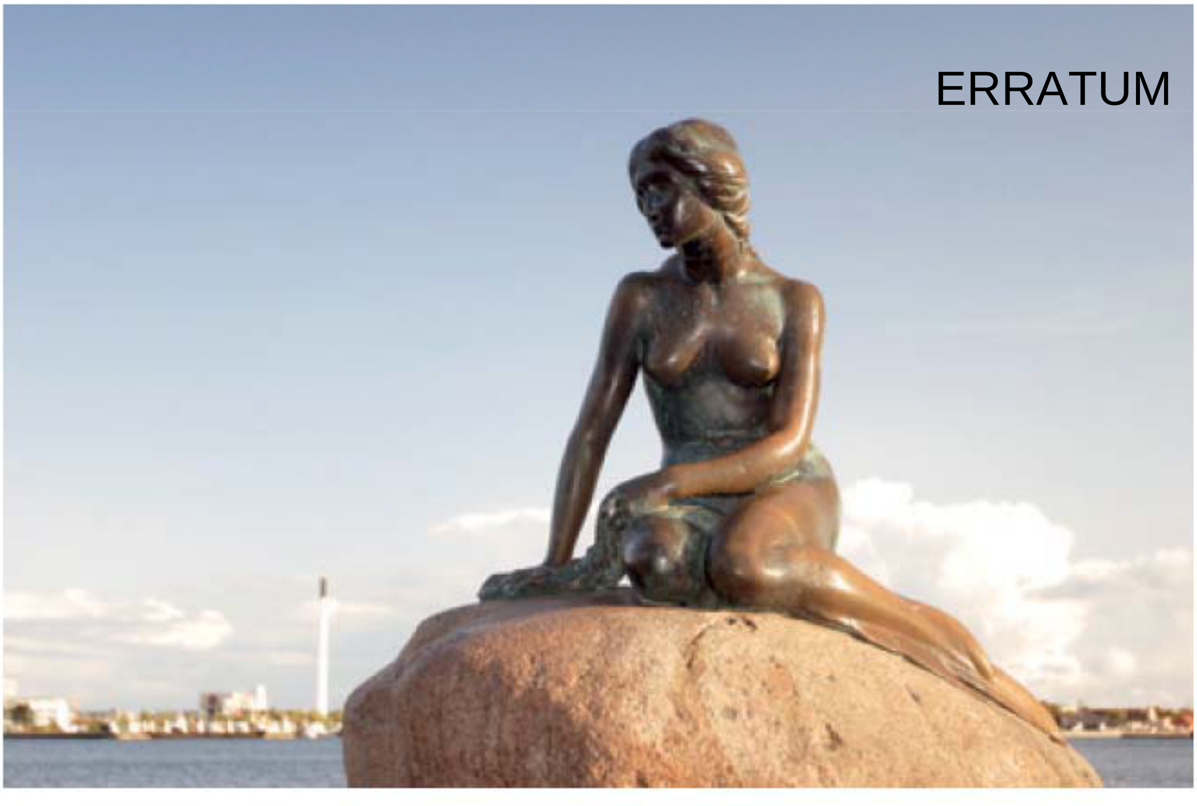
COLLECTION MONETA • 191

DOCUMENTS AND STUDIES ON 19th c. MONETARY HISTORY

Mints, Technology and Coin Production

Proceedings of the Round Table of the
"Silver Monetary Depreciation and International Relations" program
(ANR DAMIN, LabEx TransferS),
Copenhagen May 28-29, 2015

Georges Depeyrot, Michael Märcher editors



MONETA, WETTEREN 2015

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Nationalmuseet
National Museum of Denmark

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Mints, Technology, and Coin Production

Copenhagen 28-29 May 2015

The National Museum of Denmark

Room: Cinema

Everyone is welcome to attend the presentations in the cinema, but you will need to sign up by mailing Michael Märcher, The National Museum of Denmark (NMD), michael.maercher@natmus.dk before 20 May 2015.

28 May

09.15-09.30 Opening
Michael Andersen, NMD: Welcome
Georges Depeyrot, CNRS: DAMIN
Michael Märcher, NMD: Practical information

09.30-12.00 Chair: Michael Andersen, NMD

09.30-10.00 Ivar Leimus, Estonian History Museum, Tallinn
International contacts of the Tallinn mint masters in the 16-17th c.

10.00-10.30 Viktors Dāboliņŝ, National History Museum of Latvia, Riga
The curious case of mintmaster of Riga city Jost Haltermann (1660-1663)

10.30-11.00 Coffee break

11.00-11.30 Claudia Jefferies, City University London
Selective adoption of mining and minting technological innovations in Hapsburg Mexico: Centralist policy or exchange rate management strategy?

11.30-12.00 Dennis Flynn, University of the Pacific, California
Monetary Theory versus Credit Theory in Monetary History.

12.00-13.00 Lunch (speakers and chairs, Restaurant Julian)

13.00-17.00 Chair: Line Bjerg, NMD

13.00-13.30 Gitte Tarnow Ingvardson, Lund University Historical Museum
Two 17th Century War Hoards from Todarp (South Sweden)

13.30-14.00 Cecilia von Heijne, Kungl. Myntkabinettet, Stockholm
What can be learned about coin circulation from a total inventory of coin finds? Case study:
Northeastern Skåne c. 1600-1800

14.00-14.30 Coffee break

14.30-15.00 Cao Jin, University of Tubingen
Mints and Minting in Late Imperial China: Technology, organisation, and problems

15.00-15.30 Rita Martin de Sousa, University of Lisbon
Minting Techniques and the Quality of Coins produced in the Lisbon Mint House (18th - 19th centuries)

15.30-16.00 Coffee break

16.00-16.30	Ursula Kampmann Minting made in Germany, Trends in the Coin Producing Industry of Today
16.30-17.00	Seán Kenny and Jason Lennard, Lunds University Monthly Estimates of the Monetary Base in the United Kingdom, 1841-70
20.30-23.45	Dinner at Restaurant Höst (speakers and chairs only) Address: Nørre Farimagsgade 41

29 May

09.00-12.00 Chair: Helle W. Horsnæs, NMD

09.00-09.30	Ekaterina Svirina, Financial University, Moscow Denomination of coins and paper money in the Russian Empire during the end of the 18th - 19th century: some historical peculiarities
09.30-10.00	Katerina Bregianni, Academy of Athens Classical revivals in contemporary European banknotes and coins; cultural interconnections and monetary homogenization'
10.00-10.30	Hedi Saidi, University of Lille L'histoire des monnaies en Tunisie : une présence ancienne et variée

10.30-11.00 Coffee break

11.00-11.30	Jens Christian Moesgaard, NMD Medieval coining tools from Lund, Scania (present day Sweden)
11.30-12.00	Svein Gullbekk, Museum of Cultural History, Oslo Concluding remarks
13.30-	Lunch at Kanal Cafeen (speakers and chairs only) Address: Frederiksholms Kanal 18

Screw presses, Boulton presses, and Uhlhorn presses - The 19th century development in Danish coin striking machinery from an international perspective

Michael Märcher

Introduction

This article presents developments in the work-process of coin striking and discusses how the availability of new technologies and machinery interacted at the Danish mints in the 19th century.[1]

One of the two[2] Danish mints of the 19th century was situated in the capital Copenhagen. The other mint that existed 1771-1863 was located in the then second largest city of the realm, Altona, now a suburb of the German city of Hamburg.

The technological development of Danish coin production in the 19th century was characterized by the transition to mechanical operations, significantly enhanced use of machinery, and new methods of production, resulting in substantial quantitative and qualitative improvements. Horsepower, primarily used for rolling, was used until the rebuilding of the Copenhagen mint 1806-10 and the rebuilding of the Altona mint 1855-56. It was replaced by steam power that also replaced the use of manual labor in several other parts of the production.

The massive increase in the coin production's quality and quantity led to new possibilities, and it was put to use everywhere in the monetary policy. The mints were preconditions for the creation of the new, stable, and modern monetary systems that were created in the 19th century. As technical infra-structure installations the mints were part of the technology-based modernization and state-building directed to some degree by the new and often more centralized governments of the Nation-States of the 19th century. New, stable, common, and uniform monetary systems were of course vital to the development of banking, trade, and finance systems. But the importance was not limited to these economic sectors of society nor to the technological aspects. The stable and common monetary system with widespread use of coinage was – like a common language – a uniting factor; it brought different parts of society closer together both in the local, regional, and national level and between urban and rural areas.[3]

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[1] This article is based on chapters in a dissertation published 2012 about the technology and production of the Danish mints: Michael Märcher: *De kongelige møntsteder i Altona og København 1813-1873. Teknik og produktion*. Odense 2012a. Coin striking is one of several production stages dealt with in the book which is based on significant archival studies. References to archival records, books, articles etc. behind the relevant chapters in the book are not repeated in this article, but can be found in the book. The only exception is quotations that are given a reference. Most of the quotations are originally in Danish; they are here given in English. Focus has been on the meaning of the quotations, and not on the use of older words, certain words, word order etc.

[2] Norway and the Norwegian mint in Kongsberg were not part of the Danish king's realm from 1814.

[3] This article focuses on the development of coin striking machinery, for more on the effects of the development in Danish minting technology see Märcher 2012a; Michael Märcher: Coins, metals, and reforms: A survey of Danish monetary history 1813-1873, in Georges Depeyrot (ed.): *Moneys and Economies during 19th Century (from Europe to Asia). Collection Moneta 139*, Wetteren 2012b, 77-95; Michael Märcher: The 19th century development in minting technology in Denmark and Japan – and monetary transitions in Denmark, Japan, and Bornholm, in Georges Depeyrot (ed.): *When Orient and Occident Meet. Collection Moneta 176*, Wettern 2014, 169-187.

Coin striking

The striking of a coin and the coin's motif was always something special in the entire process of coin production. The striking of the blank transformed the blank into a coin. It was therefore a crucial process. In 1856 Karl Karmarsch (1803-1879) wrote about the purpose of the imprint: "es soll erstens nach dem Grundbegriff des Geldes die Garantie eines bestimmten Gehalts an edlem Metalle ausdrücken und den Nennwerth bezeichen, unter welchem die Stücke umzulaufen bestimmt sind; zweitens aber die Oberfläche dergestalt schützen, dass ein betrügliches Wegzunehmen von Metalltheilen durch Schneiden, Schaben, Feilen etc. nicht ohne sogleich sichtbare Verletzung möglich ist."[4] The imprint must therefore be as clear and complete as well as durable and consistent as possible. In addition, it also ought to be aesthetically pleasing and artistically done, so it was both trustworthy and difficult to imitate. All this required the use of a suitable technique.

Use of milling and striking with convex dies in a collar increased the coins' durability, as the edge became higher than the imprint. It protected the imprint from wear, "so daß auch das flach auf einem Tische etc. liegende Stück ausschließlich am Umkreise aufruht."[5] The imprint on coins from different years, also on coins produced at different mints, should wherever possible be homogeneous, and there should be consistency across the coin series. The introduction of die copying in the 19th century was therefore significant. The following sections first discuss the relevant 19th century coin striking machines and their role at the two mints. Then, our attention will be on collar striking, edge rimming, and die manufacturing.

The two mints in Altona and Copenhagen in the 19th century used three different types of machines for striking: hand-operated screw presses (also called spindle or swing press, fig. 1-2), steam-operated screw presses (Boulton's presses, fig. 3-4) and Uhlhorn machines (fig. 5). The blanks were struck horizontally between an upper and a lower die.

Hand-operated screw presses

The first hand-operated screw presses were used for coin production in the 16th century, but it was not until the 17th century that the mints in the Danish realm started using them. They had their heyday in Europe around 1700-1830. In Altona the hand-operated presses were in use until the 1850s and in Copenhagen until the rebuilding 1806-1810.

A hand-operated screw press consisted of a strong steel frame in which a large two-, three- or four-barreled (steep) vertically working screw was located.[6] A multi-barreled and steep screw thread increased the force of the press and was beneficial in relation to the recoil and striking speed. At the top of the screw was a large iron crossbar with weights attached. It was used to put the screw in motion. The crossbar's size, length, and weights could be varied according to how strongly the screw should hit the upper die, which it rotated down to hit. The upper die hit the blank placed on the lower die. Each screw press required a lot of space and a substantial foundation due to its strong blows. A person "stands in the pit in front of the press to operate it … when coins are struck, which must be done with rapidity, 12 to 14 men are often used at one press to swing the crossbar with ropes."[7] The number of people varied from coin type to coin type and from press to press. 4-8 men were probably normally used, and it was only when striking the largest coins that eight or more people were employed at one press.

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[4] Karl Karmarsch: *Beitrag zur Technik des Münzwesens*, Hannover 1856, 49.

[5] Karmarsch 1856, 54.

[6] The screws on the screw presses at the Altona mint were usually two-barreled, while the steam-driven Boulton presses in Copenhagen were probably three-barreled.

[7] P.R. Hinnerup: *Haandbog for Juvelere, Guld- og Sølvarbeidere*, Copenhagen 1839, 440. Ropes were used in Copenhagen around 1800. The workers could also push directly on the crossbar; this was the case at some mints, but probably not at the mints in the Danish realm in the late 18th century or the 19th century. In 1799 mint master H.I.A. Branth in Copenhagen estimated that the use of ropes was more than twice as effective as when the workers ran around and pushed the crossbar with their hands.

Recoil from the blow meant that the screw largely pulled itself up again. Therefore, the workers' job right after the blow was primarily to pull the crossbar back to the right position, while a worker removed the coin, possibly with a special coin-extraction-tool, and placed a new blank on the lower die.[8] There is great uncertainty regarding the capacity of the screw presses. Presumably, a screw press could strike up to 30 smaller blanks per minute, as the crossbar and the screw only had to be moved very little. The capacity when striking larger coins was lower – probably between 5 and 20 pieces per minute.

Boulton's steam-driven screw presses

The steam-driven screw presses developed by Boulton and patented around 1790 basically used the same striking technique as the hand-operated screw presses, but they were faster, stronger, and had automatic feeding. This meant that they could be run by just one man, who filled stacks of blanks in feeding cylinders. The steam-engine's power was used to drive the screw down with great speed and power. The first striking works with 4-6 presses that Boulton developed was a circular arrangement with a large horizontal flywheel. Boulton later developed a method so the steam-engine's force could act more directly on each press. Thereafter most of the striking works, including the one set up 1806-10 in Copenhagen with four presses, were linear arrangements in which each press could be better controlled. The faster and more powerful presses could easily strike large copper coins, and they could strike c. 40-70 blanks per minute. A Boulton press in average struck c. 40 pieces of speciedaler (largest silver coin, c. 29 grams) per minute in the 1830s at the mint in Copenhagen. The presses sometimes probably struck 60 blanks (coins smaller than 1 speciedaler) per minute, but hardly more. The steam-driven Boulton screw presses not only meant a significant increase in capacity, but also significant savings on labor. The quality of the striking itself was higher due to the increased power and new striking technique (described later). But the Boulton presses were not suitable for the thinnest coins. This is explained later on.

