



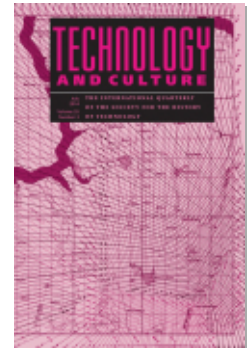
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Depersonalizing the Arcanum

Ursula Klein

Technology and Culture, Volume 55, Number 3, July 2014, pp. 591-621
(Article)

Published by The Johns Hopkins University Press
DOI: [10.1353/tech.2014.0072](https://doi.org/10.1353/tech.2014.0072)



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Depersonalizing the *Arcanum*

URSULA KLEIN

The Renaissance and early-modern courts and the eighteenth-century state bureaucracies in continental Europe often engaged “experts” for technically challenging projects such as fortification, gunnery, and naval shipbuilding; the construction of cathedrals, canals, and streets; the drainage of swamps; mining and metal production; and the making of such luxury goods as alchemical gold, artificial gems, secret remedies, and precision instruments.¹ These experts possessed outstanding technical knowledge and skill that was often combined with mathematical, alchemical, mineralogical, and other forms of natural knowledge. For many centuries they came from diverse social and educational origins. Some of them had received apprenticeship training regulated by the rules of the guilds, while others had studied at universities and were members of scientific societies and academies. But all of them carved out individual pathways to supplement institutionalized forms of education and training. Traveling, in particular, was a way of assembling and combining knowledge from many different places, arts, and sciences. Well into the eighteenth century,

Ursula Klein is a senior research fellow at the Max Planck Institute for the History of Science and professor of philosophy at the University of Konstanz. Among her recent publications are (with Wolfgang Lefèvre) *Materials in Eighteenth-Century Science: A Historical Ontology* (2007) and (edited with E. C. Spary) *Materials and Expertise in Early Modern Europe: Between Market and Laboratory* (2010). She thanks her assistant, Johannes Lotze, for his great help with archival work. She also thanks Hans-Jörg Rheinberger, director emeritus at the Planck Institute, for his financial support of this archival work.

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0040-165X/14/5503-0003/591-621

1. The term *expert* (German *Sachverständiger*) was introduced in the eighteenth century. I use it here to highlight a distinct group of practitioners who were mobilized by the state and possessed outstanding skills—mathematical, natural, and technical knowledge—and authority. Early-modern terms like *engineer*, *architect*, *mathematical practitioner*, *projector*, *chymist*, and so on denoted only subgroups of these persons. See Eric H. Ash, ed., “Expertise”; Stephen Johnston, “The Identity of the Mathematical Practitioner”; Ursula Klein, ed., “Artisanal-Scientific Experts”; Pamela O. Long, *Artisan/Practitioners*.

most of these experts were itinerant individuals offering their service to princes and wealthy patrons. Observations of the most advanced technologies in different countries; visits to marketplaces in port cities; and conversations with seafarers, collectors, and learned men widened their horizons and stimulated learning. These experts were neither ordinary craftsmen nor traditional scholars. Like scholars, they were familiar with textual traditions as well as mathematical and graphical representations; but, like craftsmen, they actively participated in the world of labor in addition to their contacts with, or even citizenship in, the Republic of Letters.² Their socioeconomic functions and knowledge evolved in small milieus that created specific demands for uncommon wit.

Among these experts, some kept their knowledge a personal secret, rendering makers' knowledge private property. To these "secretive experts" belonged the alchemists, some gunners, instrument makers, goldsmiths, makers of luxury glass, majolica, and artificial gems.³ The practical alchemists, in particular, claimed to possess insight into the *arcana naturae* that was intimately tied to their individual qualities and thus "personal knowledge" in a quite literal sense. With the establishment of the first European porcelain manufactories, a new group of secretive experts emerged: the "arcanists" (German *Arkanisten*)—men who knew the secret (Lat. *arcanum*) of how to make porcelain—and the "laboratory workers" (German *Laboranten*) who prepared the pigments, fluxes, and oils that were used for the over-glaze ornamenting and subsequent enameling of porcelain. This eighteenth-century group of secretive experts is the focus of this article, along with a particular site: the Royal Prussian Porcelain Manufactory in Berlin.

I will first describe the early arcanists' and laboratory workers' personal secrecy and then follow a process of "depersonalization" of the *arcanum* promoted by the Prussian state.⁴ Beginning in 1787, the board of the Royal

2. Diderot and d'Alembert are often presented as typical Enlightenment savants who, on the one hand, conversed with artisans, but, on the other hand, questioned their knowledge, contested artisanal secrecy, and tried to impose savants' knowledge and values of scientific openness upon them; see, for example, Peter Dear, "Towards a Genealogy"; Cynthia J. Koepp, "The Alphabetical Order"; William H. Sewell Jr., "Visions of Labor."

3. For the practical, or entrepreneurial, alchemists and secrecy, see Pamela H. Smith, *The Business of Alchemy*; and Tara Nummedal, *Alchemy and Authority*. On the personal secrecy of late-medieval gunmakers, see Rainer Leng, "Social Character," 88–89; on the personal secrecy of early modern instrument makers, see Peter Damerow and Wolfgang Lefèvre, "Instrumente und Verfahren," 317; and on the personal secrecy of glassmakers, see Marco Beretta, *The Alchemy of Glass*, 147–48.

4. The events described in the following as "depersonalization" of secrecy ought not to be confused with artisans' expropriation of skills through new technologies fostered by enlightened savants and administrations, discussed, for example, in Koepp, "The Alphabetical Order," Sewell, "Visions of Labor," and Simon Schaffer, "The Charter'd Thames." On the contrary, I would argue that the board extended the range of the

Prussian Porcelain Manufactory, directed by the influential minister Friedrich Anton von Heinitz (1725–1802), undertook activities to transform its arcanists' and laboratory workers' personal knowledge into knowledge of the manufactory.⁵ In this process of depersonalization, craft secrecy was not abolished wholesale but rather transformed into the property of the state. The process also involved other issues: refinement of the arcanists' and laboratory workers' chemical knowledge, their more formal chemical training and education, and the organization of cooperation between the arcanists, or laboratory workers, and external chemical savants.

Early-modern craft secrecy has been intensively debated and questioned in recent historiography. Pamela Long, in particular, has brought to our attention the complexity of the relationship between late medieval and early-modern craft secrecy, its protection by guilds, and the idea, promoted by certain practitioners, that knowledge should be transferred openly. S. R. Epstein, Liliane Hilaire-Pérez, and Reinhold Reith have studied in detail the concrete ways in which early-modern artisanal knowledge was transferred both vertically, between master and apprentices, and horizontally across Europe and different workshops.⁶ Generally speaking, a local guild must have been interested in transmitting knowledge from one generation to the next; knowledge thus circulated within a particular local guild but was kept secret from competing guilds. Other historians have focused on the relation between craft secrecy and inventions, tackling the question of whether enlightened elites respected artisanal inventors' interest in the private appropriation of invention in the form of a secret, privilege, or patent.⁷ Hilaire-Pérez's concept of "open technique policy" addresses a different way of dealing with inventive artisans. As she has pointed out, the eighteenth-century Lyon silk industry organized a collective management of inventions, rejecting private secrecy or privileges and instead favoring rewards of inventors.⁸

arcanists' and laboratory workers' knowledge and skill along with their request to report experiments and recipes. These experts' older epistemic, moral, and technical regime was not replaced wholesale by a new one, but rather preserved and changed in certain aspects. Furthermore, the process described in the following sections involved neither an analytical decomposition of labor (ultimately leading to Taylorism) nor a deep social conflict.

