were only moderately successful during subsequent decades, started showing a profit only after Carl Christian Friedrich Glenck had hit upon rock salt during deep-well drilling in 1818. Spurred on by the first real success of a deep well in the nearby Jagstfeld, Glenck succeeded in drilling down to a depth of 142 meters, so that the newly founded Ludwigshalle saltern had saturated brine at its disposal. Later, when a total of seven wells had been drilled, the brine was pumped partly by waterpower but also by two steam engines with an output of 2.5 hp and 2 hp respectively.

2.2 Shaft sinking

In Great Britain, rock salt was discovered very early, in 1670. John Jackson from Halton developed a rock salt deposit not far from Northwich while prospecting for coal. A report on this was published by the Royal Society in its Philosophical Transactions dated 12th December 1670: „Concerning the Discovery of a Rock of Natural Salt in that Country“ [2, p. 1]. The depth of the salt deposit is reported as follows: „The Rock of Salt, by the relation of the Work-men, is between 33 and 34 yards distant from the Surface of the Earth“. A further shaft was successfully sunk in 1779 in the Lawton region and gave rise to intensive prospecting activity. Most salt mines in England, however, were granted only a short life, for according to Calvert „the roofs in these workings began to crack“ from 1830 onwards. By 1840 some 20 mines had collapsed, and in 1881 only nine rock-salt mines were still in production. This accounts for Calvert's verdict on this industry: „Rock-salt mining in England is a dead industry“ [14, p. 100].

While the deep-well drilling technique was still at an early stage of its development in Germany, the first attempt to sink a shaft onto rock salt got under way in 1817 not far from the Friedrichshall saltern. The shaft had an opening of 5.6 times 5.15 meters, but work on it had to be discontinued at a depth of 63 meters because the large quantities of water flowing in could not be pumped off manually by the 130 men to whom the work was assigned and the delivery of a steam engine from England was delayed. The first rock-salt mine in western Europe, the Wilhelmsglück mine near Schwäbisch Hall, finally went into production after a shaft had been successfully sunk in 1823, when a rock salt deposit was reached at a depth of 114 m in only 14 months. Yet the success has to be attributed to an exceptional situation because, in contrast to Friedrichshall, the quantity of water penetrating the shaft was negligible and allowed work to proceed smoothly. Even so, the Wilhelmsglück production figures were impressive, with some 10,000 tons of rock salt having been mined by the end of 1824 [10, p. 124].

After the problems confronted in the early years, the successful development of rock-salt deposits was intensified in the second half of the 19th century. It was the fact that various new techniques could be combined that paved the way to the breakthrough, not only for the rock-salt industry but also for the parallel development in potash-salt mining, a sector not dealt with in the present context. Among the techniques were the use of the steam engine to generate an adequate pumping capacity, the improved shaft sinking technique based on the Kind-Chaudron principle, the adoption of the freezing method from the late 19th century onwards, and the improvements in shaft casing, e.g. using cast iron tubbing as introduced by the Irishman T.