The steam-driven screw presses required a strong foundation and took up a lot of space – and they allegedly made an incredible noise. It was also a great investment, and in Europe such works were apparently only installed at the mints in Copenhagen, London, St. Petersburg, and Soho. According to the Norwegian mint master Langberg, Boulton's coins had "a perfection, so they at first glance can be distinguished from all others; but the works were so expensive that only eight mints of this kind can be found in the World".[9] Despite the price, but because of the quality, Boulton's striking works would probably have become more common in Europe after the Napoleonic wars, if a revolutionary new coin striking machine (the Uhlhorn press; knuckle-lever press) had not been invented.

The four steam-driven screw presses were a key element in the mint Denmark bought from Boulton. They were seen as crucial to an improved quality of coin striking. During the negotiations with Boulton, the later Copenhagen mint master Ole Warberg in 1798 asked thoroughly of the presses that "are principal machines in a Mint ... do they strike money better in point of accuracy & neatness, can they be work'd with considerable less Expences & qvicker than the common ones, are they constructed in such a manner, that the power & celerity may be adjusted according to the size of the presses"? And Boulton answered: "The new Coining presses are ... more accurate they produce a finer polished ground & can work cheaper because one Boy of 12 Years old is capable of attending one of them when working at a rate ... [that] would require 4 or 5 Men to Coin 44"[10] pieces of 2 pennies in copper per minute. Boulton did

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[8] Feeding and extraction devices were developed in the late 18th century (probably primarily in Bologna and Paris), but they were probably never used at the hand-driven screw presses in Altona or Copenhagen.

[9] C.H. Langberg: Norges Mynthistorie senere end 1814, *Forhandlinger i Videnskabs-Selskabet i Christiania Aar 1866*, Christiania 1867, 10-39, p. 39.

[10] Birmingham City Archives, 3782: Matthew Boulton Papers, 13: Correspondence and Papers of Matthew Robinson Boulton, 110: Danish Mint 1796-1806, Reports, Estimates, Proposals, Contracts & Legal Documents, 4th and 26th March 1798.

not exaggerate the quality or quantity. His answers quite well matched the mint's experience c. 1810-1840. When the four presses after little initial difficulties came into service around 1809-10 in Copenhagen, they were generally well-functioning both in relation to quality and quantity. These modern coins of high quality with different new features were from c. 1810-1814 statutory in the Danish realm. Only a few other mints produced coins of this superior quality. Other Nordic or German mints did not start producing these modern coins until the 1820s or later.

Existing literature about minting technology has focused on the new striking technique's connection with the Boulton presses, and on the technique's continuation on the knuckle-lever presses. Little attention has been paid to the fact that the vital parts of the new technique could be – and several places were – implemented on the well-known and widely used hand-operated screw presses.[11] Focus had been on the steam power and thereby on the force of the new presses. But the new striking method primarily consisted of the convex dies and the use of a collar during coin striking – and also the simultaneous edge rimming – that improved the quality considerably. In 1812-1813 the new striking method was successfully transferred from the steam-driven screw presses in Copenhagen to the hand-operated ones at the mint in Altona. The implementation on hand-operated presses is not surprising; parts of the new technology was developed in the late 18th century at the Mint in Paris, which at that time did not have any steam-driven presses.

To improve the general state of the Danish monetary system, the Danish government wanted the new technique implemented at the mint in Altona. This could be done by alteration of the mint's hand-operated screw presses or by purchasing the necessary equipment (steam powered presses etc.) by Boulton. Therefore, several attempts to strike with convex dies without a collar in the old presses were performed at the Altona mint in the end of 1812. It was not possible even though Altona mint master Michael Flor tried to change the presses' force and the blanks' size and hardness. However, shortly thereafter Flor succeeded in striking with convex dies in a collar. The government wrote to mint master Warberg in Copenhagen, that "by some attempts at the mint in Altona, it is clear that the normal presses can strike concave coins in collars, and according to mint master Flor it only cost a little bit more [it takes longer because the speed of striking is lower] than without collars. Since it is very important that a coinage of 2 skillinge for circulation in the Duchies is started"[12] the coin technician J.F. Freund, who is familiar with the new technique, shall quickly travel to Altona with drawings of the presses and the milling machines in Copenhagen and with matrixes and poinçons for 2 skillinge. Then things happened quickly. In early 1813 Flor reported, that one of the hand-operated presses now, especially because of Freund's efforts, could without any problems strike with convex dies in a collar – and almost as fast as earlier without a collar. According to Flor, only the production of the convex dies might be a problem. The government was very pleased with the progress and generally also with the submitted samples. The samples' quality primarily differed from the coins struck in Copenhagen due to poorer milling, which the Altona mint quickly improved. So the transfer of the new striking technology from Copenhagen to Altona was qualitatively and later also quantitatively very successful. In other words, there was no reason for the Altona mint to purchase equipment from Boulton.[13]

The four steam-driven screw presses at the mint in Copenhagen and the five hand-operated strong and relatively new (second half of the 18th century) presses in Altona were a

[11] However, the most common development was that the new technique was introduced at mints when they bought or constructed knuckle-lever presses or steam-driven screw presses

[12] Danish National Archives, Den Kongelige Mønt, København, Indkomne breve, 1812, 34.

[13] The success probably meant that considerations of a purchase of a steam-driven striking works at Boulton for the mint in Kongsberg were eliminated. However, it was already in March 1813 decided that J.F. Freund's younger brother, the smith (later sculptor and professor) H.E. Freund, was to travel to the mint in Kongsberg to equip it with the new striking technology. The transfer to Kongsberg was not so successful. J.F. Freund had to replace his brother and he was probably not able to finish the job in time (before the separation of Norway from Denmark in 1814).

significant striking capacity until the second quarter of the 19th century, when the knuckle-lever presses became widespread. The two mints, however, had less striking capacity than the few other mints designed, produced, and sold by Boulton, since Soho (1799), St. Petersburg (1807), and London (1810) each had eight steam-driven presses. The mint in Copenhagen was smaller than any of these other Boulton mints. The mints in Berlin, Paris, and Philadelphia also had more striking capacity through the entire century, even though they introduced steam power later than the mint in Copenhagen. This is presumably also the case for the mints in Kremnica and Vienna. On the other hand, the mints in Braunschweig, Clausthal, Hannover, Kassel, Kongsberg, Rostock, and Stockholm had less striking capacity than the mints in Altona and Copenhagen in the first third of the century.[14]

Uhlhorn's coin striking machines

The talented inventor and machine builder D. Uhlhorn (1764-1837) had a machine shop (later a machine works) in Grevenbroich, a little northwest of Cologne. In the early 19th century (1817) he developed a new coin striking machine: the knuckle-lever press.[15] The first machine was set up at the mint in Düsseldorf in 1818, where the public saw it. Shortly thereafter, machines were delivered to the mint in Berlin, and the type soon became widespread throughout Europe.[16] After 1820 only a few screw presses were set up at European mints.[17] In the middle of 1863 Uhlhorn's factory had supplied 146 machines (table 1) for many different mints with Helsinki, Yekaterinburg, Tunis, and Madrid as the probable geographical extremes.

Uhlhorn's machine was called a knuckle-lever press because it was based on a knuckle-lever mechanism (fig. 6). The machine could exert a significant pressure on the upper die with short, quick, and rotary motions. It was equipped with a flywheel and a crank, and it could be driven by most power sources e.g. hand- or steam-power. The knuckle-lever mechanism revolutionized coin striking.[18] The mechanism was later used in many coin striking machines, for example at the important companies Heaton & Sons in Birmingham and Luis Schuler in Göppingen near Stuttgart. The machine had automatic feeding and extracting/ejecting, which combined with its successive motion meant that just one person was needed to operate one or several machines if they were powered by, for example, steam. The machine thus required less staff than the screw presses, and it also required less force.[19] It was not only at the mint in Dresden that the ordinary mint workers felt that the Uhlhorn machine "sind unsere Leichensteine".[20]

The Uhlhorn machines' striking process was also beneficial in comparison with the very strong blows performed by the screw presses. The new machines made less noise and did not require a special foundation. They were also of relatively small size, and could therefore more

[14] The striking works can hardly be compared with other works in the realm. Other production facilities with different striking works/presses did not emerge in the realm until the middle of the 19th century. The most important belonged to goldsmith J.B. Dalhoff (1800-1890). In 1828 he received a six-year monopoly on the manufacture of certain machine types, which he used to produce buttons, knives, forks etc. His striking work was insignificant compared to the ones at the mints. On at least one occasion he bought phased-out striking equipment from the mint in Copenhagen.

[15] Around 1811 I.A. Newedomski at the mint in St. Petersburg had built a knuckle-lever press and published it in Russia, but it did not become widespread. Presumably, Uhlhorn invented his machine independently of Newedomski.

[16] The machines' rapid success and introduction to Prussian coin production were partly due to Uhlhorn's connection with the Prussian mint director C.F. Goedeking (1770-1851). Uhlhorn's machine was copied by Thonnelier at the mint in Paris, and Thonnelier's presses were used among other places in France and the United States.

[17] Die hubbing presses are here disregarded.

[18] Apart from the so-called roller striking, coins were previously struck using either a hammer or a screw.

[19] In the 19th century the striking machines were produced in four sizes, so each machine was designed for certain coin sizes. The largest machines required c. 1 hp around 1880, while the smallest could be driven with just c. $^{1}/_{6}$ hp.

[20] Max Barduleck: *Die letzten Jahre der Münze in Dresden*, Paul Arnold (ed.), Berlin 1981, 42.

easily fit in at mints. The knuckle-lever mechanism also meant that the usage of the expensive coin dies were lower than the screw presses'. The machines were more complicated than the hand-operated screw presses, which meant more difficult repairs etc., but once they were successfully put into operation, they were generally very stable. This is illustrated by the fact that Uhlhorn machines from the first half of the 19th century were in operation for more than 100 years, for example at the mints in Copenhagen and Vienna. Many persons and mints were quickly excited about the new machines. The advanced mint in Munich stated in 1841: "das während des 15-jährigen Gebrauchs nie eine Hauptreparatur nötig gewesen sei", and at the mint in Dresden it was said, "diese Maschinen leisten in der Tat Unglaubliches, sie ersetzen gewisser maßen den menschlichen Geist."[21] The machines' capacity was significant. Already the first machine from 1818 could strike 40 blanks per minute, which significantly surpassed the virtually ubiquitous hand-operated screw presses. In the 19th century steam-driven Uhlhorn machines could strike about 60-70 smaller blanks (up to 20 mm) per minute or 45-50 pieces of 1 speciedaler per minute. It was at least twice as much as the hand-operated screw presses and also more than the steam-driven screw presses.

Until the rebuilding of the Copenhagen mint in 1806-1810, the mint had several large and small hand-operated screw presses of which some were old and/or weak. After the rebuilding some of them were transferred to the Altona mint that used hand-operated screw presses into the 1840-50s. Since its establishment in 1770-71 the mint in Altona had four rooms for striking in which five screw presses were installed. As mentioned, this was in international perspective a significant striking capacity until the second quarter of the 19th century. The two Danish mints did not buy or manufacture hand-operated screw presses in the 19th century.[22]

In 1822 (perhaps earlier) the two mints in Altona and Copenhagen became aware of the new coin striking machines installed in Düsseldorf and Berlin.[23] Correspondence between the Altona mint master J.F. Freund and Krupp in Essen about cast steel shows that Krupp advised Freund to contact mint director Goedeking (fig. 7) in Berlin for drawings of the new machine.[24] According to Krupp, Uhlhorn would not provide drawings. Freund probably received information from Berlin, where he had very good connections.[25] Although the two mints were aware of the new machines, no initiatives were so far taken towards acquisitions or tests. This was probably due to the fact that both mints were still able to strike coins effectively with their quite new or newly improved striking equipment. Their equipment was enough to meet the demand for coins. Thus, new investments should primarily be considered in relation to ordinary operating economy such as for example wages and consumption of coal, and this did not occur until the mid-1830s.

At the end of 1836 the Copenhagen mint considered the ordered production of small coins[26] at the mint in Copenhagen for the Danish colonies in the West Indies (now U.S. Virgin

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[21] Both quotations are from Manfred Ganschinietz: *Diedrich Uhlhorn 1764-1837: Leben und Werk,* Grevenbroich 1987, 18.

[22] The die hubbing press bought at Boulton for the mint in Copenhagen is ignored in the last sentence. The realm's mints did not produce screw presses themselves; the ones bought in the 18th century probably almost all came from Norway, Northern Germany, or Sweden. Three screw presses were around 1770 produced at the cannon foundry etc. at Frederiksværk in Zealand, and one of these, a large one c. 4 tons, was set up at the Altona mint in 1772, while the two others were probably sent to the mint in Copenhagen.

[23] Perhaps Uhlhorn was at the mint in Copenhagen around 1820; Friedrich von Schrötter: *Das Preussische Münzwesen 1806-1873*, vol. 1, Berlin 1926, 245: "Um die neuesten englischen Prägewerke kennen zu lernen, hatte Goedeking den Uhlhorn nach Kopenhagen geschicht". Such a visit is not known from the available archival material and does not fit with the relevant cases from 1820 and 1822. Goedeking was at the Copenhagen mint in 1814 to see the new machinery.

[24] In 1820 Freund was allowed by the Ministry of Finance to make a model of one of the technically updated screw presses at the mint in Altona for Goedeking. In those yeas much was done in Berlin with regards to tests, acquisitions, and construction of different striking machinery.

[25] One of his brothers had a machine works in Berlin that supplied some equipment to the Berlin mint.

[26] Standard coins are coins produced according to the monetary standard in use, while small coins are coins produced below standard, with insufficient intrinsic value, and normally only for domestic use.

Islands). Copenhagen mint master G.W. Svendsen pointed out that it would be inconvenient to strike smaller coins as for example a 2 skilling (13 mm, c. 1.1 grams) in silver with the steam-driven Boulton screw presses. He therefore recommended the purchase of an Uhlhorn striking machine. According to Svendsen it was widespread in Germany and it could with 1-2 persons strike 60 blanks per minute. It was especially good at striking smaller coins and could be operated by steam power. Earlier this year, Svendsen had been on a study tour to mints in Germany, where he had seen the Uhlhorn machines in use. He was impressed, but he failed to convince the Ministry of Finance. The small coins for the colonies were subsequently struck at the hand-operated presses in Altona.