5. The minister's name was first written "Heynitz," but during his stay in Prussia it changed to "Heinitz." On Heinitz, see Wolfhard Weber, *Innovationen*.

6. Pamela O. Long, *Openness, Secrecy, Authorship*; S. R. Epstein, "Craft Guilds"; S. R. Epstein and Maarten Prak, eds., *Guilds*; Liliane Hilaire-Pérez, "Inventing in a World of Guilds"; Liliane Hilaire-Pérez and Catherine Verna, "Dissemination of Technical Knowledge"; Reinhold Reith, "Circulation of Skilled Labour"; Karel Davids, "Craft Secrecy in Europe"; Karel Davids, "Public Knowledge and Common Secrets"; Larry Stewart, "Science, Instruments, and Guilds"; and Carlo Marco Belfanti, "Guilds."

7. See Anne-Françoise Garçon, "Les dessous des métiers"; Liliane Hilaire-Pérez, "Diderot's Views"; Liliane Hilaire-Pérez, *L'invention technique*; and Pamela O. Long, "Invention."

8. The eighteenth-century Lyon silk industry consisted of workshops within a guild

Our general picture of early-modern craft secrecy is more complicated, however, by the fact that there were also some early-modern master craftsmen who actively hid some parts of their know-how from the apprentices and journeymen working in their workshop. Reinhold Reith has argued that these *arcana artis* in a strong sense were exceptional cases that involved particular recipes for precious dyestuffs, glazes, and material transformations.⁹ Among them he also included the arcanists' recipes for the making of porcelain. But there were also forces in the royal porcelain manufactories that went in the opposite direction. Generally speaking, the royal manufactories sought to limit private secrecy. The ateliers of the Gobelins in Paris, for example, were run by private entrepreneurs possessing both workforce and knowledge; but the board of the Gobelins also organized inspections and exercised some control over recipes.¹⁰ As we shall see in the following, a similar policy was also pursued at the royal porcelain manufactories, though at different times.

The *arcantum* of the Royal Prussian Porcelain Manufactory was depersonalized in the context of a more comprehensive reorganization of the manufactory taking place between 1787 and 1793. In this process, science was both an instrument for securing Minister von Heinitz's reforms (along with the abolishment of personal secrecy) and an internal part of the reforms. Thus, the following story can be told from two different perspectives, which are complementary: first, from the perspective of the relationship between porcelain manufacture and science, studying processes of manufacture and the distinct roles given to chemistry and mineralogy in the context of manufacture; second, from that of the depersonalization of secrecy, asking the questions of how this was done locally, who was interested in it, and for what reasons. In this article, I take the second perspective, which allows me to address particular issues presently discussed in the combined historiography of science and technology concerning the fate of craft secrecy at the beginning of industrialization and the evolution of the modern figures of the technical expert (or "technician," "engineer," "technocrat") and the specialized scientist.¹¹

system that was additionally regulated by the state; see Hilaire-Pérez, "Inventing a World of Guilds"; Dominique Foray and Liliane Hilaire-Pérez, "The Economics of Open Technology."

9. Reinhold Reith, "Know-how," 371–73.

10. Bruno Belhoste, *Paris Savant*, 174–78.

11. For the alternative perspective, see Ursula Klein, "Chemical Experts." The more general issues addressed in the latter essay concern the role played by chemistry in porcelain manufacture, the establishment of formal technical training along with the formation of "technological sciences," and the functions of sciences, natural and technological, in the modern state bureaucracy and industry.

Early Arcanists and Laboratory Workers

Porcelain, imported from China, was one of the most expensive luxury goods in early-modern Europe. The demand for these white, translucent, and heat-resistant ceramic goods increased significantly in the sixteenth century. A century later, china became the great passion of princes and the upper classes, who also supported efforts to imitate it. The first European hard-paste porcelain, which was almost identical with the imported china, was “invented” in 1708 by the German alchemist and apothecary Johann Friedrich Böttger (1682–1719).¹² Böttger had long collaborated with Ehrenfried Walther von Tschirnhaus (1651–1708), mathematician and director of the chemical laboratory of the Saxon elector Friedrich August I, and with the Saxon mining official Gottfried Papst von Ohain (1656–1729). In 1710 Friedrich August I founded the first porcelain manufactory in Meissen, located in his castle *Albrechtsburg*. By the end of the century, the Holy Roman Empire hosted some twenty porcelain manufactories, among which the state manufactories in Meissen, Vienna, and Berlin were the most famous.¹³

If the initial invention of porcelain had taken years of painstaking chemical experimentation, its subsequent commercial production meant further, almost endless technical challenges. In the royal porcelain manufactories, the arcanists tried to make the best porcelain out of locally varying ingredients. To their recurrent tasks belonged quality control and chemical analysis of the ingredients for the porcelain paste, calculation of the proportions of the ingredients, based on their chemical analysis, and supervision of the workers who actually made the paste. They also elaborated the recipes for the glaze and supervised the glazing and firing of the porcelain.¹⁴ Furthermore, they carried out experiments for improving all these items. The “laboratory workers,” who prepared materials for painting on porcelain and enameling, were looking for better ways to maintain the quality of long-used pigments and further experimented with new materials to extend the spectrum of colors and improve enameling. Both groups of experts first considered their recipes, and changes thereto, as a property of their own instead of communicating it to the manufactories’ boards.

In the early years of the porcelain manufactory of Meissen, Böttger was

12. In 1708 Böttger and his laboratory assistants achieved a breakthrough in their attempts to make commercially useful porcelain, but the invention was a long process. In its early stage, Tschirnhaus made the most important contributions; see Ulrich Pietsch, “Tschirnhaus und das europäische Porzellan,” 65–74.

13. Gustav Kolbe, *Geschichte der Königlichen Porcellanmanufaktur*; Erich Köllmann and Margarete Jarchow, *Berliner Porzellan*; Arnulf Siebenecker, *Offizianten und Ouvriers*; Otto Walcha, *Meißner Porzellan*.

14. Siebenecker, *Offizianten und Ouvriers*, 101, 236–48. Unfortunately, the archival material provides no information about interactions and exchanges of knowledge between the arcanists and the *ouvriers* supervised by the arcanists.

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the only person who possessed knowledge about all parts of the manufactory's *arcanum*: the making of the porcelain paste as well as the glazing and firing of the porcelain ware. The alchemist was a true "expert," knowledgeable in chemistry and skilled in reproducing china. The first so-called "arcanists" of the manufactory—the chemist-physicians Jacob Bartholmäi and Heinrich Wilhelm Nehmitz—were familiar only with parts of the *arcanum*; Bartholmäi knew the recipe for the paste, whereas Nehmitz was responsible for glazing and firing. Like Böttger, these arcanists experimented with raw materials stemming from different deposits, and they varied their recipes for the paste and the glaze according to the locally available, variable raw materials.¹⁵ Until 1731 these arcanists kept their experiential knowledge and recipes as private property.¹⁶ The board of the manufactory was informed about the raw materials for the paste and the glaze, which it ordered and bought, but it had no insight into details of the recipes.