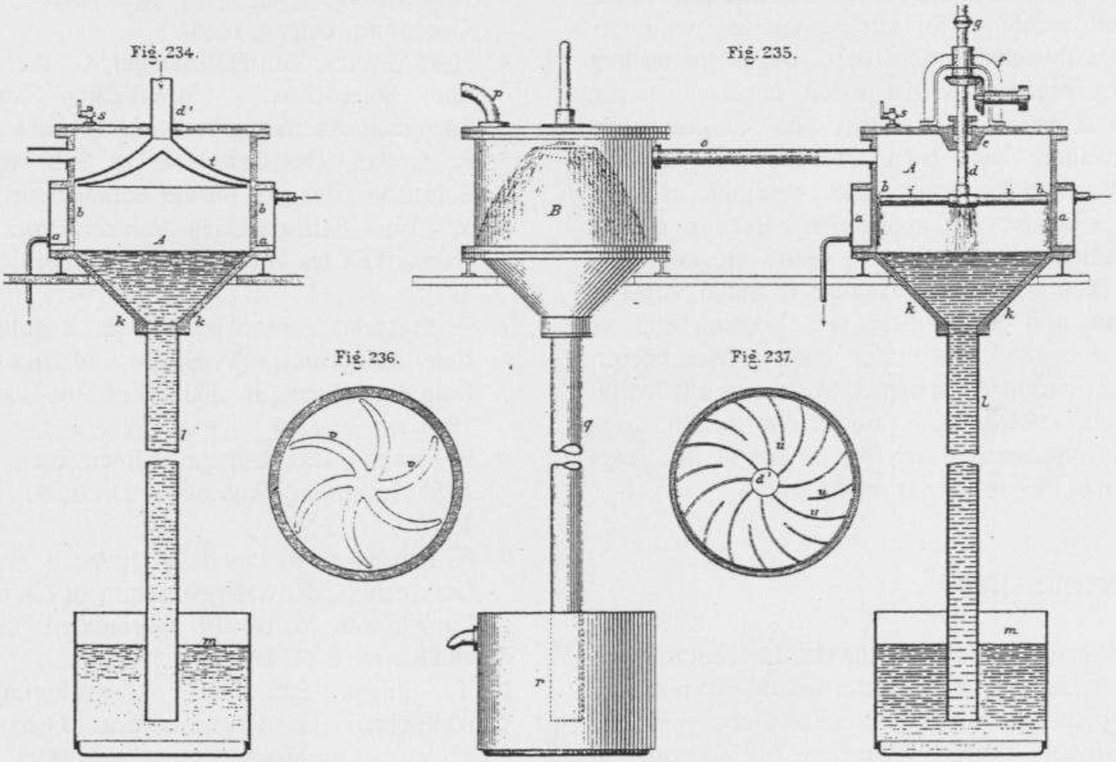

Figure 4. Vacuum apparatus by Knoop, 1887 [18].

Mulvany into the mining industry on the Ruhr from 1855 onwards. The supremacy now attained by rock-salt production in south-western Germany over the previously dominant evaporation technique is documented in Figure 3. The period between 1872 and 1908 saw a six-fold increase in the proportion of rock salt compared with evaporated salt [15].

3. USE OF THE VACUUM TECHNIQUE IN THE EVAPORATING PROCESS

In the second half of the 19th century, the piped steam pan technique asserted itself increasingly in Germany and Austria as well as in England and America, although this technique – to which no further reference is made here – represented only a transitional stage until supplanted by the use of vacuum pans. In 1900 Fürer [16], the director of the important Schönebeck saltern, pointed out that a more favourable effect could be achieved by evaporating the brine under vacuum than with other techniques using steam.

The vacuum-process evaporating technique was developed in the 19th century but had to wait until the early 20th century for its breakthrough. Important developments of this innovative technique are documented in the sugar industry, where the use of vacuum evaporators in Liverpool is recorded from 1813 onwards. An early patent for this method in salt production was granted in 1839, also in England, to John Reynolds. However, it is not yet known whether this technique led to the construction of a corresponding plant. Although this technique was deployed in America in the 1880s, the first vacuum plant was not put into production by the Salt Union until 15th March 1906. By 1912 another plant of this type had been added, with the Salt Union having at its disposal in that year the impressive number of 684 open evaporating pans in addition to the two vacuum plants[17]. In Germany and Austria, it was only towards the end of the 19th century that the debate on the pros and cons of the vacuum technique for salt evaporation got under way. In this context Carl Baltz, one of the leading saltern specialists of that period, stated: „In recent times a profusion of rather odd salt-production contrivances have been invented and patented, which .... in the fewest cases were able to make inroads into practical application" . Even so, patents for vacuum-type evaporating plants are known to have been granted, for example to Anton Vogel of Hallein and to Freiherr von Bechtolsheim of Munich in 1882, to the trade union in Aschersleben in 1885 and to A. Knoop of Minden in 1887 (Fig. 4). Baltz referred more positively to the Rittinger-Piccard apparatus which was in use at the Swiss saltern of Bex as early as the 1870s [18].

4. CONCLUSION

The modern salterns of the late 18th century were evaporating salterns characterised by exceptionally long graduation works and stacked-timber yards. By the early 20th century the picture had undergone a fundamental change, with the image of modern salt production being reflected in mining shafts and in the noise of steam engines. The wood-fired open evaporating pans had given way to steam pans and vacuum evaporators, and coal – which had been introduced into saltern operations in the 16th century – had finally superseded wood as a firing material, thanks to the development of the railway network. The economic efficiency of salt works had taken a leap forward, and it can be safely assumed that salt production in central Europe underwent at least a ten-fold increase between 1800 and 1900.

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