ON IGNATIUS BORN'S EIGHTEENTH CENTURY SO-CALLED EUROPEAN AMALGAMATION PROCESS

By

É. VÁMOS* and F. SZABADVÁRY

Department for General and Analytical Chemistry,
Technical University Budapest

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In the circles of mining and metallurgical experts of the end of the 1780s much attention was attracted by and many debate was focussed on the process of the so-called European amalgamation for silver production first applied on an industrial scale in 1786 at the village of Szkleno (Glashütte) near the town of Selmecbánya in Hungary (today Banska Stiavnica, Czechoslovakia).

Amalgamation itself, i.e. the extraction of precious metals from their ores with mercury, is a process of antiquity. It was used regularly in Spanish America, introduced as adapted to the extraction of silver from copper ores in 1554 in Mexico by Bartolomeo de Medina and in 1571 in Peru by Fernandez

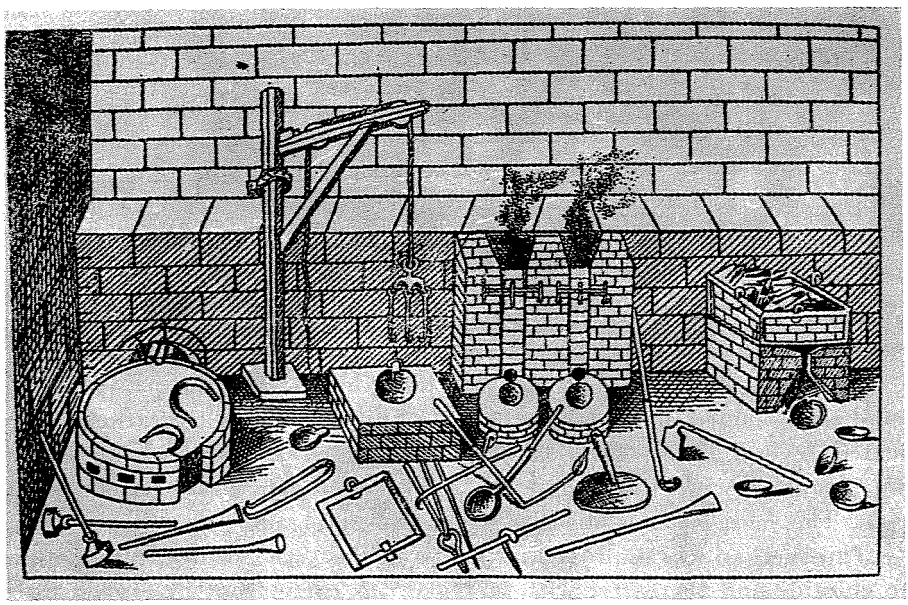


Fig. 1. Silver production by the liquation furnace method. From "Mittelalterliches Hausbuch" (1482)

* National Museum for Science and Technology, Budapest, XI. Kaposvár u. 13.