Later in the 1830s, Svendsen again argued without success for the purchase of an Uhlhorn machine for the production of smaller coins. The lack of success was probably influenced by an evaluation made by the skilled engineer and mint principal E.D. Ehlers (1812-1893). He had stayed at the mint in Berlin to learn about minting techniques as part of his major European travels 1837-40, but he was not impressed by the Uhlhorn machines. In March 1838 Ehlers wrote back to the important and influential government official J. Collin (1776-1861) in the Ministry of Finance "Uhlhorn machines ought probably not to be acquired for the Danish mints, as has been suggested, even not for smaller coins, since these are expensive and it has turned out that they easily break down and are unable to make a sharp strike ... their capacity are not higher than the screw presses, since they so often come out of order."[27] The literature on the machines in Berlin or archival material associated with the use of Uhlhorn striking machines at the Danish mints do not in any way indicate that Ehlers' observations were correct. However, it would not be surprising if there were technical difficulties with the very first machines. The Uhlhorn machines generally seem to have been sound and reliable. Collin and others had no way of knowing that, and there was no reason to doubt the observations made by engineer Ehlers. Svendsen hardly knew that Ehlers did not support him. In 1839, Svendsen for example wanted Ehlers to visit Uhlhorn's factory and place an order. Svendsen expected that the Nationalbank would soon start withdrawing the copper tokens issued by its predecessor, the Bank of the Realm, after the Napoleonic Wars and the Danish state bankruptcy (a great monetary reform) in 1813. This withdrawal would neccesitiate a large-scale production of silver small coins. The monetary development was correctly analyzed by Svendsen, and in 1841 the production of this silver small coinage led to the purchase of the first Uhlhorn machine for the two mints.

Uhlhorn machines and the two mints

The production of silver small coins (4 skilling, 16 mm, c. 1.85 grams) had a negative impact on both rollers and milling machines in Copenhagen. The smaller coin of a harder silver alloy (25 % silver) created obstacles for the used and so far successful machinery, and the production of the coins was particularly inexpedient for the steam-driven presses. The thinness of the coin challenged the milling and the striking in a collar. The low diameter of the coin was also a problem for the expensive die manufacture, as the steam-driven presses required dies of a particular size and thickness. This meant that the dies for 4 skilling basically should have the same base as dies for 1 speciedaler. An Uhlhorn coin striking machine was faster and required less force, and it could strike coins with fewer, smaller, and cheaper dies. It was not only the price of steel for dies that affected the die price, but also that the die manufacturing incl. the hardening was more difficult and took longer time the larger the die was. The dies also had a longer durability in the Uhlhorn machines.

Although both Ehlers (now factory inspector in Altona) and also mint master Freund in Altona previously had been skeptical about the profitability of the Uhlhorn machines, they both supported mint master Svendsen in 1841. All three now agreed that an Uhlhorn machine would be advantageous for the production of smaller coins. The durability of dies in an Uhlhorn

[27] The Royal Library, Copenhagen, Collins Brevsamling XXIIa, Ehlers in Berlin to Collin, 1st March 1838.

machine was in Copenhagen in 1841 assumed to be 25% longer than in the screw presses. A production of approximately 50,000 marks (almost 12 tons) of silver in small coins was planned and it would with the old presses require approximately 1,000 dies. There was thus a significant saving of about 200 dies with an Uhlhorn machine. In addition there would be savings on fuel, payroll, etc. The approximately 50,000 marks of silver could be sent to the mint in Altona, but that was expensive, and also inconvenient due to the subsequent distribution that would require shipments of coins back to Copenhagen. It was without doubt possible to save more than a couple of thousand rigsbankdalers, if the small coins were produced in Copenhagen incl. striking on a new Uhlhorn machine. The economic argument was convincing, since such a machine only cost 2-3,000 rigsbankdalers and were supposed to have a delivery time of 2-3 months. Therefore, by royal decree from July 1841 the mint in Copenhagen was allowed to purchase the realm's first Uhlhorn coin striking machine.[28]

Ehlers ordered the machine and Uhlhorn confirmed that it could be delivered in 8-10 weeks. The mint wanted Uhlhorn to come to Copenhagen and set up the machine. Uhlhorn had to know the size of the desired coins, and blanks for 16, 8, 4, 3 and $^1/_5$ skilling were sent to him. As mint master Freund in Altona became aware of the approval of the purchase and that both mints should produce small coins, he asked for an Uhlhorn machine for the mint in Altona: "When I several years ago visited the mints in Berlin and Schwerin, I saw and examined the machines made around 20 years ago by Uhlhorn, on which coins are struck fast and easily. Back then the machines to me seemed so complicated that one had reason to suspect that it would often break down and need repairs and thereby delay production more than advance it. I have therefore, and especially since no large-scale production of small coins has been planned, not thought more about these machines or wished to have one at this mint. Now on the contrary, when I hear that both mints should very soon begin large-scale production of small coins, to which the five big presses are not as convenient as one could wish for, when producing such small coins, and also when I from Ehlers and other knowledgeable and reliable men learn that the Uhlhorn machines in the recent years are improved a lot or at least simplified and more durable that it is found reasonable and beneficial to purchase such a machine for the mint in Copenhagen, I am convinced that such a small machine would also be very beneficial to the production of smaller coins at this mint."[29]

In another letter five days later Freund pointed out that a production of half a million rigsbankdalers in small coins in Altona was planned.[30] So the approximately 2,000 rigsbankdalers for an Uhlhorn machine would quickly be realized, since the mint would have a capacity problem with the striking process – especially when the coinage of larger standard coins continued. Freund was soon allowed to buy a machine of the same type (an Uhlhorn machine for smaller coins) as the mint in Copenhagen.

Only around 100 rigsbankdalers could be saved by joint delivery of the two machines, which would delay the one for Copenhagen several months. Ehlers therefore made sure that the two orders were kept separate. Both mints urgently wanted to get the machine installed. In Copenhagen it was not going well with the striking of the thin 4 skillings in the steam-driven presses, and J. Collin in December 1841 wrote to Freund: "here we long for the Uhlhorn machine, it was supposed to arrive in the middle of last month."[31] The machine was delayed, because Uhlhorn was busy supplying machines to the mint in Vienna, which was a more important customer to him. Already before 1833 the Vienna mint had bought six machines, and bought seven more in the 1840s.[32]

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[28] The coinage was ordered in June 1841 and the mint should use the screw presses until the new striking machine arrived.

[29] Danish National Archives, Finansministeriet, Sager til Møntjournalen, Freund's letter from 13th August 1841.

[30] Since a lot of silver small coins were produced in Altona in 1836, Freund in his argumentation had to point out why the situation was different in 1841 than in the 1830s in relation to, for example, the production volume and the improvements of the Uhlhorn machines.

[31] Danish National Archives, Den kgl. Mønt, Altona, Indkomne breve, 1841, 69.

[32] It was at the same time clear that Uhlhorn could deliver to Altona first in summer 1842, and this is why

Uhlhorn and the machine came to Copenhagen in January 1842, and he quickly set up the machine.[33] It was in relation to both operations and capacity successful, as from the beginning it could strike 50-60 blanks for 4 skilling per minute, when it was operated by three workers – one man put blanks in the feeding tube and two men drove the machine. It should be connected (belt drive) to the steam engine as fast as possible, so the same amount could be produced by just one person. The new machine could only with difficulty strike 16 skilling (21 mm, c. 4.2 grams) due to lack of strength. This fact and the otherwise immediate success meant that talk in Copenhagen, especially among Svendsen and Collin, about purchasing another machine commenced as early as the end of January 1842. It should be a bigger one that could strike larger standard coins. It would only cost about 1,000 rigsbankdalers more than the first for which the expenditure was approximately 2,400 rigsbankdalers. Collin immediately thought it was a good idea and suggested to Freund that the order from the Altona mint be changed to a medium size machine for the mint in Copenhagen, and that the smaller machine in Copenhagen be sent to the mint in Altona.

Collin's and Svendsen's considerations must be understood in the light of the immediate success, optimism, etc., which quickly became attached to the realm's first Uhlhorn machine. Freund, however, quickly made Collin think again and brought him back down to earth by drawing attention to the fact that there was no problem with the striking of the larger coins on the steam-driven screw presses in Copenhagen. Therefore, the purchases of larger machines were redundant or would make some of the expensive and still quite effective steam powered presses obsolete. If another machine should be purchased for Copenhagen, it had better be another one for smaller coins, since the first one despite its success could not quite keep up with the other stages of production at the mint, when the mint was only producing smaller coins that were not weighed piecewise. At the mint in Altona, it was assumed that there was a technical problem with the striking of larger standard coins on an Uhlhorn machine of medium size. Freund wrote to Collin: "According to Mr. Alsing[34] and several others that know the medium size machine, it will have difficulties striking 1 rigsbankdaler, because this coin type had a deeper motif than the German talers, even though I always want to improve the machines at this mint, then I do not think I would argue for a medium size machine for a purpose for which the screw presses in Copenhagen and here are appropriate."[35] Therefore, no changes were made in the order from the mint in Altona, and in July 1842 Uhlhorn stayed a week at this mint and installed a machine (fig. 8) for smaller coins. It was tested by striking c. 20 rigsbankdaler in $^1/_5$ skilling (14 mm, copper, c. 1.5 grams), and it quickly worked without problems. The machine, like the one in Copenhagen, meant a significant efficiency improvement and promptly got a great deal of the striking tasks. After almost half a year Freund wrote to the Ministry of Finance about how it had turned out with this new wonder, which then had struck more than 1 million pieces of 4 skilling "we are certain that this beautiful machine with the same use of power and time as the old presses strikes twice as many coins. Also, it uses fewer dies than the old presses, but this advantage is significantly reduced since it costs more to manufacture the dies for it."[36] The success continued with both machines, and during the 1840s they also struck some larger coins such as 16 skilling and coins for the Danish West Indies.

In 1847, the gradually inadequate performance of the steam engines was crucial for the acquisition of the next Uhlhorn machine for the mint in Copenhagen. After the (re)introduction

considerations about cancelling the order originated. It was not advantageous to purchase machinery at that time if most of the small coins were already produced. To Collin, Ehlers pointed out that Freund could turn to Roessler in Darmstadt, who also built knuckle-lever presses. However, the order was not changed.

[33] The machine is preserved at The Danish Museum of Science and Technology. The museum received it in 1960 from The Royal Mint. After some improvements and increase of speed in the 20th century, it was probably regularly in use until the 1950s.

[34] H.F. Alsing among other things worked with die manufacture.

[35] Danish National Archives, Den Kgl. Mønt, Altona, Kopibog, 2nd February 1842.

[36] Danish National Archives, Den Kgl. Mønt, Altona, Kopibog, 2nd December 1842.

of the silver standard in 1845 a significant production of larger standard coins, especially for the Nationalbank, had taken place in Copenhagen. The mint was operated for longer periods of time with full force and the inadequate performance became a problem especially in the beginning of 1847: "As known, our mint among other imperfections also has the problem that due to the lack of power from the engine, the Boulton presses cannot be used when the large rolling works is in full operation, and the latter is needed every second day for the production of 1 speciedaler, and for this reason it has this winter several times been difficult to deliver 100,000 rigsbankdalers in 1 speciedalers per week to the Nationalbank, when private persons should also have 1 speciedalers for their delivered silver."[37]

Mint master Svendsen therefore wanted to buy an Uhlhorn machine for larger standard coins, and he also had other arguments. He pointed out that if the 1 rigsbankdaler banknotes were to be replaced by coins, the pressure on the mint's capacity would increase.[38] Moreover, there were several sound financial arguments when one considered that the machine would only cost about 4,000 rigsbankdalers. Svendsen believed that the mint itself could install the machine. More important was the fact that the machine only required approximately 25% of the power needed to run the Boulton presses – and also the Uhlhorn machine could be driven by 2-4 men if necessary due to the lack of steam power. According to Svendsen, it was economically more profitable to drive the Uhlhorn machines by hand power, if the steam engine could not supply other machinery alongside the Uhlhorn machines. Svendsen was allowed to buy the machine that should strike 48 times per minute as the smaller Uhlhorn machine did. The machine was completed in late 1847, but it did not arrive at the mint before late in 1848 probably because of the First Schleswig War 1848-1850.[39] The mint installed it, and after a few trial strikes of 1 rigsbankdalers it worked well and stably. There were no problems with the dies or the quality of the striking as suspected at the Altona mint in 1842.[40]

A competent visitor from Dresden was not impressed by the Altona mint in 1854: "Zum Prägen ist nur eine Uhlhornsche Maschine vorhanden, ausserdem aber noch 4-5 Spindelmaschinen".[41] Literature often points out that the Uhlhorn machines very quickly replaced the screw presses, for example that "Screw presses were used in Sweden until 1827, when the knuckle-lever presses displaced them".[42] Most places e.g. the mint in Berlin had a transition period of several years. This was also the case for Sweden, where screw presses apparently played a significant role until at least the 1850s. A transitional period also existed at the mints in Altona and Copenhagen, where screw presses and Uhlhorn machines complemented each other for c. 14 and 22 years respectively.

It was obvious that new machinery for striking was necessary when the Altona mint was rebuilt in the middle of the 1850s. 5-10 workers could be saved and the striking speed doubled with the use of steam power and larger Uhlhorn machines. Ehlers, who was responsible for the rebuilding, was on a study tour to a newly built mint in Utrecht, which in the middle of the 1850s was supplied with more than 20 new Uhlhorn machines that should strike several hundred

[37] Danish National Archives, Den Kgl. Mønt, Copenhagen, Kopibog, 1847, 6.
[38] The 1 rigsbankdaler notes were called in and withdrawn 1848-49.
[39] The machine does not seem to be preserved, and it is not known when in the 20th century it was phased out. It was later than 1927 and probably after 1945.
[40] In 1846 the Norwegian mint engineer C.W. Gelertsen from Stockholm did offer to build striking machines of Uhlhorn principle to the mint in Copenhagen. He had built several for the mint in Stockholm and one for the Norwegian mint in Kongsberg. Although his machines and recommendations undoubtedly were fine, the Copenhagen mint did not buy from him, when a new machine was needed in 1847. Mint master Svendsen in Copenhagen did not think there was any reason to buy a machine of Uhlhorn principle from Gelertsen, when an original could be bought cheaper from Uhlhorn's factory that had manufactured many machines for many mints.
[41] Paul Arnold & Ulli Arnold: Münzstättenbesichtigungen der Sächsischen Münz- und Hüttenmeister Gustav Julius Buschick und Theodor Choulant, *Numismatische Studien*, vol. 9, Hamburg 1991, 14.
[42] Erik Person 1935: Mynt- och Medaljpräglingstekniken intill omkring 1800, *Kulturen. En Årsbok*, Lund, 75-102, p. 92. The mint in Stockholm had screw presses, homemade (Gelertsen) knuckle-lever presses and in 1830 and 1857 purchased original Uhlhorn machines of small coins size and double taler size respectively.

million copper coins for the Dutch colonies (fig. 9). Ehlers had no doubt that the Altona mint needed at least two Uhlhorn machines for striking the largest coins. One machine should be of the largest type for striking coins up to 41 mm in diameter. Even though the price would be close to 5,000 rigsdaler per machine, the amount would quickly be realized when four men could strike 20-30,000 pieces of 2 rigsdaler (taler size) per day, since it now required 18 men and several screw presses to strike c. 10,000 per day. The mint could save more than 20 rigsdaler per day in wages when there was a lot of activity.