In the context of the discovery of a betrayal in 1731, however, the Meissen board changed its policy.¹⁷ One of the arcanists had apparently forwarded some of his recipes to the French. The board then ordered its arcanists to write down their recipes in "books of Arcana" (*Arcanabücher*) owned by the manufactory, and strictly forbade them to keep experimental notes in private houses rather than the manufactory's secret closet. Personal secrecy seemed to be a privilege that facilitated betrayal as well as unjustified claims for money. In addition, the board had long been concerned with the problem of preserving the arcanists' knowledge, which was easily lost in case they prematurely died.¹⁸

In 1731 the board of the Meissen Manufactory also appropriated the secret of making pigments. Before 1731, the court painter Johann Georgius Höroldt, who was responsible for the preparation of pigments and ornamenting porcelain, had been an independent artist who worked with his own equipment and artisans belonging to his workshop. In the reorganization of the Meissen Manufactory in 1731, however, Höroldt became an "inspector," his artisans state-employed workers, and his secrecy gave way to written reports and an experimental notebook belonging to the manufactory.¹⁹

The Royal Porcelain Manufactory of Sèvres pursued a similar policy. Here the state tried to get hold of the recipes from early on, which also became manifest by the fact that the term "arcanist" was not used at Sèvres. Beginning in 1757, the chemist Pierre-Joseph Macquer (1718–1784) per-

15. Walcha, *Meißner Porzellan*, 27.

16. *Ibid.*, 81.

17. *Ibid.*, 81–86.

18. The problem of the arcanist's premature death, caused by unwholesome work, was addressed as early as 1704; as a solution to this problem, officials then suggested that two arcanists be employed; see Eberhard Knobloch, *Ehrenfried Walther von Tschirnhaus Gesamtausgabe*, 5. For the same reason, the number of arcanists increased to four in 1731; see also Walcha, *Meißner Porzellan*, 81–85.

19. Walcha, *Meißner Porzellan*, 48–71, 82–84.

formed hundreds of experiments, partly in collaboration with the apothecary chemist Antoine Baumé, which eventually led to his discovery of hard-paste porcelain at Sèvres in 1768. He continued his experiments to improve porcelain well into the 1780s. Yet Macquer, the manufactory's "*académicien chimiste*," was not allowed to keep his recipes a secret. As historian of chemistry Christine Lehmann has pointed out, he "was accountable to the Manufactory and the results of his work belonged to the State."²⁰

By contrast, during the entire reign of Frederick II, the Royal Prussian Porcelain Manufactory in Berlin accepted the personal secrecy of its arcanists and laboratory workers. This policy changed only after Frederick's death in 1786, when Minister von Heinitz became responsible for the manufactory and instigated its reorganization. The manufactory's first arcanist, Ernst Heinrich Reichard, was a sculptor, of whom little is known.²¹ After his death in 1764, an accountant of the manufactory named Theodor Gotthilf Manitius (unknown–1796) took his position. Manitius had first been Reichard's assistant and learned the *arcantum* from him personally; accordingly, an "instruction for Manitius" from 1763 stipulated that he "had to communicate to him all parts of the secret to make true porcelain."²² The manufactory had a second arcanist, named Joachim Duwald (1716/7–1791), who was a former potter; he was only responsible for the furnaces and the firing of porcelain wares. Unsatisfied with the artisanal status of these two arcanists, Frederick II ordered the creation of a third position for "a good chymist," following the example of the Meissen Manufactory.²³ Thus, in spring 1766 the physician Wilhelm Kretschmann (unknown–1774), from the Prussian city of Halle, became "Chymicus and Arcanist" of the manufactory.²⁴ After his death, the physician and chemist Johann Schopp (unknown–1797) became his successor. Even less is known about the manufactory's first "laboratory workers." Their first supervisor was the court painter Johann Christoph Jucht from the Duchy of Ansbach, who had been hired by Frederick II personally in 1764.²⁵ Here, too, the king emulated the Meissen Manufactory, where the court painter Johann Gregorius Höroldt organized the ornamenting of porcelain as well as the materials necessary for it.²⁶ In the 1780s, the manufactory's pigment laboratory (*Farbenlaboratorium*) was supervised by the painter Franz Tittelbach; he lost his position in 1786 when Heinitz became responsible for the manufactory.

The archive of the Royal Prussian Porcelain Manufactory provides no

20. Christine Lehman, "Pierre Joseph Macquer," 331.

21. Reichard was an arcanist in Johann Gotzkowsky's private manufactory and then appointed as the king's arcanist when the king bought the private manufactory. For this paragraph, see Siebeneicker, *Offizianten und Ouvriers*, 145–150.

22. Quoted in Siebeneicker, *Offizianten und Ouvriers*, 147.

23. Johann Georg Grieninger, "Vom Ursprung und Fortgang," 284.

24. Grieninger, "Vom Ursprung und Fortgang," 284.

25. Siebeneicker, *Offizianten und Ouvriers*, 147.

26. Walcha, *Meißner Porzellan*, 48–71, 82–84.

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information about its first arcanists' and laboratory workers' practical activities. It holds no records, in particular, about their experiments and recipes—in strong contrast to the period after Heinitz's reorganization in 1786–87 when the board requested written recipes. Apart from the 1763 instruction to Manitius (*see above*), the lack of any written-down recipes and experimental reports before 1786 is the strongest indicator of personal secrecy. The reluctance of the old arcanists Manitius and Schopp to cooperate with Heinitz and to hand out their recipes points in the same direction (*see below*). Furthermore, given the fact that the savant Jeremias Benjamin Richter, who became an arcanist of the manufactory in 1797, again claimed the right of personal secrecy, which is well documented (*see below*), I would hypothesize that personal secrecy was quite a widespread habit among the eighteenth-century German arcanists. This hypothesis is supported by contemporary publications on porcelain manufacture; one author wrote that this art was “concealed in the thickest cover of secrecy (*Arkanisterey*)” and that the arcanists gave themselves a “mystical outlook (*mystisches Gesicht*).”²⁷

Why did the early arcanists and laboratory workers keep their knowledge a private secret? Clearly, ownership of knowledge entailed privileges, and the tradition of the *arcana artis* abetted the preservation of privileges. Since several early-eighteenth-century arcanists were alchemists or chemists, however, it is perhaps not too farfetched to recall another early-modern tradition of secrecy that was also related to makers' knowledge. In the Renaissance and early-modern period, the terms *secretum* or *arcanum* had a broad cultural meaning. People's everyday ontology included the assumption of hidden entities and webs of relationships producing phenomena, including marvels, that could not be explained.²⁸ These unintelligible or “occult” forces, as the Aristotelians called them, were also designated *arcana naturae* and *arcana Dei*, secrets of nature and of God. This ontology was interconnected with an epistemology that postulated that some individuals possessed uncommon knowledge about the *arcana naturae*, and even the *arcana Dei*, and further that their knowledge was genuinely personal, depending on their peculiar moral and epistemic virtues. Prior to the Enlightenment, these ideas were so widespread in Europe that some scholars speak of an “age of secrecy.”²⁹ The alchemists are perhaps the best-known individuals who claimed to possess personal knowledge and ac-

27. Franz Joseph Weber, *Die Kunst*, vii. An example of another publication on the making of porcelain is Nicolas-Christiern de Thy, Comte de Milly, *Die Kunst das ächte Porcellan zu verfertigen*.