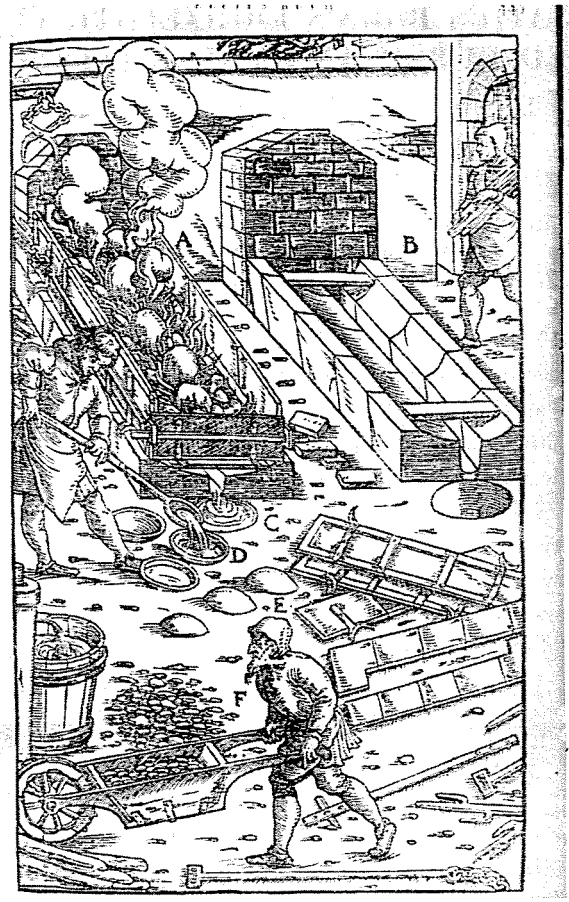
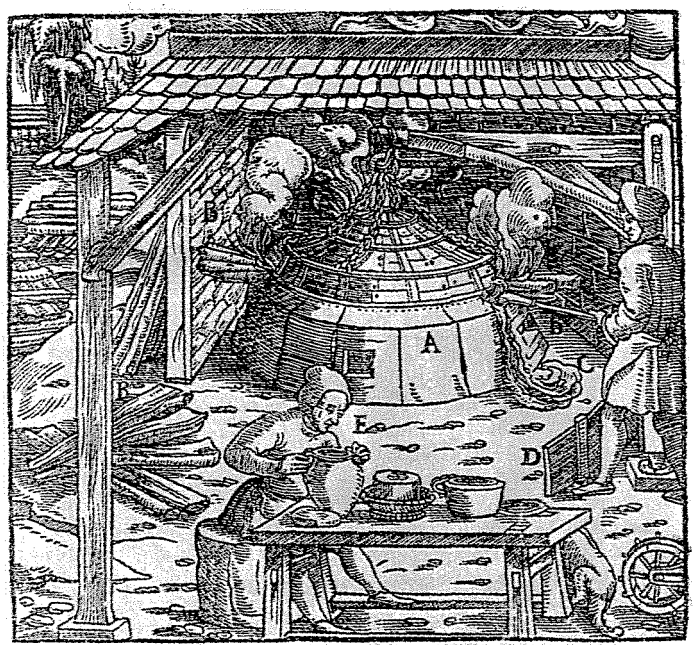


Fig. 2. Liquation furnace (Agricola: De re metallica 1556)

de Velasco. Its first description survives in Alvaro Alonso Barba's "Arte de los metales", dated 1637 [1]. The essence of the method was that finely grinded ore was mixed with common salt and piled up in little heaps on a paved ground then tramed on by horses or men. This was called tituration and was repeated several times. Then mercury was added and the whole titurated again, trunked with water and the silver amalgam was pressed through textile. The mercury was distilled from the amalgam.

This method was improved by Barba in the 17th century so that mixing with chloride and thereafter with mercury was carried out in copper kettles. The chemical process of the method is very complicated and there are several interpretations. The formation of copper(I) and copper(II) chlorides plays an important role in it. This procedure required much mercury and took several weeks.



Der Ofen A. Die Holzſcheite B. Die Silberglätte C. Das Blech D.
Ein hungriger Meiſter iſt Butter, damit das Gift, welches der Herd ausatmet, ihm nicht ſchadet; denn ſie iſt ein Spezialmittel dagegen E.

Fig. 3. Cupellation furnace (Agricola: De re metallica 1556)

In this time the liquation-furnace method was applied for the above purpose all over Europe. This latter had probably been first introduced at about 1460 in Nuremberg. The first illustrated description of it is in the manuscript "Mittelalterliches Hausbuch" from 1482 [3] (Fig. 1). In the centre there is a pair of blast furnaces, in which ore is melted with charcoal, then heated (revived) with lead. The product, a copper-lead-silver alloy solidified in the form of discs, is packed with wood in the liquation furnace (right) on the iron plates. Heated to a lower temperature lead containing the silver dropped between the iron plates, while the copper remained on the plate. The argentiferous lead was then heated in the cupellation furnace, where lead was roasted to litharge which ran out, while the pure silver remained in the furnace. The same method is described very minutely in Agricolas "De re metallica" (1556) from where we took the pictures of the liquation and the cupellation furnace (Fig. 2, 3) [4]. The method required much fuel. Therefore Ignatius Born elaborated a new amalgamation method for silver production.