Two machines were ordered: one of the largest type was delivered in May 1855 and one of the second largest type, not delivered until May 1856.[43] The late delivery was primarily due to Uhlhorn being busy with the production of machines for the mint in Utrecht. The Altona mint installed the machines, but Uhlhorn was probably present at the first trial strikes with the largest machine. It was not driven by steam power in the beginning, since steam power was not yet fully installed at the mint. The machine was nevertheless successful from the beginning. In July 1855 Freund wrote to the Ministry of Finance: "When the largest Uhlhorn machine is driven by horse power 25,000 pieces of 1 rigsdaler are struck daily, which is more than ever produced here."[44] And in September 1855 he wrote to Uhlhorn that from the installation "bis zum heutigen Tage ist auch nicht die allergeringste Reparatur an derselben erforderlich gewesen, obgleich sie bereits ca. 2,400,000 Rthlr. in $^{1}/_{1}$ Rthlrn. ausgeprägt hat."[45] The mint thereafter had two large and one small Uhlhorn machine.[46] In the few periods when smaller coins were produced in Altona after the rebuilding, the small machine was not able to keep up with the large amount of blanks that the new Altona mint was able to produce. Although mint master Alsing several times around 1860 made the ministry aware of this, he was not allowed to buy another small machine.

When the dismantling of the Altona mint was decided in 1863, the three Uhlhorn machines, dies, and other things related to the striking process were the first things to be shipped to Copenhagen. The small machine and one of the larger were soon installed at the mint in Copenhagen and driven by steam power; the mint then had four steam-driven Uhlhorn striking machines. When the mint in Copenhagen bought its first two Uhlhorn machines in the 1840s, parts of the striking equipment from Boulton became obsolete, but with four steam-driven Uhlhorn machines operating from about 1864, the entire Boulton striking works was phased out.[47] From 1864 until the rebuilding in the 1870s the mint did not have capacity problems related to striking. At the rebuilding no one doubted that all five Uhlhorn machines should be installed. The five machines were the mint's only striking machines for the rest of the century.

The striking capacity was adequate in Copenhagen in the 1870s, but it was not noticeable compared to foreign mints that often had significantly more machines. The five machines in Copenhagen partly came from the Altona mint. Therefore, both mints could be expected to be among the smallest mints with regards to striking since the 1830-40s, but this was not quite the case. Many mints, for example Berlin, Birmingham, Brussels, Kremnica, London, Munich (which already had five original Uhlhorn machines in 1835), Paris, Philadelphia, Stockholm, Vienna, Utrecht, and several Russian mints did indeed have more striking capacity. Most of them changed earlier than the mints in Altona and Copenhagen to striking machinery based upon the knuckle-lever mechanism. However, there were also several mints of more comparable size that did not invest in knuckle-lever presses until the 1840-60s. There were, for example, no knuckle-lever presses in 1836 at the mints in Braunschweig,

[43] The machines do not seem to be preserved. They were phased out after 1927, probably first after 1945.
[44] Danish National Archives, Finansministeriet, Sager til Møntjournalen, B435.
[45] Danish National Archives, Den Kgl. Mønt, Altona, Kopibog, 13th September 1855.
[46] The old and worn screw presser were scrapped or sold; their time was over.
[47] The eight steam-driven screw presses at the Royal Mint in London were not superfluous until the 1870s, when the mint bought ten new striking machines so it had in total 14 striking machines (knuckle-lever presses) from Heaton. The new machines from Heaton could strike 90 blanks per minute, and the Royal Mint later expanded to 18 machines. At the mint in Birmingham (earlier Soho) the last steam-driven screw press was phased out in 1882.

Clausthal, Hannover, and Kassel – and in 1854 still none at the mints in Braunschweig and Hannover.

The mint in Kongsberg bought its first original Uhlhorn machine in the early 1860s, at which time it already had two other knuckle-lever presses, the first built by C.W. Gelertsen in Stockholm. The mint in Helsinki bought two Uhlhorn machines for the new Finnish mint in the early 1860s. Apart from the mints in Altona and Copenhagen, few mints in Northern Europe used only original Uhlhorn machines and did not construct striking machines themselves. Several German mints and the mint in Stockholm built several machines. That is one of the reasons why the mint in Stockholm had eight striking machines already in 1857.

Striking in a collar

Edge rimming stopped being an independent production stage in the realm's coin production in the first quarter of the 19th century, since methods were developed that made it possible to conduct the edge rimming as part of the striking with a convex die in a collar (fig. 10). The edges were rimmed primarily to prevent filing and counterfeiting. Aesthetical matters were secondary.[48]

Striking in a collar was a big advantage for the quality of the striking. The metal could no longer flow out to the sides unchecked when the dies hit the blank. The collar held the metal/the milled blank between the dies, which improved the quality of the struck motif and made sure that the blank/coin kept its milled, circular, and regular shape.

Striking in closed collars of iron or steel had been known for more than 100 years, but normally only medals and very few coins were struck in collars. The closed collar held onto the struck blank/coin and would cause problems for most edge rimming that would either be incomplete during the striking or be destroyed when the struck coin was pushed out of the closed (un-split) collar.[49] Therefore, the closed collar could not immediately be used for mass production of coins. At the mint in Paris especially J.-P. Droz in the 1780-90s (further) developed the split collar (virole brisé, fig. 11). It opened and closed around the blank due to the pressure from the dies.[50] The spilt collar made mass striking in a collar possible, and the blank/coin could at the same time be edge rimmed if the inside of the collar was engraved. When the striking pressure was sufficient, the blank would expand a little horizontally during striking and thereby be edge rimmed as the blank's edges were pushed against the decorated inside of the collar. The technique was put to use in France, and was with Droz transferred to Boulton's Soho, where it was combined with the development of steam-driven screw presses. The presses were designed so that one of the dies pushed the struck coin out of the split collar. They could probably also eject coins of closed collars that were already incused edge rimmed or without any edge rimming. This new collar striking technique was transferred to the mint in Copenhagen with the mint purchase from Boulton.

Striking in a collar was one of the main features in the significant qualitative improvement of coins that Boulton stood for. Therefore, the Danes during the purchase from

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[48] Small coins were not edge rimmed. This matter was discussed in 1857. The borderline was at the 4 skilling that should not be edge rimmed, since it made counting slower. It was furthermore claimed that it was a coin type often used by the lower social classes: "The edge is easier filled with uncleanness which contribute to a nasty appearance. The knurled edge is furthermore primarily a protective measure against clipping and filing, but with a coin with 25% silver of this size there is only little danger of damage by greedy persons, and since the small coin types actually begin with these coins, then I [probably mint master H.F. Alsing in Altona] do not understand why these as well as the other small coins should not have a smooth edge that is also easier for the production." Danish National Archives, Den Kgl. Mønt, Altona, Indkomne breve, 1857, 89.

[49] A closed collar could be used if the edge rimming was a transverse knurled rimming, but this was not the case in the realm around 1800.

[50] The split collar was probably developed in the 16th century, but did not become widely used due to the necessary precision and the subsequent slow striking, which it demanded.

Boulton were sure that the new mint should be able to perform collar striking. However, in 1798 Warberg during negotiations with Boulton asked how the necessary edge rimming could be done faster and easier. Boulton replied: "My Milling Machines for putting marks or inscriptions upon the Edges of the pieces is also improved as by it one Girl is capable of Milling on the Edges 15000 pieces per Day for which I pay her ten pence. But the Neatest Edges & the most difficult to be counterfeited are such as are struck in polished Steel Collars by which the roundness & the Diam of the pieces is perfectly ascertained whereas no money now cut in Europe is perfectly round or of equal Diam. & from these circumstances many other advantages arise."[51] It was convincing and not entirely wrong. With the steam-driven presses at the same time Boulton was able to strike faster than anyone else. From 1808-10 the new mint in Copenhagen was equipped to and managed to strike in a collar. It was not a problem when the steam engine and the screw presses were installed and usable dies were present. As previously discussed the technique was transferred to the Mint in Altona in 1812-13, after which the realm's mints were striking in collars. This is still the case.[52]

The transition to all coins being struck in a collar took place early at the two mints due to the purchase from Boulton and the technological transfer to Altona. Few other mints were using collar striking at the end of the Napoleonic Wars, for example London, Paris, St. Petersburg, and Soho. The technique was apparently not introduced until the second half of the 1820s in Stockholm. A few German mints (especially Berlin and Munich) tried and used collar striking from around 1815-25, but the technique was generally not introduced at German mints until the century's second quarter, it especially lasted long before all smaller coins were struck in a collar. The mint in Braunschweig was for example not able to strike in a collar before 1835.

Edge rimming

Until the 1820s the mints in Altona and Copenhagen edge rimmed blanks before striking on the edge rimming machines mentioned by Boulton in 1798. Smaller coins were generally not edge rimmed. The edge rimming should essentially prevent counterfeiting and filing. Therefore, it should as far as possible have a design that made it technically difficult to imitate. Since it was almost impossible to cast neat fake coins with edge rimming, counterfeiters had to add the edge rimming after casting. At the same time, it should preferably not be possible to file off metal of a coin, and then edge rim the diminished coin so that it could again be used in circulation.

The edge rimming used in the realm c. 1810-20 was an incused narrow rimming. It could be imitated, mainly because it was pressed into the edge, and secondly because the motif was small and simple. Work was conducted at the mints to improve the edge riming to make counterfeiting and filing more difficult. The promoter was then acting mint assayer and later (1819-56) mint master Freund in Altona. The first attempt was in 1817. Mint master Branth in Altona wrote that "Freund, hat eine Einrichtung erfunden, wodurch den Platten, in desselben Augenblick wie sie gerändert werden, zugleich ein Inschrift im Rand gegeben werden kann."[53] It is probably too much to call it an invention. Freund had probably 'just' modified the technique in use from old edge rimming equipment and applied it to a milling machine which largely worked like the older edge rimming devices. Three trial pieces of 1 rigsbankdaler in copper were sent from Altona to Copenhagen. Two of them are preserved (fig. 12), and they have deepened inscriptions respectively HELD KONGEN HELD FOLKET (Good luck/fortune to

[51] Birmingham City Archives, 3782: Matthew Boulton Papers, 13: Correspondence and Papers of Matthew Robinson Boulton, 110: Danish Mint 1796-1806, Reports, Estimates, Proposals, Contracts & Legal Documents, 4th and 26th March 1798.

[52] Perhaps the two Danish mints primarily used closed collars when striking silver and copper coins after the 1810-1820s. The predominant transverse knurled rimming or the absence of rimming were evidently compatible with the use of closed collars.

[53] Danish National Archives, Den Kgl. Mønt, Altona, Kopibog, 25th November 1817.

the king and the people) and GUD BESKYTTE DANNEMARK (God protect Denmark).[54] This improvement did not solve the problem with the incused edge rimming, but it did make the motif less simple and opened the possibility of edge rimming being text. The latter was in the realm a new thing on the milling machines, but had regularly been used at the older equipment.

Freund's first attempt to improve the edge rimming did not lead to any changes, but the next one in late 1820 did. Freund had produced samples of 1 speciedaler with a raised (opposite incused) transverse knurled rimming, which compared to previous edge rimming better protected against counterfeiting and filing and also produced beautiful coins. Freund rejected assumptions that the raised rimming was significantly more exposed to wear. According to Freund, studies of coins that had circulated for a long time showed that the wear was on the obverse and reverse sides of the coin and not on the edge. The raised edge rimming was more beneficial than the incused and the Ministry of Finance (Collin) expressed his satisfaction with this and the aesthetic improvement, "that we are agreed that the pieces are very beautiful".[55] The king in January 1821 approved that the "single knurled edge rimming for the new speciedaler can be used, and these coins should hereafter always be produced with such an edge rimming."[56] The change was announced; Freund put the announcement in *Altonaer Mercur* and in the *Liste der Börsenhalle* in Hamburg. It was a significant qualitative improvement of the coins, which meant a slightly different look.

When the relatively new mint master in Copenhagen, Gerlach, was preparing a production of 1 speciedaler in early 1822, the question about edge rimming was revisited.[57] Gerlach submitted samples to the Ministry and argued on the basis of technical and economic examples that the edge rimming used in Altona could be imitated manually after filing. His proposal was an incused edge rimming, which Freund should comment upon. Freund rejected Gerlach's arguments, but in June 1822 was ordered by J. Collin to investigate and submit samples with both incused and raised edge rimming. Freund submitted 14 pieces of 1 speciedaler and pointed out that it was always easier to imitate incused edge rimming than raised, but that the incused did however have an advantage in relation to wear.

Freund had worked with the productive side of the matter: "The best means against counterfeiting is undeniably a raised edge rimming since it cannot again be created once removed, but exactly this edge rimming is the most difficult of all to produce as the striking is done with usual speed. After I for some time thought about how this type of edge rimming was made, I thought that I was capable of a simple way, without altering the coin presses, to produce this edge rimming. Therefore the mint made a striking-collar, and these samples I send are struck in this new collar. With this attempt, I have convinced myself that it is possible to mass produce coins with a raised edge rimming without delay in the striking process."[58] In other words, it was probably not until the summer of 1822 that one of the two mints started using engraved collars thus combining two hitherto independent work processes. Freund probably had some relevant knowledge from abroad. The mints thereafter used engraved collars, when striking larger coins, which improved their quality and protection against counterfeiting and filing.[59] The change had far-reaching implications, just like the introduction of collar striking around 1809-13. The two mints used engraved collars from the 1820s; the edge rimming was normally transverse knurls. The Royal Mint in Copenhagen still uses engraved collars.