28. A good overview of the premodern ontology incorporating secrecy is contained in David Lindberg, *The Beginnings of Western Science*, 245–353.

29. Daniel Jütte, *Das Zeitalter des Geheimnisses*. We may distinguish this broader cultural meaning of secrecy from the ordinary craft secrecy, regulated by the guilds, by designating it “philosophical secrecy” (the German word *weltanschaulich* would be better). However, we must immediately add that, in practice, “philosophical” secrecy and craft secrecy were sometimes intertwined.

tively concealed it as a sign of their exclusive epistemic and moral status but also to advertise their expertise and make money. As Pamela Smith has pointed out, some goldsmiths made similar claims.³⁰ In the tradition of the “books of secrets,” the mixing of philosophical and craft secrecy was quite common.³¹ The authors of these books, also designated “professors of secrets,” were regarded as searchers after things whose nature was manifested only to a few; at the same time, their secret knowledge was understood as practical knowledge.³²

It is not unlikely that the arcanists and laboratory workers profited from the value of personal secrecy in the traditions of alchemy and books of secrets. Since these men did not publish their ideas, however, we have no direct evidence for this assumption. But independent of the question of how they legitimized their personal property of the *arcanum*, the claim that many of them tried to keep the *arcanum* a personal secret is substantiated by the archival material from the manufactories of Meissen and Berlin.

The Royal Prussian Porcelain Manufactory of Berlin

The Royal Prussian Porcelain Manufactory of Berlin was founded in 1763, at the end of the Seven Years’ War (1756–63). It belonged to the large-scale industry of the time with a high degree of division of labor, a complex organization, and it comprised several buildings (fig. 1).³³ In 1763 the manufactory employed 134 workers, designated *ouvriers*, and twelve officials (*Offizianten*).³⁴ Two years later, the number of workers doubled, and in the 1780s further increased to an average of 400. In the same period the number of officials increased to more than 30.

About 40 percent of the manufactory’s *ouvriers* were highly qualified artists and craftsmen who had been apprenticed to a master of the manufactory for six to seven years and were relatively well paid. To this group belonged the painters and the artistic workers who formed the porcelain figures, the masters responsible for tools and machines (locksmiths, carpenters, coopers), and the laboratory workers working in the “pigment laboratory,” who are highlighted in this essay (fig. 2). In the context of the

30. Pamela H. Smith, “What Is a Secret?” 48. See also Pamela H. Smith, *The Body of the Artisan*.

31. William Eamon, *Science and the Secrets of Nature*.

32. William Eamon, “How to Read,” 26. In their introduction, Leong and Rankin also state that for many individuals, “secrets held the key to unlocking the mysteries of nature, curing disease, maintaining good health, making practical everyday substances, and even creating wondrous tricks.” These individuals, they further point out, understood themselves as practitioners who possessed insight in the hidden *arcana naturae*, not accessible by ordinary men. See Elaine Leong and Alisha Rankin, “Introduction,” 3.

33. For a more detailed description of the various working processes involved in porcelain manufacture, see Klein, “Chemical Experts.”

34. The two following paragraphs are based on Siebenecker, *Offizianten und Ouvriers*, 87–88, 236–40, 452.

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FIG. 1 The Royal Prussian Porcelain Manufactory, located close to Leipziger Platz. (Source: 1818 drawing by Eduard Gaertner, courtesy of the Stiftung Stadtmuseum Berlin, Inv. Nr. VII 59_582w. Reprinted with permission.)

manufactory's reorganization in 1786–87, the laboratory workers were promoted to the group of officials. Below, we will follow the pathway of the manufactory's first laboratory worker, who received a more formal chemical training and education after the manufactory's reorganization.

The corps of officials consisted of the manufactory's two directors, accountants and other specialists for commerce (approximately 60 percent in 1790), as well as artistic and technical experts (roughly 40 percent). The group of *technical* officials, discussed in detail in this essay, included the manufactory's two arcanists and, after 1786, the laboratory workers (two to three men) too.

The manufactory's arcanists and laboratory workers were directly involved in the labor process, but they were not craftsmen or artisans in the traditional sense. They were "experts" (German *Sachverständige* or *Sachkundige*) in the sense of specialist practitioners who possessed outstanding knowledge about technical processes and things (*Sachen*), combined with natural and/or mathematical knowledge, and were mobilized by the state.

In addition to its internal technical experts, the manufactory also engaged savants recognized as chemists and mineralogists, and some savants also made suggestions on their own for improvements to manufacturing. Thus, in the late 1770s the Prussian mining councilor, chemist, and mineralogist Carl Abraham Gerhard (1738–1821) studied cobalt ore, smalt, and *bleu royal* to be used as a pigment for painting on porcelain.³⁵ For

35. Carl Abraham Gerhard, "Nouvelle Méthode." On Gerhard, see Ursula Klein, "Savant Officials."

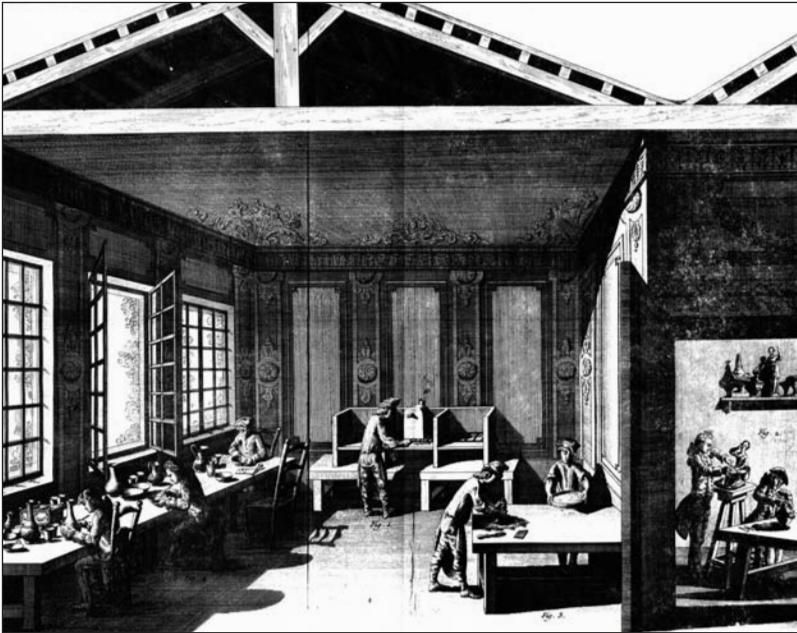


FIG. 2 The left side of the illustration depicts the grinding of pigments, painting, and enameling in a muffle furnace. (Source: Comte de Milly, *Die Kunst das ächte Porcellan zu verfertigen*, translated and annotated by Daniel Gottfried Scherber [Königsberg and Leipzig, 1774], plate VIII.)