Ignatius Born was born in Gyulafehérvár (Hungary) December 26, 1742. He began his studies in Vienna by the Jesuits and joined later the order but

Fig. 4. Ignatius Born (1742—1791)

after sixteen months he left it. He studied law and natural sciences in Prague, travelled in Germany, Netherlands and France. In 1770 he joined the office of mines in Prague, in 1776 he was called to Vienna by empress-queen Maria Theresa for arranging the imperial mineralogical collection. In 1779 he became counsellor of the court and leader of the Chamber of the Mines and Mint. He was interested in many fields, first in mineralogy, mining and economy, he wrote several books on these topics. He was a typical enlightened personality of the 18th century of European fame, active in the fraternity of Freemasons, too. He founded a scientific periodical entitled "Physikalische Arbeiten der einträchtigen Freunde in Wien". Born died in Vienna July 25 1791 [5].

Born began his experimentation in Vienna. He rented a laboratory for his purpose from a chemist called Bousaign and, for two years, covered

Ueber das Anquicken der gold- und silberhältigen Erze, Rohsteine, Schwarzkupfer und Hüttenspeise.

Von

Ignaz Edlen von Born,

des R. R. Ritter, kaiserl. königl. wirklichen Hofrath bey der Hofkammer in Münz und Bergwesen, der kaiserl. Akademie der Naturforscher, und jener zu St. Petersburg; der königl. Akademien der Wissenschaften zu London, Stockholm, Upsal, Lund, Göttingen, Toulouse, Turin, und Siena, wie auch anderer gelehrten Gesellschaften Mitglied.

Wien, bey Christian Friederich Wappler.

1786.

Fig. 5. The book of Ignatius Born on his amalgamation process (1786)

the expenses of the experiments himself. Ferber, a contemporary writes that he spent 20 000 florins on equipments, material and the wages of the workers [6]. As his experiments were successful, he wrote a petition to Joseph II in autumn 1784 describing the advantages of his process and asking to be allowed to present it. The appointed experts went to see the experiments in January 1785. One of them, count Zinzendorf reports that the first demonstration was a failure and it had to be repeated [7].

The new amalgamation process consisted, in brief, of heating the ore, subsequently to roasting with common salt, grinding and sieving and finally heating it in copper kettles with mercury, water and common salt. During heating the material, which was not allowed to reach the boiling point, was agitated by a wooden grate. The operation took 20 to 24 hours. Afterwards the amalgam was eliminated by washing and the gold or silver was obtained from the amalgam by distillation. The most important step in the new procedure consisted of the previous roasting of the ore.