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[54] The letter S is inverted in the legend.
[55] Danish National Archives, Den Kgl. Mønt, Altona, Indkomne breve, 1820, 137.
[56] Ibid, 1821, 3.
[57] No coins were produced in Copenhagen in 1821.
[58] Danish National Archives, Den Kgl. Mønt, Altona, Kopibog, 17th Juli 1822.
[59] The Ministry of Finance did not take any formal decision on the use of engraved collars, but ordered that also 1 speciedalers produced in Copenhagen should have a raised knurled rimming.

Die manufacture

Production of dies took place independently from the rest of the production process.[60] At the mint purchase from Boulton, a new type of dies (convex) and die copying technique (hubbing) were introduced in the realm. The new die technique was part of the new striking technique and was therefore introduced at both mints at the same time as the collar striking (c. 1808-1814). The two mints were, as with other parts of the new striking technique, among the first to use the new type of dies and the new die copying technique.[61]

The purchase from Boulton included die material and different hardening facilities, and also a large hand-operated die hubbing press (screw press) that was used for die copying and medal production until 1910 when it was replaced by the mint's first friction-wheel press.[62] The mint also bought a lathe from Boulton, mainly for the turning of dies. It was the first steam-driven lathe in the realm. The turning of dies was the main problem when the new die technique was transferred from Copenhagen to Altona. The dies continued to crack during striking in the spring of 1813, because they were weakened by the previously used turning. The problem was solved when the Altona mint bought two lathes in 1813. The mint already had a very large screw press that was strong enough to work as die press.[63]

Coin dies were manufactured at the two mints and at mints in general by the blacksmith and sometimes a turner. The latter turned the dies that were forged of very good steel by the blacksmith. The two mints almost always used cast steel from the well-known companies from the beginning of the 19th century and into the 20th century: Krupp in Essen, Benjamin Huntsman, and Sanderson Brothers in England. All three delivered to several European mints. The two mints helped each other with steel supplies and exchange of experiences, and the Altona mint also exchanged experiences with die steel with the mint in Berlin. Generally, the dies were a little different, as fitting different striking machinery. After the introduction of the new die technique c. 1808-1814, one end of the die was turned, so they were round and convex for the sake of striking in a collar. When engraved the dies were hardened. This strengthened the die and basically took place at the mints as normal hardening of steel did elsewhere. The engraved die was heated, so it was red hot, and then abrupt quenched in water. The dies were hardened with much caution, preferably in coal dust or granulated leather, and it was done in cast pots and usually in special hardening ovens. It took time and cost some money to produce a die, so it was very unfortunate if it cracked during hardening. It did not happen that often. Probably less than 10 dies cracked during hardening at the two mints combined per year.

The die cutter/medalist usually engraved a matrix (negative engraved original die) which motif was transferred to a poinçon (positive original die, patrix), at first cautiously, by more and more powerful blows in the die press (fig. 13). It is called raising a poinçon. The poinçon was used to strike coin dies (negative engraved) in the die press. It is called to sink a

[60] Die manufacturing was a complicated process, and some of the details in each press', machine's, medalist's, mint's etc. approach were different. Therefore, die manufacturing is here explained very simply; especially with regards to matrix', poinçons, die hubbing, and reductions, but also when it comes to hardening and polishing, which could be done in several different ways.

[61] The two mints several times helped the Norwegian mint in Kongsberg with steel for dies or new, turned, and convex raw dies – especially in the 1820s, when the Kongsberg mint was starting up production of larger coins with the use of the new striking technology (convex dies in collars). The Kongsberg mint had regularly received dies from Copenhagen before 1814.

[62] Friction-wheel presses were developed in the second half of the 19th century and used at several mints. They gradually replaced the hand-operated presses as die hubbing presses. According to the Northern and Western European development it was chronologically a little late, when the Copenhagen mint got a friction-wheel press in 1910. The old hubbing press from Bolton underwent several major repairs. It was impressive that it lasted 100 years as a medal and die hubbing press.

[63] The strong press in Altona was possibly built in Frederiksværk around 1770. It was used to die manufacture (primarily sinking of dies; the matrix engraving and poinçon raising was primarily done in Copenhagen in the 19th century) till the rebuilding of the mint in the 1850s, when it was replaced by a the steam-driven Boulton press – probably one that became obsolete in Copenhagen, when the Uhlhorn machines were acquired.

die. The new die piece was re-engraved after raising or sinking. In the 18th century, the presses' force and the other die techniques incl. the steel quality had not been sufficient to transfer the entire motif of a die to another die with just one poinçon. Previously, smaller or larger parts of each die's engraving/motif were produced with the use of smaller poinçons or punches and/or hand-engraving. The new die copying technique of the 19th century was therefore a significant improvement. Now, the entire motif was transferred on just one occasion and the dies for striking were therefore identical. It was a significant and long-sought improvement of the finished coins' quality, which also meant that there was less of the time-consuming and thereby expensive engraving work.

A successful matrix could be used to produce several poinçons and thus hundreds of dies that could strike millions of blanks. A die could usually strike tens and sometimes hundreds of thousands of blanks. The average figures that continuously rose in the 19th century and often lay on tens of thousands of blanks, were influenced by the fact that some dies sunk or cracked at the first blow. Die durability depended on the dies' and the blanks' forms, material, size, and of the striking machinery. The different quality requirements for each coin type also had influence. Gold coins should for example be perfect and with a sharp and clear strike, while a less sharp motif was accepted on small coins. Therefore, the dies for gold coins were replaced proportionally faster than dies for small coins. The motif also affected the needed number of dies for a certain coinage. The motifs were changed several times in the realm in the 19th century due to the mints' requests, e.g. in 1852-1853 where a larger and higher portrait of King Frederik VII on 1 skilling after a short coinage was abandoned in favor of a smaller portrait.[64]

The increased die durability and the die hubbing meant that the die manufacture roughly could keep up with the mints' general increase in capacity and larger productions. However, it meant that much work had to be put into the engraving of the matrixes that had to be absolutely perfect. Therefore, the start-up of new coinages was usually delayed due to lack of dies, as matrixes and poinçons first had to be perfect. Before hardening the matrix, a trial strike on a soft metal like lead was normally done, and this trial piece had to be approved by the governmental agency managing the mints. When the sample was approved, which it usually was, the matrix was hardened and then poinçon raising started. The lack of usable dies was sometimes the bottleneck in 19th century coin production, as it had also been in the second half of the 18th century.

Reducing machines could be used to copy a coin motif to different sizes and thereby save time and money at the engraving and make the different coin types look as much as possible like each other. Reducing machines could on the basis of larger positive dies or other modeled positive originals cut positive copies in steel (poinçons) in various sizes, making it possible for the different denominations in a coin series to carry the exactly same motif e.g. a portrait in different sizes. The die cutter/medalist could engrave the motif in a larger format in for example wax, which was easier to do than in steel. If the original engraving/material was negative, a positive cast could be taken from it and used in the machine. Pantograph-cutting/-engraving machines for coin production were developed before 1800 (mainly in Paris), and reducing machines became fairly common at European mints during the 19th century. Despite the fact that they were a great advantage in coin production and used into the 21st century at many mints, the two Danish mints did not have any in the 19th century (fig. 14).

The two mints managed to get through the century without their own reducing machines and produced almost all matrixes, poinçons, and dies by engraving and copying on die press (fig. 15). Employees at the mints knew of the machines, but there does not seem to have been suggestions for the purchase of reducing machines, although they qualitatively and probably also financially had been an advantage. The explanation is probably that the monetary policy's demand for copies of various sizes was limited and that the machines still were not that good – especially not fast and accurate enough to be either indispensable or beneficial for the

[64] The dies were examined for cracks, cleaned, and polished before, during, and after the striking. In the 1830s the mint in Copenhagen apparently acquired a die polishing machine.

manufacture of poinçons that should only be used for one size/one type of coin or medal. New coin series with the same motif were only planned a few times 1813-1873.

A reducing machine was only used once for the realm's coinage during the period 1813-1873.[65] The skilled and enterprising medalist F.C. Krohn at the mint in Copenhagen in 1849 suggested that a portrait poinçon of 1 speciedaler size engraved by him be sent to the mint in Stockholm and there copied into six smaller sizes (fig. 16). The argument was primarily that for the first time it would create uniformity throughout the Danish king's (Frederik VII, 1848-1863) new coin series. It would also speed up production if Krohn did not have to engrave all the matrixes. The mint in Stockholm had for many years had so-called portrait-cutting-machines and approved of the idea and it was not very expensive. Krohn also wrote that he would have turned to the mint in Berlin that had a good machine, if it had not been for the First Schleswig War. The Ministry of Finance allowed Krohn to send a poinçon with the king's portrait to Sweden through the Danish Foreign Ministry. Seven good reductions were made, and most of them were later used with great success in Danish coin production. Despite this success, apparently no considerations about purchase or use of a reducing machine came forward, when the next king came to throne in the 1860s or during the monetary reforms of the 1870s. The two mints in that field differed from the general development in minting techniques, as many mints frequently used reducing machines in the 19th century.[66]

Summary

The transition to produce the concave, rimmed, well- and collar-struck completely identical coins that are still produced today took place in the first half of the 19th century in the realm of the Danish king as in most of Europe. The new type of coin was better protected against filing, counterfeiting, wear, and fracture, and could be produced faster and cheaper.

Major qualitative and quantitative improvements in coin striking took place. The force of the striking presses, die hubbing with matrixes and poinçons on large hand-operated screw presses and the collars that held the blanks during the striking with convex dies improved the coins' quality significantly. Presses with more powerful blows, good lathes, good steel, import of technology from mainly England and several attempts at the two mints were among the preconditions for the mints' transition to produce the new industrialized coins. Quantity-wise, it was especially the new striking machinery that made striking more efficient. One of the prerequisites was the development of die hubbing, so die production could keep up with the new efficient striking machinery. It also helped that edge rimming, formerly an independent production stage, could be conducted together with the striking from the 1820s.

Most of the new striking technology was transferred to the mint in Copenhagen with the purchase of an entire mint from Boulton. The acquisition was made to enhance the quality of the realm's coins and because the Copenhagen mint needed renewal. The new striking technology was associated with the new striking works that is the four new steam-powered screw presses which replaced the hand-operated screw presses. The hand-operated screw presses had been used in the realm's mints since the 17th century. Around 1813 the mints managed to transfer the new striking technology from Copenhagen to the 4-5 hand-operated screw presses in Altona, which was an extraordinary achievement. As some of the first places in the world, the realm's two mints both used the new striking technology.

Until the second quarter of the century, the two mints had considerable striking capacity from an international perspective. This position was then reduced since almost all European mints gradually went from hand-operated screw presses to knuckle-lever presses (especially Uhlhorn machines) and the foreign mints were at the same time to a continuously larger degree

[65] Perhaps some of the realm's medalists had seen or even used reducing machines at foreign mints.

[66] The mint in Helsinki did not buy a reducing machine before the 1940s, but had managed to get by especially due to help from the mint in Stockholm. The mint in Kongsberg was also helped by the Stockholm mint, but purchased a reducing machine in 1883.

run by steam power. The steam-powered screw presses, which the Copenhagen mint had from Boulton, in Europe existed only in England, Copenhagen, and St. Petersburg. Although they in most cases were good, stable, in general, and particularly with regards to speed, surpassing the hand-operated screw presses, they could not match the knuckle-lever machines that were cheaper to purchase and operate, faster, smaller, and easier to use and set up and also required less staff and maintenance.

Although knuckle-lever presses quickly became widespread, there was in the realm no talk about investing in them until the second half of the 1830s. The relatively late reflections were primarily due to the existing striking facilities in Altona and Copenhagen that were relatively newly improved and sufficient. The main proponent for the purchase of knuckle-lever presses was mint master Svendsen in Copenhagen, who pointed out that it was economically unbeneficial to strike small silver coins on the steam-powered screw presses in Copenhagen. This point and the fact that Uhlhorn presses on other mints had demonstrated that they were both stable and very efficient led to the purchase of one Uhlhorn machine in 1841-42 for each of the realm’s two mints. The investment was successful, and the two very efficient machines took over significant portions of the realm’s coin striking. Later in the 1840s in Copenhagen and at the rebuilding of the mint in Altona in the 1850s respectively one and two much larger Uhlhorn machines were purchased with significant efficiency improvements as immediate result. It was necessary in Copenhagen because of the increasing production activity and decreasing steam power. In Altona the decision was based on experience. The mint during rebuilding wanted to phase out the hand-operated screw presses and be equipped with Uhlhorn machines that were estimated to be more than 10 times as effective. After the dismantling of the Altona mint in 1863, the mint’s three Uhlhorn machines were transferred to Copenhagen, and from about 1864 and the rest of the century all Denmark’s coins were struck on Uhlhorn machines in Copenhagen.

Table 1. Original Uhlhorn machines produced/delivered 1818 - 27th August 1863.