some unknown reason, his suggestion was not approved. Another chemist and member of the Royal Prussian Academy of Sciences was more successful: Franz Carl Achard (1753–1821).³⁶ In 1779 Frederick II ordered the manufactory’s laboratory workers to perform experiments for the imitation of *bleu mourant* (dying blue), a light blue color that was prepared at Sèvres after 1753.³⁷ He further asked Achard to supervise these experiments and to use his “chemical knowledge” to invent a reliable recipe for the pigment.³⁸ On 15 January 1780 the king pronounced that “the professor of chymistry Franz Karl Achard created several samples of *bleu mourant*, which must now be submitted to further assays in the manufactory, be carefully applied on porcelain and then tried in the fire.”³⁹ As a result of these experiments, the manufactory created in 1784 its new decoration

36. On Achard, see Hans-Heinrich Müller, *Franz Carl Achard*.

37. The Meissen Manufactory imitated *bleu royal* after 1765; Walcha, *Meißner Porzellan*, 163.

38. KPM archive, XVII.12, fol. 8 [2].

39. Quoted in Claudia Tetzlaff and Hartmut Krohm, *KPM Welt*, 75. According to Tetzlaff and Krohm, the Royal Porcelain Manufactory of Berlin (KPM) is still using this recipe today and keeps it secret (*ibid.*).

bleu mourant and immediately applied it to a new dinner service for the king, which visitors to German museums can admire today.

Before 1787, the hiring of savant chemists and mineralogists as external experts to the manufactory was a rarity. After the manufactory's reorganization, however, this became a more standard practice (*see below*). Heinitz permanently engaged chemists and mineralogists—Martin Heinrich Klaproth, Dietrich Ludwig G. Karsten, Sigismund Friedrich Hermbstaedt, and Alexander von Humboldt—as external inspectors and experimenters who collaborated with the manufactory's arcanists and laboratory workers and also became their teachers, offering chemical and mineralogical courses.⁴⁰ The minister further promoted the transformation of the manufactory's laboratory into a place of sustained chemical experimentation, in addition to its predominant older function as a site of production. He thus paved the way for a kind of expertise that implemented scientific chemical knowledge in a more sustained way than before. The new policy of innovation had consequences for the manufactory's *arcanum* as well. As it promoted collaboration and communication between internal and external experts, personal secrecy became additionally problematic.

Minister von Heinitz was a man of the Enlightenment and cameralism, but he was not a utopian dreamer who would have nourished abstract ideas about the usefulness of science per se. He was a practical man, long experienced in the technicalities of mining and manufacture, who had a pragmatic attitude toward the sciences. He fully endorsed the high value that Enlightenment circles attributed to knowledge, without equating “knowledge” with scientific theory. Instead, his understanding of knowledge and technical innovation was accompanied by attempts to find new ways to combine practitioners' knowledge with knowledge produced by empirically minded savants. Thus, his ideal was the expert who integrated artisanal knowledge with insights into things and processes (*Sachwissen*) stemming from chemistry, mineralogy, mathematics, and other “useful sciences.”⁴¹ His goal was not just the “application of science” but rather the creation of a new type of science that combined technical with natural knowledge—what would later be called “engineering sciences” and “technological sciences.”

In the next sections, I will follow the process of depersonalization of the *arcanum* between 1787 and 1793, which is well documented in the archive of the manufactory. Heinitz, its main organizer, systematically recruited

40. On Humboldt's experiments at the manufactory, see Klein, “Chemical Experts.”

41. “Useful science” is an actors' term. It should be noted, however, that Heinitz never wholeheartedly supported the so-called Mining Academy of Berlin, as Berlin was a residence town rather than a mining center that would have allowed the combination of “theory and practice.” The “Mining Academy of Berlin” was founded in 1770; compared to the mining academies of Freiberg and Schemnitz, it was not a true school or academy but rather an irregular series of lectures, organized by the Mining and Smelting Department. See Ursula Klein, “Ein Bergrat.”

young men to be trained as laboratory workers and arcanists who were ready to share their knowledge and recipes with the manufactory's board as well as with external chemical experts. I will describe Heinitz's strategy, following the training and education of the manufactory's first laboratory worker and later arcanist, Friedrich Bergling (unknown–1797). Bergling almost embodied Heinitz's ideal expert. As I will demonstrate as well, chemical and mineralogical science played an important role in this process, as an internal part of the minister's reform of expertise as well as an instrument for establishing new values in the administration.

1786–1787: Heinitz's Reorganization of the Manufactory

Shortly after Frederick William II had ascended the throne, the Royal Porcelain Manufactory was reorganized in several respects. In April 1787 Minister von Heinitz, who had long been charged with the administration of the Prussian mining and smelting industry, convinced the king to establish an administrative board, consisting of the two former directors, the mining councilor Friedrich Philipp Rosenstiel (1754–1832), who worked in Heinitz's Mining and Smelting Department, and Heinitz himself as the board's president. In this way he linked the porcelain manufactory to the general Prussian state administration in Berlin, the *Generaldirektorium*, although the king formally remained at the top of the administrative hierarchy.

The newly established board adopted the so-called collegial system (*Kollegialprinzip*) of the Prussian state administration, according to which all decisions were made collectively. At their weekly meetings the four board members first discussed economic, administrative, and technical issues and then cast their vote. Minister von Heinitz was clearly the most powerful person on the board, but the new link between the manufactory and the *Generaldirektorium* also involved the reporting and justification of orders. Moreover, the collegial system presupposed that all board members had access to knowledge that was relevant for their decisions. This was incompatible with the fact that the manufactory's arcanists and laboratory workers kept their knowledge and recipes a personal secret. It was one reason, among others, why Heinitz set out to abolish personal secrecy by shifting it to the board.

Before Heinitz had entered Prussian service in 1777, he had been a leading mining official first in the Harz region and then in Saxony. He was a co-founder of the Mining Academy of Freiberg in 1765, a new type of teaching institution established for the education and training of Saxon mining officials.⁴² The immediate incentive for establishing this new way of educating and training mining officials, in Freiberg and elsewhere in

42. Alexander von Humboldt's training and education at Freiberg provides related insights; see Ursula Klein, "The Prussian Mining Official."

continental Europe, was a notorious lack of qualified technical experts in state-directed mining. Among its long-standing goals were reforms to the state administration, the abolishment of “corruption and ignorance” in the state administration, the “improvement” of manufacture, and fostering of the “common good” (actors’ terms).⁴³ Knowledge and savants’ values as discipline, diligence, open communication, and the willingness to write reliable reports became instruments to achieve these goals. Inversely, the personal secrecy of technical mining officials became an obstacle in this context.