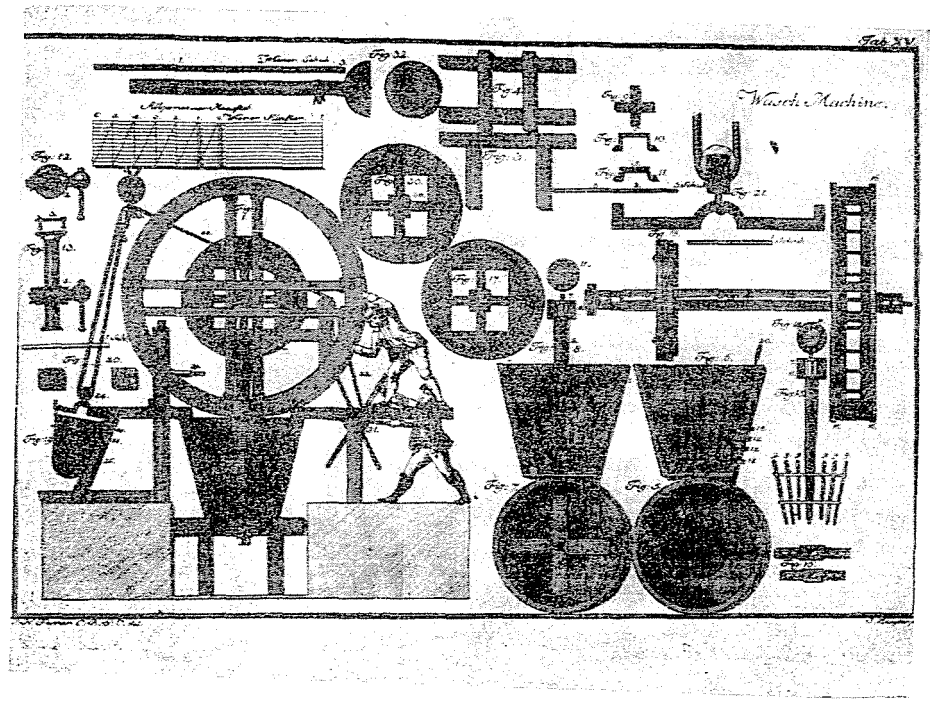


Fig. 6. The amalgam-washing equipment (Table XV from Born's book)

On the basis of the Vienna experiments Born obtained the permission to build an equipment for large scale trials. As a place for this he chose Szkleno, a small village near Selmec. This was an ideal place for metallurgical experiments as the well-known Mining Academy was established since 1763 in Selmec. One of its professors, Anton Rupprecht, became another assistant with Born's experiments.

Crell's periodical, the "Chemische Annalen" reported already in its first 1786 volume on the results of the Szkleno experiments. According to this report 120—160 centners of ore were amalgamated here daily from which silver could be extracted with a loss of only 2—3% by a single amalgamation process. The periodical also reports on the visit of mining counsellor Count Thun to Szkleno who checked the method on behalf of the Royal Court and found it advantageous. He suggested to discontinue the use of the dripfurnace and to introduce amalgamation [8].

Still in 1786 Born's book on the process appeared under the title "Ueber Anquicken der gold- und silberhaltigen Erze, Rohsteine, Schwarzkupfer und Hüttenspeise". From its preface we learn that amalgamation was ordered to be introduced all over the Hapsburg Empire and the first large-scale works were already under construction. The readers' attention was also called to the

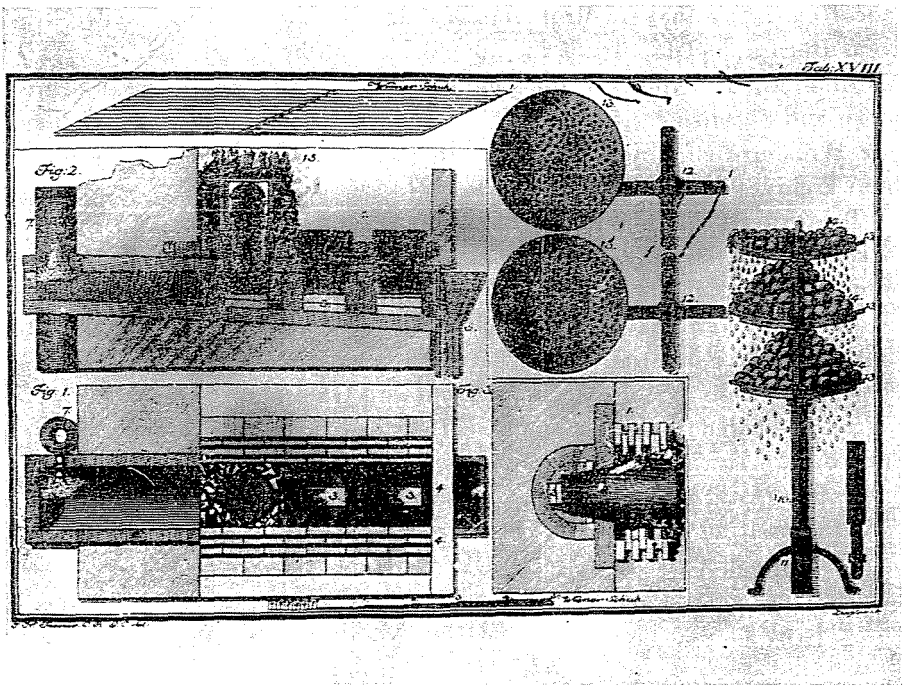


Fig. 7. The amalgam annealing furnace (Table XVIII from Born's book)

fact that anyone interested in the method could visit the amalgamating works [9].