No.	Year	Machine type/size	Mint
1	1818	4 groschen	Düsseldorf
2	1819	Small coins	Düsseldorf
3	1819	Small coins	Düsseldorf
4	1819	Taler	Berlin
5	1820	4 groschen	Düsseldorf
6	1821	Small coins	Berlin
7	1821	Taler	Düsseldorf
8	1821	Small coins	Berlin
9	1822	Guilder	Utrecht
10	1822	Guilder	Utrecht
11	1822	Guilder	Utrecht
12	1823	Taler	Utrecht
13	1825	Small coins	Düsseldorf
14	1826	4 groschen	Vienna
15	1827	Small coins	Münich
16	1828	Small coins	Schwerin
17	1828	Small coins	Münich
18	1829	Taler	Vienna
19	1829	Small coins	Karlsruhe
20	1830	Taler	Münich
21	1830	Small coins	Stockholm
22	1830	Small coins	Vienna
23	1831	Small coins	Wiesbaden
24	1831	Taler	Karlsruhe
25	1832	Small coins	Vienna
26	1832	Small coins	Vienna
27	1832	Zwanziger	Vienna
28	1833	Guilder	Münich
29	1834	Taler	Münich
30	1837	Taler	Naples
31	1838	Guilder	Karlsruhe
32	1838	Guilder	Wiesbaden
33	1838	Taler	Stuttgart
34	1839	Small coins	Stuttgart
35	1839	4 groschen	Dresden
36	1839	Small coins	Dresden
37	1840	Guilder	Frankfurt
38	1840	Small coins	St. Petersburg
39	1840	Small coins	Yekaterinburg
40	1840	Small coins	Frankfurt
41	1841	1 & 2 kopek	Yekaterinburg
42	1841	2 & 3 kopek	Yekaterinburg
43	1841	Small coins	Copenhagen
44	1842	Guilder	Vienna
45	1842	Guilder	Vienna

No.	Year	Machine type/size	Mint
46	1842	Small coins	Altona
47	1842	Taler	Vienna
48	1843	Small coins	Hannover
49	1843	Taler	Paris
50	1844	Taler	Hannover
51	1844	Taler	Utrecht
52	1844	5 ruble	St. Petersburg
53	1844	5 ruble	St. Petersburg
54	1845	5 ruble	St. Petersburg
55	1845	5 ruble	St. Petersburg
56	1846	Taler	Utrecht
57	1846	Taler	Brussels
58	1846	Taler (for rubles)	St. Petersburg
59	1847	Medium size	Brussels
60	1847	Taler	St. Petersburg
61	1847	Taler	Wiesbaden
62	1847	Taler	St. Petersburg
63	1847	Taler	Copenhagen
64	1848	Taler	Hannover
65	1848	Taler	Utrecht
66	1848	Taler	Tunis
67	1848	Small coins	Utrecht
68	1849	Zwanziger	Prague
69	1849	Taler	Vienna
70	1849	Taler	Vienna
71	1849	Zwanziger	Vienna
72	1849	Taler	Rome
73	1849	Guilder	Vienna
74	1850	Medium size	Rome
75	1851	Taler	Tunis
76	1852	Taler	Dresden
77	1852	Medium size	Madrid
78	1852	Taler	Bologna
79	1852	Medium size	Tunis
80	1852	Small coins	Tunis
81	1852	Small coins	Tunis
82	1852	Medium size	Tunis
83	1853	Medium size	Tunis
84	1853	Medium size	Tunis
85	1853	Small coins	Bern
86	1853	Small coins	Dresden
87	1853	4 groschen	Dresden
88	1854	Taler	Turin
89	1854	Taler	Genoa
90	1854	Double taler	Dresden
91-112*	1855-56	Guilder	Utrecht

No.	Year	Machine type/size	Mint
113	1855	Double taler	Altona
114	1855	Medium size	Bern
115	1856	Taler	Altona
116	1856	Double taler	Naples
117	1856	Double taler	Hannover
118	1857	Double taler	Stockholm
119	1857	Taler	Utrecht
120	1857	Taler	Utrecht
121	1857	Double taler	Vienna
122	1857	Double taler	Vienna
123	1857	Small coins	Rome
124	1858	Medium size	Stuttgart
125	1858	Double taler	Kremnica
126	1858	Taler	Kremnica
127	1858	Taler	Kremnica
128	1858	Medium size	Bologna
129	1858	Double taler	Naples
130	1859	Double taler	Naples
131	1859	Taler	Alba Iulia
132	1859	Double taler	Bern
133	1859	Double taler	Stuttgart
134	1859	Double taler	Frankfurt
135	1859	Double taler	Münich
136	1861	Medium size	St. Petersburg
137	1861	Medium size	St. Petersburg
138	1861	Medium size	St. Petersburg
139	1861	Medium size	St. Petersburg
140	1862	Small coins	Great London Exposition
141	1862	Double taler	Great London Exposition
142	1862	Taler	Helsinki
143	1862	Medium size	Helsinki
144	1862	Small coins	Berlin
145	1862	Small coins	Berlin
146	1863	Small coins	Berlin

Source: The National Museum of Denmark, The Royal Collection of Coins and Medals, XVII b 200: Photocopy of a list at the mint in Kongsberg, Norway regarding Uhlhorn machines delivered 1818-1863.

* To strike 2½, 1, and ½ cents in copper for the Dutch colonies in Asia, c. 4,000 tons.

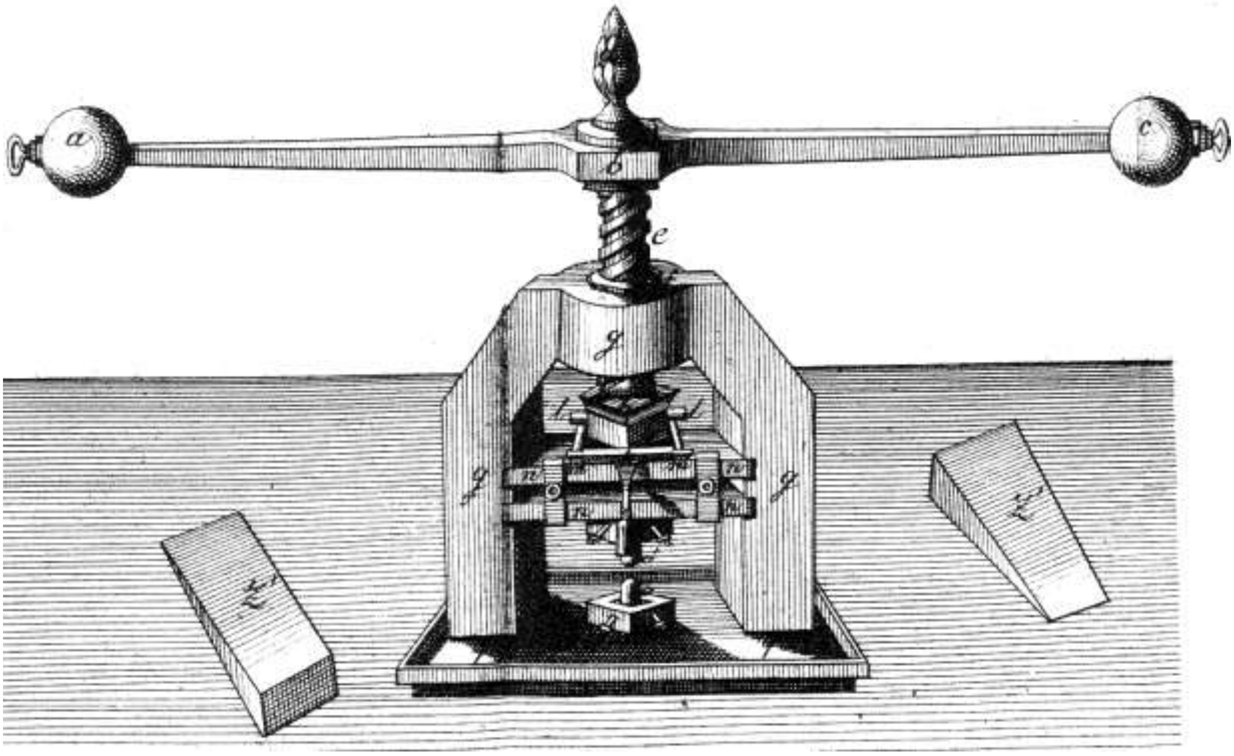

Fig. 1. Typical hand-operated screw press from the 18th century.
Illustration from Johann Georg Krünitz: *D. Johann Georg Krünitz's ökonomisch-technologische Encyklopädie*, vol. 79, Berlin 1805.

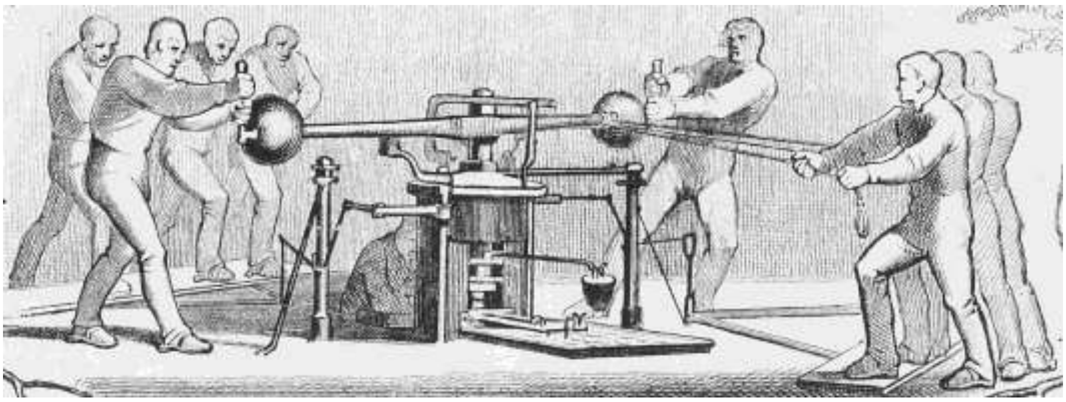

Fig. 2. Hand-operated screw press, first half of the 19th century. Drawing from receipt used at the mint in Altona.
The Danish National Archives.

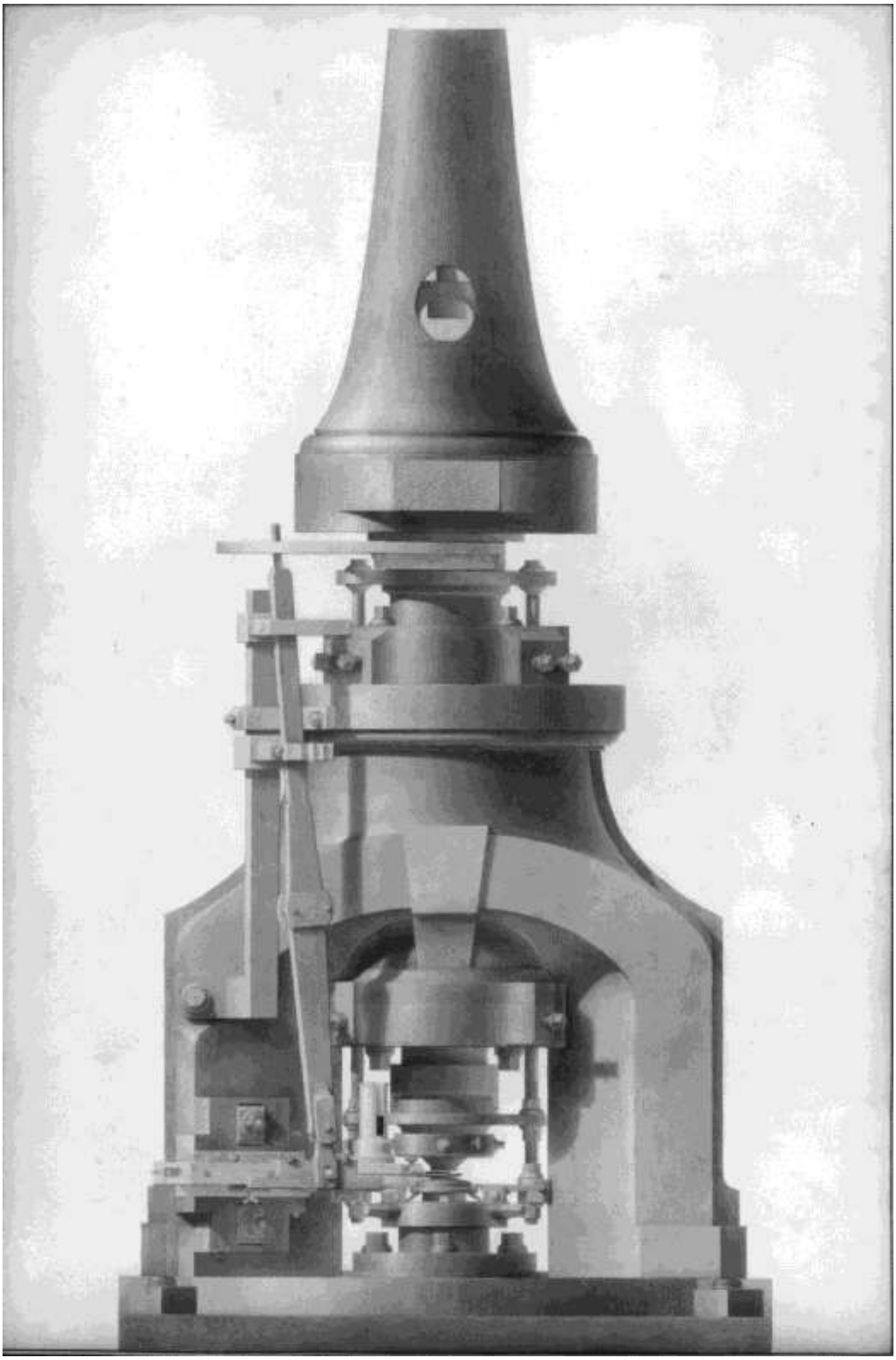

Fig. 3a.

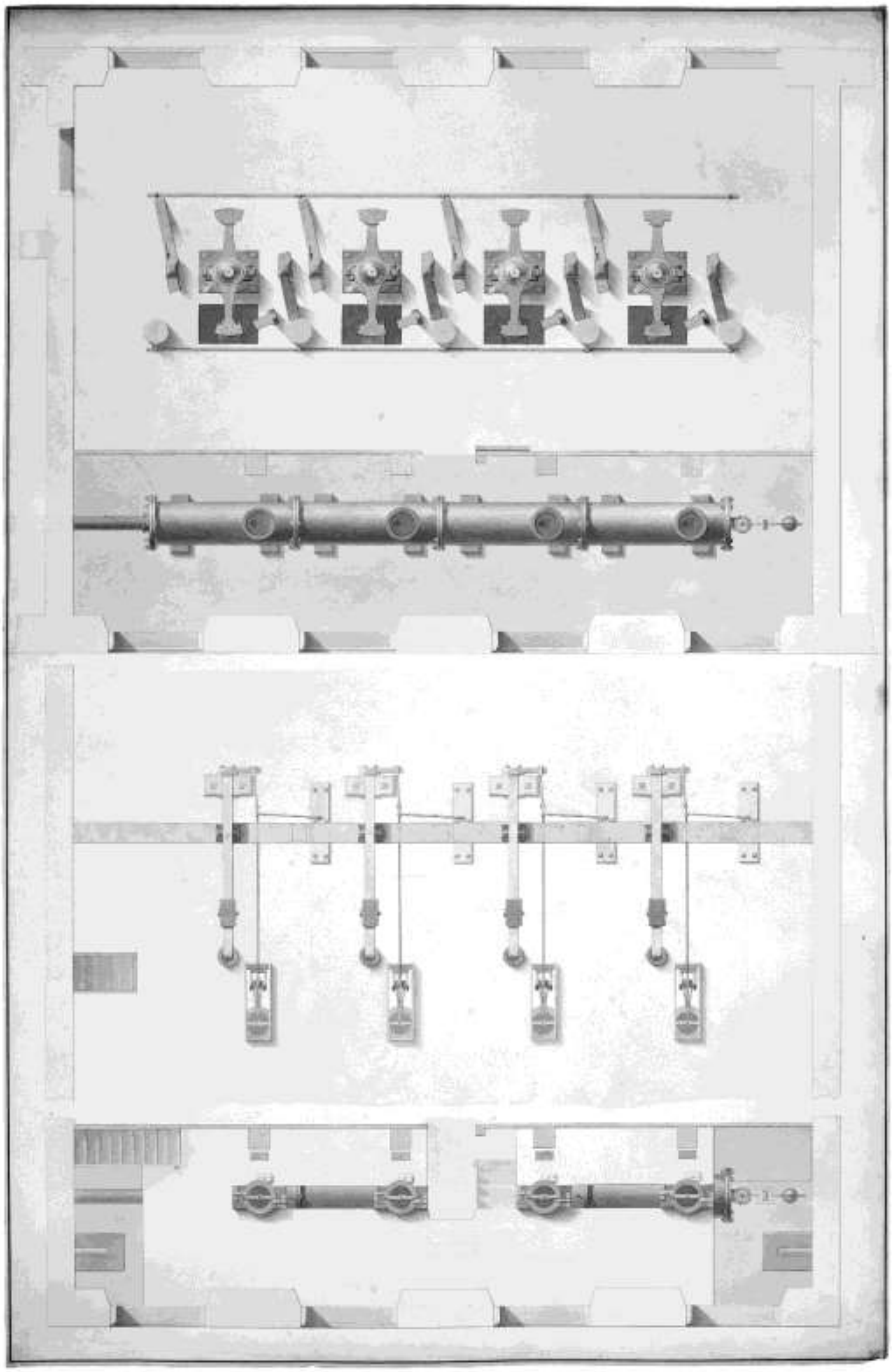

Fig. 3b.