The former Saxon mining official was well informed about the abolishment of personal secrecy at the Meissen Manufactory in 1731. During his service in the mining administration of Saxony, he had also been responsible for the Meissen Manufactory.⁴⁴ As he had spent the period from fall 1775 to spring 1777 in France, he may have been acquainted with the policy of the Royal Porcelain Manufactory of Sèvres as well. The reorganization of the Berlin Porcelain Manufactory in 1786–87 provided a good opportunity to elaborate a strategy that followed these earlier examples. The fact that the manufactory’s arcanists, laboratory workers, and the supervising painter Tittelbach were relatively old around this time facilitated his endeavor. Heinitz’s first step was the organization of inspections of the most important technical sectors of the manufactory.

INSPECTION OF THE PIGMENT LABORATORY

In spring 1787 the newly established board of the porcelain manufactory began to inspect three technical sectors, which belonged to the manufactory’s *arcanum*: the preparation of the porcelain paste; the preparation of pigments; and the furnaces and firing processes. In all three sectors, the first step was to get an overview of the existing practices and recipes. Since the preparation of the paste, glazing, firing, and the making of pigments belonged to the arcanists’ and laboratory workers’ private secrets, this was no easy task. Director Grieninger, now a member of the manufactory’s board, had long respected the value of personal secrecy, and it seems that he hesitated to break with this tradition.

The archival material provides many examples of Grieninger’s ignorance of the *arcanum* and the old arcanists’ and laboratory workers’ reluctance to hand out their recipes. Hence, the board organized experimental reconstructions of the existing recipes, based on the scattered information

43. These terms should not be taken as mere rhetoric. In the absolutist German states, most of the leading officials were noblemen who had not been educated and trained for any technical work. For these officials, technical and scientific knowledge was clearly not a high value. By contrast, reformers like Heinitz highlighted knowledge, argued for technological improvement, and deplored ignorance and corruption in the administration; see Andre Wakefield, *The Disordered Police State*, 26–48.

44. Wolfhard Weber, “Probleme des Technologietransfers,” 195.

that was available (*see below*). On 9 June 1787, “after repeated requests” by Heinitz, Grieninger forwarded the first bit of information about the production of the paste, conceding that it was still incomplete.⁴⁵ The manufactory’s oldest arcanist, Manitius, presumably claimed the right to private secrecy. The younger arcanist, Johann Schopp, who was a physician and chemist, was less reluctant, but he too was not ready to fully communicate his knowledge. The dense archival record of the board’s activities contains not a single recipe or report by any of the existing arcanists and laboratory workers. Thus, two weeks later, on 25 June 1787, Heinitz ordered the first experiments with various kinds of stones and earth involved in porcelain production.⁴⁶ The inspection of furnaces, which will not be further discussed in this essay, began on 27 July 1787.⁴⁷ The increasing shortage of wood stimulated trials to find substitutes for wood and improve the furnaces to save fuel.

In the case of the inspection of the pigment laboratory, the board organized a committee for an inspection, consisting of mining councilor Friedrich Philipp Rosenstiel (1754–1832), who was the minister’s organizing hand, the arcanist Dr. Schopp, and, as an external expert, the Berlin chemist Martin Heinrich Klaproth (1743–1817), who was the most famous German chemist of the late eighteenth century. Klaproth was also one of Heinitz’s most reliable scientific experts.⁴⁸ In 1784 the minister had hired him to teach at the so-called Mining Academy in Berlin, and since then he had frequently drawn on his chemical expertise.⁴⁹ In what follows, I concentrate on the work of this inspection community, which provides excellent insight into Heinitz’s strategy of depersonalizing the *arcana* as well as his implementation of chemical and mineralogical science.

Preparing the work of the committee for the inspection of the pigment laboratory, Rosenstiel first tried to gain access to the relevant recipes. On 2 June 1787 he asked Grieninger “to hand over quickly the papers contain-

45. KPM archive, XVII.27, fol. 7 [5].

46. KPM archive, XVII.27, fol. 8 [6].

47. *Ibid.*, fol. 18 [13].

48. On Klaproth, see Georg Edmund Dann, *Martin Heinrich Klaproth*. At the time, Klaproth’s academic reputation derived from his public lectures and chemical teaching, his comprehensive knowledge about material substances, and his outstanding analytical methods and skills, which enabled him to make sensational discoveries of new substances between 1789 and 1803. He was of humble social origin (his father was a tailor), and he was an apothecary by profession. He had never visited a university and received an ordinary pharmaceutical apprenticeship. In 1780 he had bought A. S. Marggraf’s apothecary shop in Berlin, and he ran this shop until 1800, when he became the director of the laboratory of the Royal Prussian Academy of Science. Before 1800, his pharmaceutical laboratory was also a site of frequent scientific experimentation. In 1788 the apothecary-chemist became a member of the Royal Prussian Academy of Sciences and was thus formally recognized as a savant (*Naturforscher*).

49. The so-called Mining Academy of Berlin was not a true technical college (see note 41).

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ing the so-called Arcanum, in order to enable his Excellency [von Heinitz] to inform himself about the techniques of preparing pigments and to then give more distinct orders to the H[erren] Schopp and Klapproth for carrying out the planned inspection."⁵⁰ As in the case of the *arcanum* of the paste, he encountered obstacles. Grieninger first provided only part of the requested information, limited to a list of ingredients. Not until late June was he able to deliver several copies of recipes as well.⁵¹ We can conclude from the board's subsequent request to experimentally reproduce all of the recipes that they were still incomplete and inaccurate.⁵² Hence, on 4 July 1787, when the inspection committee was formally established, the board formulated the following goals.⁵³ It wished that:

an exact examination of the pigment laboratory of the Royal Manufactory [be] undertaken, in order to get information about the state of this laboratory with respect to the quantity and quality of raw materials used for the preparation of the various pigments as well as about the laboratory workers' techniques for preparing the individual pigments and the fluxes.

Here, "exact examination" meant not just control but also the acquisition of recipes and crucial technical knowledge. In addition, the committee had to check the quality of the laboratory instruments and furnaces and further observe whether the laboratory workers "worked with exactitude and cleanliness and according to the good principles of chemical science." It had also to examine the quality of the finished pigments and to answer the question of "whether all of them possessed the required *égalité*, so that it was certain that they always yielded the same effects when used in painting."⁵⁴ The latter item was, in more modern terms, a quest for standardization.

The order further requested that the inspection committee make proposals for improvements and begin "to perform chemical experiments of its own."⁵⁵ In addition to the main goal of the inspection—reconstructions of the laboratory workers' recipes—improvements and invention were a second goal from early on, which became more important later. As figure 2 shows, the preparation of pigments, ornamenting, and enameling was work on a small scale. Hence, explorative experiments performed for technological improvement were not faced with the problem of scaling up. In 1787 the board was interested primarily in finding a white pigment for covering spots on the porcelain wares as well as in the discovery of a sub-

50. KPM archive, XVI.27, fol. 3 [1].

51. KPM archive, XVII.12, fol. 7 [1].

52. As I mentioned above, the archival material does not include the old recipes.

53. KPM archive, XVII.12, fols. 9 [3]–10 [4].

54. *Ibid.*, fol. 9 [3].