As can be seen, much was done to popularize the process. An Imperial Decree ordered to introduce Born's method in the aerarian plants and make it generally known. It was expected that beside saving wood and time, the method would make it possible to increase the sale and export of mercury in which the Hapsburg Empire was very interested. Here we have to mention that in the same year it was allowed to re-set into operation the mercury works in Körmöcbánya (Kremnitz) and Besztercebánya (Neusohl) prohibited in 1580 [10]. Thus the propagation of the amalgamation process became an interest of the treasury. Hence, on the one hand, for a 10-year period the inventor was awarded one third of the difference in profit of the amalgamation process as compared to the melting method and for another 20 years of operation 4%; on the other hand, visas were granted to all the foreign experts interested in the new process. Born himself encouraged the invitation of foreign experts, because some officials at the Court disapproved of his method. Among these we mention the name of Joseph Freiherr von Leithner (1743—1822) who was at that time Commissioner of the Court in Idria where great mercury mines worked and obtained in 1790, after Born's death, his place

at the Royal Chamber of Mint and Mining. By the approval of the foreign experts Born hoped to silence his adversaries at the Court.

In 1786, 27 experts from English, Danish, French, German, Russian, Spanish and Swedish territories were granted to study the mines and furnaces of the Hapsburg Empire. The pertinent documents have been collected from Vienna archives by Renée Gickelhorn [11].

The experts did not arrive to Szkleno all at the same time. In general, they spent there several months. e.g., Johann Jakob Ferber, chief counsellor of mining in Prussia spent there one month, von Trebra, deputy inspector of mines in Hannover arrived from Zellerfeld for 3 months and Johann Daniel Weber came for 7 months. They visited the amalgamation plant and listened to the explanations of it leaders Rupprecht and Haidinger. Some of the visitors, e.g. Trebra, carried out experiments of their own with ores brought from their countries [12]. In the course of the experiments they too, modified and improved the process. They visited the works in the neighbourhood applying the traditional melting process as well.

The experts present in Szkleno at the same time gathered for a meeting somewhat similar to a conference of our days when the inventor arrived. This meeting is often considered as the first international scientific conference ever held. The foundation of the first international scientific-technical association the "Sozietät für Bergbaukunde" was decided here. This organization had members all over Europe and even overseas. It worked efficiently for some years but disappeared during the wars following the French revolution. Its organization was made public by its own publication the "Bergbaukunde" [13] and its history was treated in several papers [14].

According to J. G. Hoffinger, chief medical officer of the Chamber of Mining who was the medical expert present, the conference lasted 4 weeks, whereby the participants gathered every morning under the chairmanship of Born [15]. They discussed whether the melting or the amalgamation process was more economic. Papers of various lengths were prepared on the topic by seven of the participants.

The papers were collected by Ferber who published them in a volume [6]. Ferber became a devoted recorder of the Szkleno meeting. In another volume of his published equally in 1787 and dealing with his work on the improvement of amalgamation, he again described his experiences in Hungary [16]. When he became a member of the Berlin Academy, he devoted his inaugural address to this topic. Moreover, he contributed to the volume mentioned above with a short appreciatory study.

The Spanish mining expert and director of the Mexican mines d'Elhuyar, who was one of the discoverers of metallic tungsten in 1784, stressed in several of his papers that originally he was not much interested in the amalgamation process. One year before Born, his brother had carried out experiments in

South America to compare amalgamation as used over there with the melting process. There, the mercury process proved less advantageous. However, the method shown in Szkleno differed in many respects from the one used in South America. Born's process was entirely approved by d'Elhuyar, too.