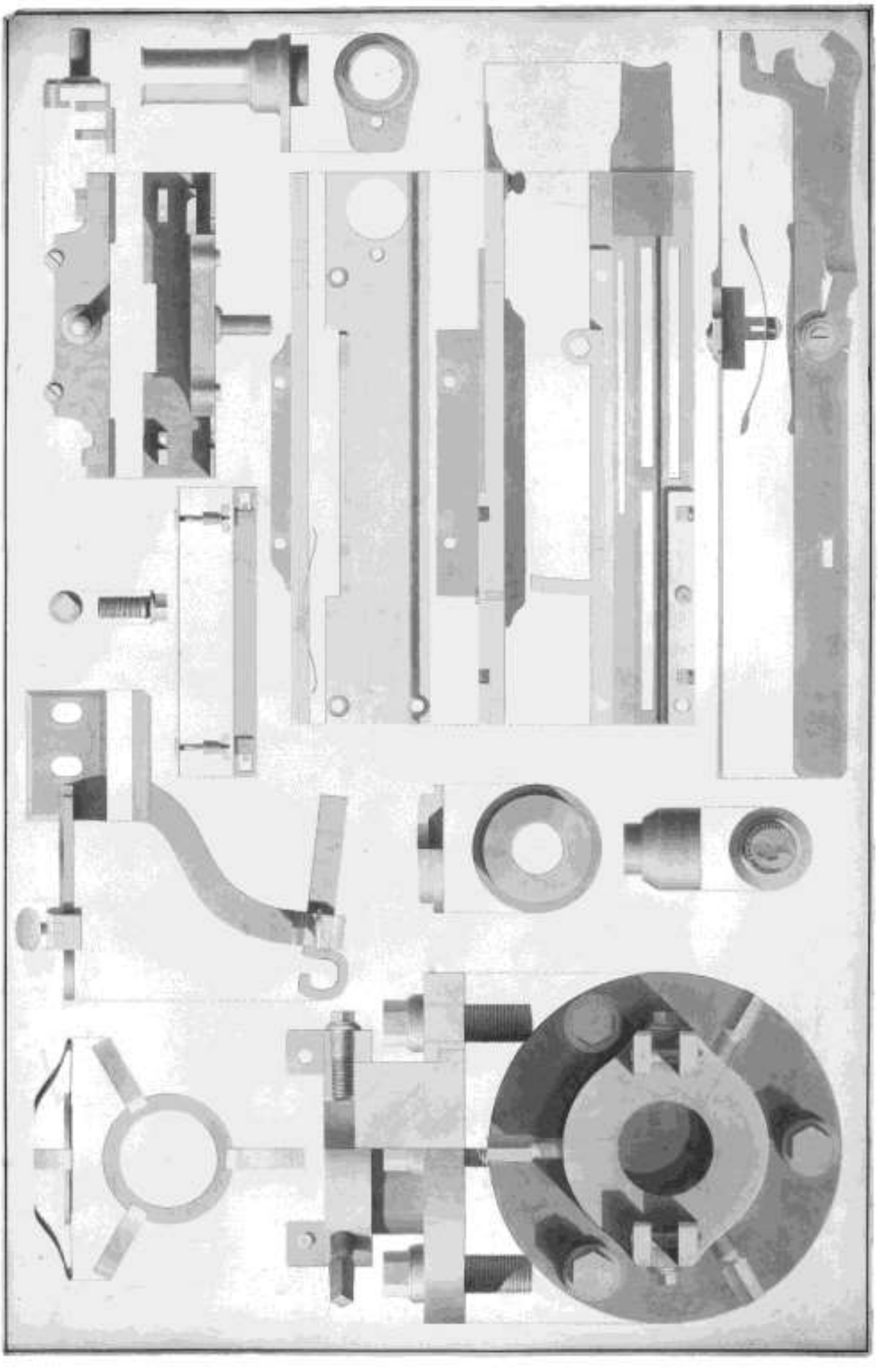

Fig. 3c. Three drawings related to the four Boulton presses at the mint in Copenhagen.
Probably drawn 1820-1840 by an A.C. Olsen.
The original drawings measure c. 65x100 cm.
Photos: John Lee. The National Museum of Denmark.

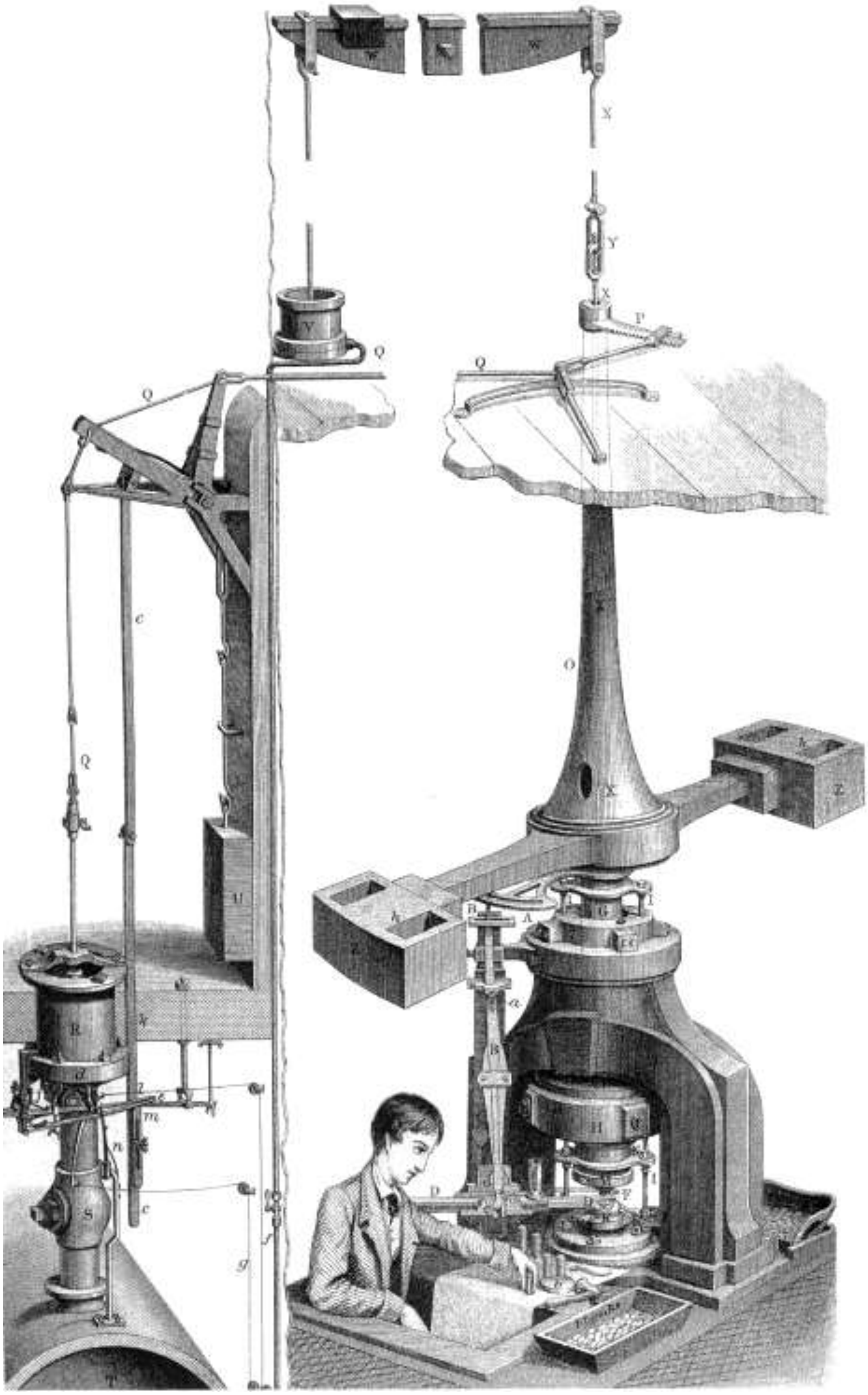

Fig. 4. Boulton’s steam-driven screw press at the Royal Mint in London.
This striking works was put up at about the same time as the one in Copenhagen, and they were probably quite similar.
Illustration from George Frederick Ansell: *The Royal Mint*, London 1870.

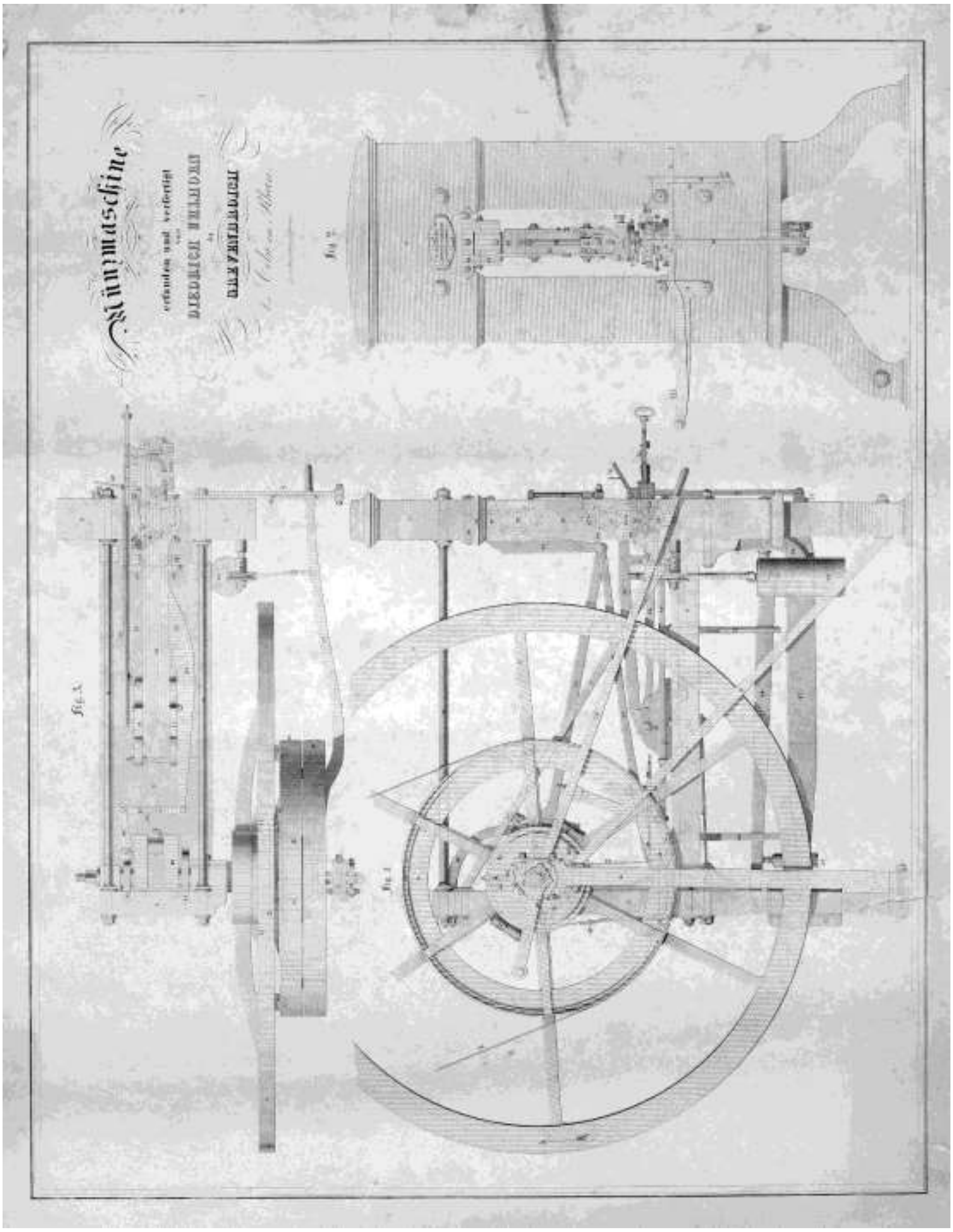

Fig. 5. Uhlhorn’s coin striking machine from different angles.
Printed in Germany c. 1820-1850. 50x65 cm. Came from the mint in Altona to the mint in Copenhagen to The National Museum of Denmark. Photo: John Lee.