55. *Ibid.*, fol. 10 [4].

stitute for minium (a lead oxide), which was used as an additive (flux) to the pigments to lower their smelting temperature.⁵⁶

At its close, the order contained an interesting remark concerning secrecy. It stipulated that “the preparation of pigments belongs to the secrets of the *Manufactory*, which the arcanists and laboratory workers are obliged to preserve; hence it is necessary that the commissioners maintain confidentiality.”⁵⁷ Accordingly, the chemist Klaproth had to be sworn to secrecy, as Achard had before him. In this way, the board redefined the ownership of the *arcanum*: it belonged to the manufactory.

The inspection committee was expected to do its work over the next three months and to finish its report by October at the very latest. However, things turned out somewhat differently. It seems that the arcanist Schopp did not meet the committee’s expectations. In the committee’s report, which appeared only two years later (on 22 June 1789), he was no longer mentioned; nor were any of his recipes mentioned elsewhere. Instead, the name of another man turned up: Friedrich Bergling. Bergling was the first laboratory worker of the manufactory who was actively recruited by Heinitz and received some formal chemical education and training. He was exactly the type of expert the minister had in mind when he set out to reorganize the manufactory: knowledgeable, diligent, reliable, and willing to openly report his experiments and recipes to the board.

Written Reports by the Laboratory Worker Bergling

On 28 December 1787 Rosenstiel remarked in a protocol of one of the board’s regular meetings that it was “necessary to train proficient people for the arcanum and the laboratory, in order to avoid mischief in the case of deaths or other changes.” Therefore, he continued, Minister von Heinitz wanted him to search for two young men who possessed “good, basic chemical knowledge (*gute chemische Vorkenntnisse*)” to be further trained in the preparation of porcelain paste and pigments.⁵⁸

56. *Ibid.*, fol. 9 [3]. Multicolored decoration of porcelain was performed over glaze, after completion of the main firing at 1450°C, which covered the porcelain figure with glaze. Pigments were mixed with fluxes and oil for painting. The ornamented porcelain figure was then fired once more individually in a small glazing (muffle-type) furnace at a temperature of ca. 800°C. At this temperature the pigments smelted and fused completely with the glaze. Pigments for multicolored decoration were different kinds of metal oxides, which had high, slightly differing smelting points. In order to achieve uniform fusion of the different pigments, fluxes such as minium, borax, soda, and potash were added. Among these materials, minium was a problem. As Director Grieninger pointed out in a written report to the board, it often caused unwanted changes in the colors (KPM archive, XVII.27, fol. 5 [3]).

57. KPM archive, XVII.12, fol. 10 [4], my emphasis.

58. KPM archive, II.1, vol. 1, fol. 28 [17].

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This decision was Heinitz's first step to put his strategy of depersonalizing the *arcanum* into practice. The board soon found two young candidates, one a pharmaceutical administrator (*Provisor*) in the town of Wittenberg, and the other the apothecary Friedrich Bergling, who lived in Berlin. In early January 1788 Heinitz asked the chemist M. H. Klaproth in a letter to examine Bergling's "chemical knowledge" and to send him an evaluating report.⁵⁹ On 10 January Klaproth wrote back that he had examined Bergling the same day, including the list of his questions along with Bergling's answers. All eight of the questions concerned knowledge about material substances, ranging from the way to identify and classify them to their composition, characteristic reactions, and techniques of preparation. "Although he does not lack skill and knowledge," Klaproth concluded, "he is still backward concerning the proper scientific part of chemistry." He recommended that Bergling should attend his chemical course, combining it with "diligent reading of good textbooks," and at the same time perform some practical work in the manufactory's laboratory. For the latter practical part of his training, he further recommended keeping a notebook.⁶⁰

Heinitz immediately accepted Klaproth's recommendation to combine practical training with formal instruction through textbooks and lectures. Two weeks later, on 29 January, he hired Bergling as a "laboratory assistant" to be further trained as a true "laboratory worker."⁶¹ In May the following year, Bergling moved on to the full position of a laboratory worker, which then belonged to the group of officials. One of his first obligations was to repeat and study all chemical operations carried out in the pigment laboratory.⁶² A few weeks later, on 16 June 1789, Bergling wrote a report about the laboratory, including a long list of items to be improved. At its end, he added the following request: "I wish that a part of the work that is performed by Riedel himself—the preparation of gold [pigment], purple, violet, . . . dark and new blue would be entrusted to me."⁶³ It seems that the older laboratory worker Riedel did not want to communicate the *arcanum* to the newcomer Bergling. The archival material does not contain reports or recipes by him. Riedel retired as late as 1796, and he presumably did not change his mind in the years before then. Hence, until 1791 much of the work of Bergling and of the inspection committee was concerned with experimental reconstructions of recipes for pigments.

On 22 June 1789, just six days after Bergling had completed his report, Rosenstiel presented the report of the inspection committee.⁶⁴ In the ac-

59. Ibid., fol. 28 [17]. KPM archive, V.6, fol. 2.

60. KPM archive, V.6, fol. 3.

61. KPM archive, V.6, fol. 6.

62. KPM archive, V.6, fol. 10.

63. KPM archive, XVII.12, fol. 16 [10]. For details concerning this report, see Klein, "Chemical Experts."

64. KPM archive, XVII.12, fols. 18 [12]–32 [26]. The committee now consisted just

companying letter he remarked that his and Klaproth's own views "often coincide with Bergling's ideas."⁶⁵ This remark, like many similar ones, is indicative of the inspection committee's style of working. The high mining official Rosenstiel and the chemist Klaproth supported Bergling and collaborated with him rather than exploiting his handiwork. It is not unlikely that Bergling's earlier report was even the blueprint of the committee's report. Collaboration between different types of experts was one of Minister von Heinitz's most important goals and an intrinsic part of his policy of innovation. Needless to say, the value of collaboration excluded secrecy.

The committee's own report was critical, too. Like Bergling, Rosenstiel and Klaproth lacked in the laboratory good furnaces, balances, vessels, cabinets for storing materials, and many tools, "whose lack is utterly unpleasant for a clean chemist (*reinlicher Chemist*)."⁶⁶ They had even observed that the old laboratory workers sometimes used their bare hands instead of ladles to take substances out of vessels. The lack of good instruments meant that the old laboratory workers could not weigh the ingredients for preparing pigments and fluxes precisely. Furthermore, many of the materials were impure and not well stored and ordered. The report also emphasized the importance of standardizing the ingredients for the preparation of pigments and fluxes. As commercial materials were often impure, the quality of the finished pigments varied too often; hence, the commissioners pointed out that it was "too unsafe to depend on merchants."⁶⁷ They thus recommended constructing a storeroom and stocking up on ingredients for at least a whole year. Moreover, they recommended performing quality tests on materials. Until 1786 the pigment laboratory was primarily a kitchen in which pigments, fluxes, and oils were made. Now, it was to be transformed into a true chemical laboratory, implementing the values of chemistry.