As for Trebra, he was primarily induced by his lack of confidence to visit Selmec. He was convinced of the feasibility of the process, but not of its rentability. However, having carried out experiments of his own on the spot and having studied the accounts, he found that it might be promising to introduce the process also in his province of authority.

The most detailed analysis of the process shown in Szkleno was given by Olaus Henkel who had arrived from Norway. After a comparison of a multitude of data, he found amalgamation, from the technical aspect, more advantageous than the melting process. However, from the aspect of rentability he did not find it suitable for his own country. According to his opinion the new process might be useful for countries lacking in wood and such that are not compelled to import from abroad at least one of the accessories necessary in large amounts, i.e. mercury or common salt. In Norway, wood being the only raw material to be found in abundance, melting seems more economic.

Johann Daniel Weber, although not a well-known expert, was the one that spent the longest period in Selmec. In his detailed comparative study he enthusiastically approved of the new process. From his study it can be most clearly understood that the appreciatory statements of the experts of international call were not only a means of propagating the process abroad, but of promoting its recognition in its own country as well. (In spite of the support of the Court, the realization of the process was greatly hampered by the Hungarian mining offices.)

The volume was completed by the very interesting expertise of János Hoffinger (1756—1792), the chief medical officer of the Chamber of Mining, who compared the two processes from the aspect of labour hygiene. It is worthwhile to review his communication more detailed because it seems to be a very early example of examining a new technology from the point of view of public health. At the same time it is a report in details on the technology, as well.

His short report on amalgamation starts with the assumption that every industrial work must be a priori detrimental to health. This was, of course, absolutely true in the case of the two processes compared, since one of them utilized mercury and the other one lead. After this exposition Hoffinger gives an analysis of the steps of the amalgamation process. He remarks that wet crushing of the ore would be preferable as compared to the dry procedure, but estimates roasting and sieving as entirely innocuous. Neither did he observe any peril during the 24-hour heating of the ore with mercury and water, since in this procedure the mass did not reach temperatures high enough to make

the water boil or the mercury evaporate. This he assumed to be confirmed, apart from his own measurements, by the fact that mercury losses during the process were slight. The next step involved elimination of excess mercury by pressing as carried out in sacks and washing of the kettles. The ball-shaped pieces of the mass were then piled on trays placed one above the other and heated until elimination of the mercury. In his report Hoffinger still expressed the opinion that during the above procedures human hands were in contact with mercury only for a very short time. Thus he considered amalgamation less harmful than liquation, since the former process involved much less hot working places than the latter.

The appreciation of the mining experts of international reputation and of the learned physician, furthermore, to a considerable extent also the interest of the treasury brought about the rapid spreading of the process. Amalgamating works were built in 1786 in Joachimsthal (Bohemia), in Halsbrücke and Clausthal on German territory, in Brixen (Tyrol), Jekaterinburg (Russia), Adelsdorf (Norway) as well as in several places in Columbia and Peru [17].

However, amalgamation lost its significance as quickly as it had become known. The Szkleno plant was dismounted as soon as 1793 and Hungary returned to melting. This was mainly due to the fact that amalgamation lent itself in the first place to processing silver ores, the recovery of gold being lower than with the melting process. The ores of Hungary were of a relatively high gold content, thus the extraction of the latter gained importance.

Summary

All over Europe from the 15th century on the liquation furnace process with lead was used for gaining silver from copper ores. In Spanish-America an amalgamation method with mercury and using sodium chloride was elaborated and applied. This method which was made up of complicated chemical processes and was quite inefficient, was modified by Ignatius Born. He installed a pilot plant near Selmec in Hungary, and invited experts from several European countries for studying and reporting on the method. Particularly interesting of these reports is that of the physician J. Hoffinger because he described the method from medical point of view. This is one of the earliest documents of labour hygiene.

Born's method became common soon all over Europe but was given up after a short time.

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Éva VÁMOS 1053 Budapest, Múzeum krt. 9.
Prof. dr. Ferenc SZABADVÁRY 1521 Budapest