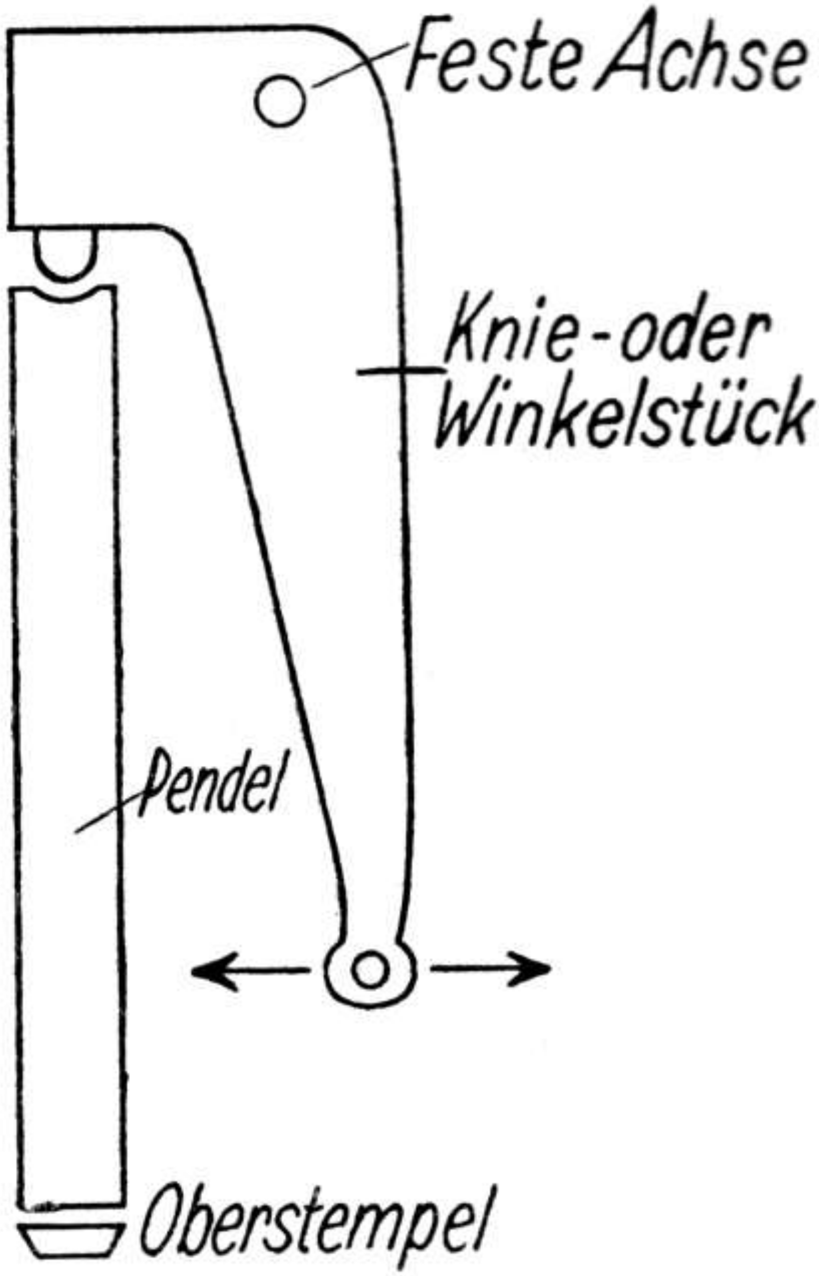

Fig. 6. The knuckle-lever mechanism in the Uhlhorn machine.
Illustration from Friedrich Frhr. V. Schrötter (ed): *Wörterbuch der Münzkunde*, Berlin/Leipzig 1930.

Fig. 7. Copper medal from 1843 with portrait of the Royal Prussian Mint director C.F. Goedeking and mint machinery on the reverse. 45 mm.
The National Museum of Denmark.

Fig. 8a.

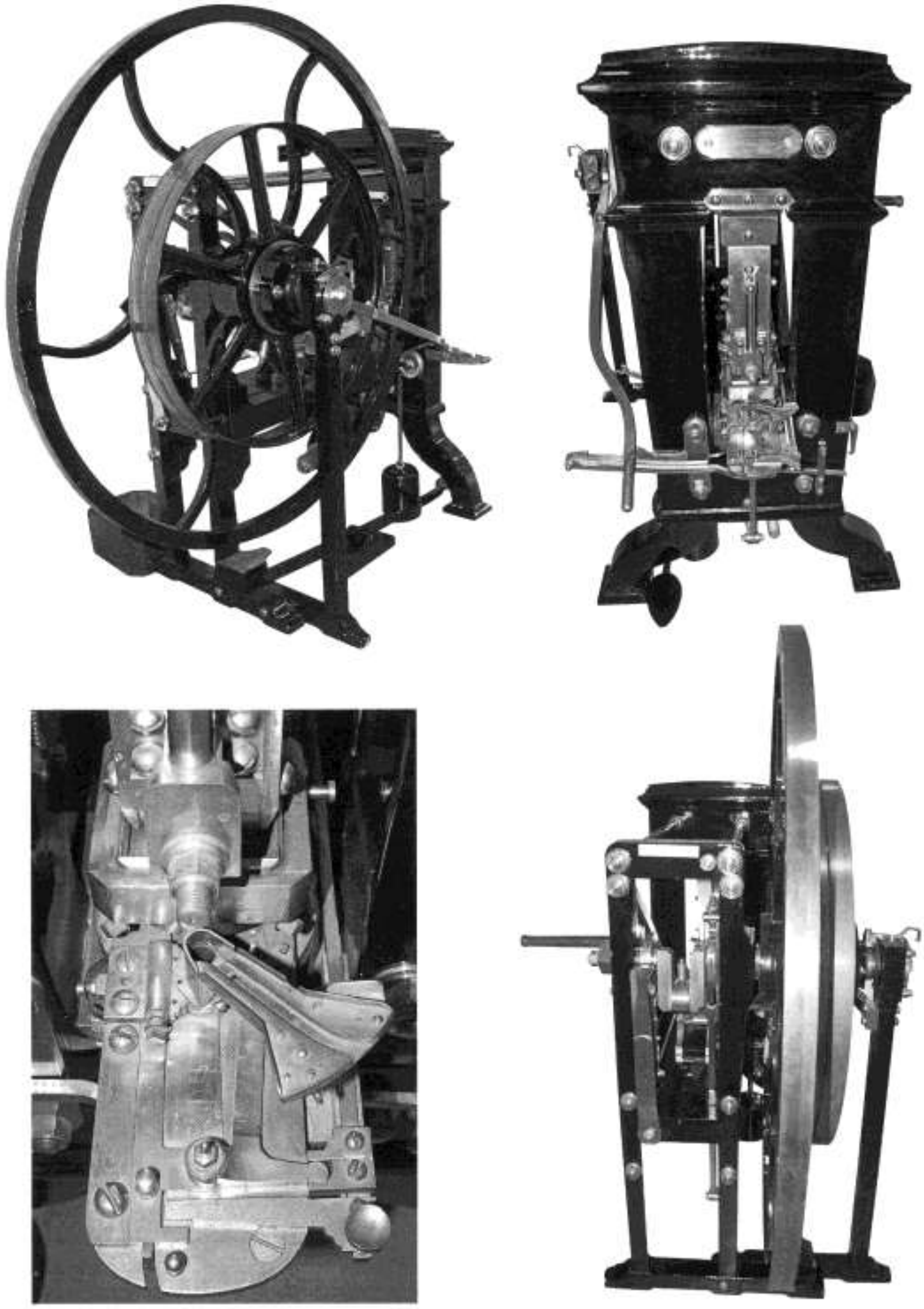

Fig. 8b. The realm’s second Uhlhorn machine that was set up summer 1842 at the mint in Altona. It was in 1863 transferred to the mint in Copenhagen, where it apparently was used to May 1961.
Measures c. 185x200x80 cm. The National Museum of Denmark.

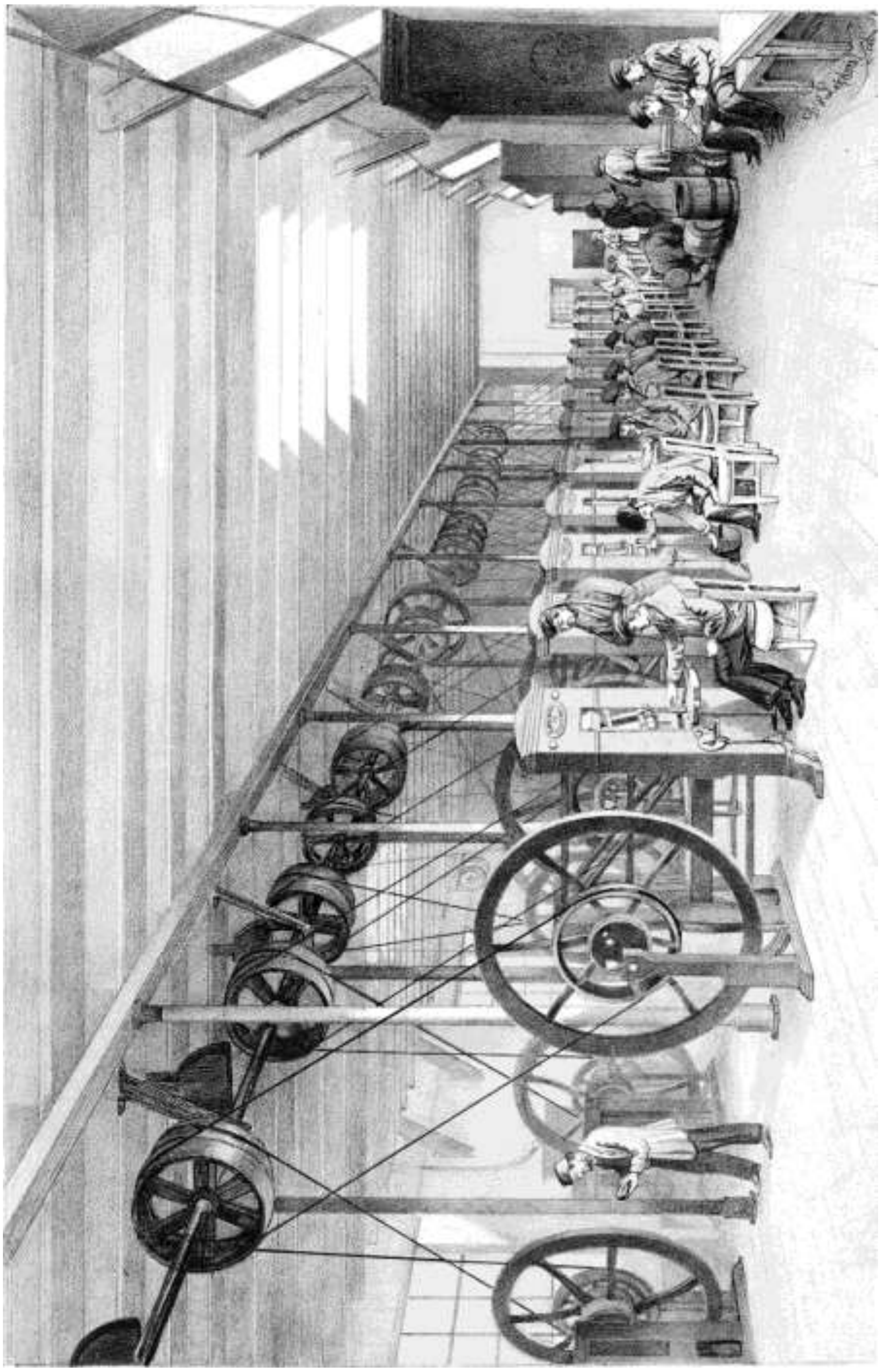

Fig. 9. The impressive striking hall at the mint in Utrecht from the 1850s. It had two long rows of steam-driven Uhlhorn machines.
Photo: John Lee. The National Museum of Denmark.

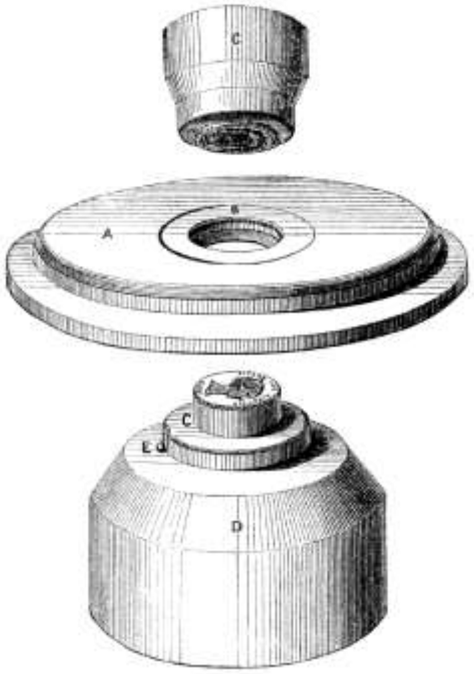

Fig. 10. Dies and collar. Illustration from Ansell 1870.

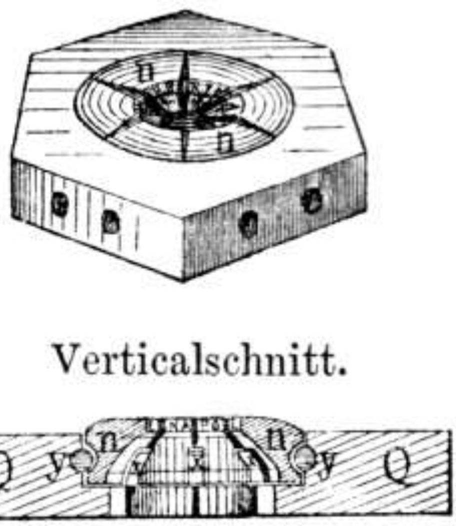

Fig. 11. Split collar from the 19th century. Illustration from E. Schlösser: *Die Münztechnik*, Hannover 1884.

Fig. 12a.

Fig. 12b. Trial pieces of 1 rigsbankdaler in copper with incused rimming. C. 2.6-8x30.5 mm. Weights 14.15 and 14.84 grams. Photos of edges: John Lee. The National Museum of Denmark.

Fig. 13. Four steel dies showing the process of die manufacture (different coin types) under the reign of Christian VIII (1839-1848).
The motif is transferred from one die to the next by raising or sinking. To the left a punch, then a matrix, then a poinçon, and to the right a finished die.
They measure 24-37x35-42 mm and weigh 110-322 grams.
Photo: John Lee. The National Museum of Denmark.

Fig. 14. Denmark’s first reducing machine. It was of the widespread type *Janvier*, and it was bought directly at Janvier in Paris in 1904 for the mint in Copenhagen.
The Danish Museum of Science and Technology.

Fig. 15. Coin dies of steel for four different coin striking machines used within the realm in the 19th century. To the left two dies for hand-driven screw presses, note their basis and the neck to hold a collar on number two from the left. The first one is from the period before collar striking. The largest, number three, is for the steam-driven Boulton presses, and it can hold a massive collar. The last and smallest die is for Uhlhorn presses. The first three are taler dies, while the last is a 16 skilling die.
They measure 37-68x42-67 and weigh 322-1187 grams.
Photo: John Lee. The National Museum of Denmark.

Fig. 16. 1 rigsbankdaler poinçon with the portrait of Frederik VII, probably engraved with the use of reducing machine at the Mint in Stockholm. 30-32x36 mm.
Photo: John Lee. The National Museum of Denmark.

Contents

This series of volumes *Documents and Studies on 19th c. Monetary History* aims to republish the main documents related to the question of bimetallism at the end of the 19th century. The series will include several sub-series devoted to the International Monetary Conferences held in various capitals during the second half of the century and to the specific situation of different countries (i.e. India, Japan, United States of America, China, etc.), since the question of monetary systems was a global question. It will also include specific studies on monetary questions and on monetary history.

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