The commissioners' report also contained a long list of ingredients for the pigments and fluxes, which was part of their attempt to shift the *arcanum* away from the individual laboratory workers and toward the manufactory's board. They deplored, however, that their list, prepared by Director Grieninger, was still incomplete.⁶⁸ In an appendix to the report, the commissioners presented a total of eighteen recipes for the preparation of pigments (fourteen) and fluxes (four).⁶⁹ Based on the information forwarded by Grieninger and Riedel, Klaproth and Bergling had performed experimental trials to reproduce the manufactory's long-used pigments and

of Rosenstiel and Klaproth. For details concerning this report, see Klein, "Chemical Experts."

65. KPM archive, XVII.12, fol. 17 [11].

66. KPM archive, XVII.12, fol. 24 [18].

67. KPM archive, XVII.12, fol. 19 [13].

68. KPM archive, XVII.12, fol. 19 [13].

69. KPM archive, XVII.12, fols. 26 [20]–30 [24].

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fluxes. The recipes were short, resembling the type of recipes presented in the pharmacopoeias of the time. They first presented a list of ingredients, along with their quantities, and then gave some basic information about the techniques and tools to be used. For each single material, Klaproth added personal information about the best place, or the best local artisan or merchant, to buy the purest materials. This was one way in which the experienced apothecary chemist, who participated in an international commercial network, sought to improve manufacture.⁷⁰

Many of the inspecting committee's suggestions for improvements were soon put into practice. As early as 20 August 1789, Grieninger Jr., who was an assistant on the manufactory's board, reported on the enlargement of the laboratory, which was necessary for installing a distillation retort, and the improvements of storage devices as well as the purchase of many new barrels, glass vessels, and tools.⁷¹

From 1787 until 1791 the inspection committee was occupied with visits of the laboratory, the examination of existing materials, and the reconstruction of recipes for preparing pigments, which had long been the personal *arcanum* of the laboratory workers. During these three years, collaboration between Klaproth and Bergling intensified. The two men continually exchanged ideas about improving existing pigments. Klaproth made comments on Bergling's suggestions, written on the margins of the latter's report or in his own report, and Bergling took up Klaproth's suggestions or commented on them. At the same time, Bergling and Klaproth still had a student-teacher relationship. Bergling asked Klaproth for advice and help when problems occurred, and Klaproth continued to recommend books to him.⁷²

In April 1791 Bergling finished another report about the preparation of pigments, fluxes, and oils.⁷³ Around this time, he had become the most important experimenter for the inspection committee. The style of his report was, in principle, the same as Rosenstiel and Klaproth's earlier report about this part of the *arcanum*: a presentation of recipes. Bergling presented a total of forty recipes for different pigments and fluxes, which relied on numerous experimental trials and repetitions of trials, in which he had varied the proportions of ingredients or techniques. Half a year later, on 19 September 1791, Rosenstiel delivered the committee's second report to the board, the opening paragraph of which reads as follows:

70. Klaproth also offered his help to gain access to pure copper and tin from overseas. He also sold pure materials that he had prepared in his own pharmaceutical laboratory. Thus Klaproth began to experiment with *Magisterium plumbi* to be used as a substitute for minium, which had been one of the board's main concerns (see above), and he further sold pure nitric acid to the manufactory; *ibid.*, fols. 20 [14] and 38 [32].

71. KPM archive, XVII.12, fols. 11 [5]–14 [8]. The expenses for the enlargement and improvement of the laboratory, listed by an accountant, amounted to 95 Thaler; *ibid.*, fol. 35 [29].

72. KPM archive, XVII.12, fol. 53 [47].

73. KPM archive, XVII.12, fols. 36 [30]–49[43].

Following the order of your Excellency [von Heinitz] I had a meeting with Professor Klaproth and Herr Bergling, and *we have studied in fine detail Bergling's essays* about the materials used in the laboratory of the Royal Porcelain Manufactory and about the preparation of fluxes for gold, silver and so on and of the pigments.⁷⁴

Again, this statement demonstrates that Klaproth and Rosenstiel regarded the laboratory worker Bergling as their collaborator. Far from enforcing the Enlightenment savant's abstract scientific ideas onto the artisan, they first read his essay before they added their own.⁷⁵ Although the laboratory worker clearly had a lower social status than the professor and the high official on the manufactory's board, there is no indication that the latter two men would not have taken his report and suggestions very seriously.

INVENTIONS

After 1791, Bergling and Klaproth also performed a larger number of inventive experiments. In its first report from 22 June 1789, the committee had reported just one invention, namely the use of "Platina" (platinum) for ornamentation.⁷⁶ Klaproth also reported the invention to the Royal Prussian Academy of Sciences, including a demonstration of samples of porcelain ornamented with platinum.⁷⁷ In the committee's second report, inventions moved more to the foreground. It had long been a goal of the directors of the porcelain manufactory to produce new shades of colors. One of the greatest achievements in this respect was Achard's invention of *bleu mourant* in 1780. In their own experiments, Klaproth and Bergling were able to prepare the pigment "gold purple" without the use of tin; a darker "dark blue" by adding pyrolusite (natural manganese dioxide); a "dark yellow" with "regulus of antimony" instead of raw antimony; a "light brown" with sublimated zinc instead of calamine; and a darker "chestnut brown" by adding pyrolusite. Moreover, Klaproth suggested testing entirely new pigments containing scheelite, lapis lazuli, and "uranium."⁷⁸ Among these substances, uranium was a "scientific material" that Klaproth had just discovered in September 1789.⁷⁹ In the context of his discovery, he

74. KPM archive, XVII.12, fol. 50 [44], my emphasis.

75. See note 2.

76. KPM archive, XVII.12, fol. 21 [15].

77. Martin Heinrich Klaproth, "Über die Anwendbarkeit." Klaproth described the technique of preparing and using platinum for ornamenting porcelain and recommended its use as a substitute for silver, since silver did not coat the porcelain sufficiently and quickly lost its luster. On the history of platinum, see Bernhard Neumann, *Die Metalle*, 353–64.

78. KPM archive, XVII.12, fols. 51 [45]–53 [47].

79. Klaproth reported his discovery of uranium to the Royal Prussian Academy of Sciences on 24 September 1789; see *Registres de l'Académie*, in *Archiv der Berlin-Brandenburgischen Akademie der Wissenschaften* (ABBAW), I-IV-32, fol. 81. His first

had also examined the possible use of the “uranium calx” (uranium oxide) for coloring glass and porcelain.⁸⁰ Bergling continued Klaproth’s earlier experiments and described their results in three reports in 1792.⁸¹ He successfully prepared a new pigment with “uranium” as well as one with scheelite, which yielded “a nice yellow color.”⁸²

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Around 1791 Bergling had become an experienced “laboratory worker,” preparing pigments and fluxes in the manufactory’s laboratory and performing experiments on them. At this time, the preparation of pigments and enameling was one part of the manufactory’s *arcanum*, separated from its second part, the making of the porcelain paste, glazing, and firing, which was in the hands of the arcanists. Yet Heinitz had other plans: he wanted to unify the responsibility for the two parts of the *arcanum*. The new type of arcanist he had in mind would be responsible for both fields. What is more, his chemically trained arcanist would be a reliable, communicative man willing to write down what he knew—in notebooks, collections of recipes, and written reports to the board.

On 26 May 1791 the king pronounced a new *règlement* for the manufactory’s personnel, which brought Heinitz a step nearer to his goal.⁸³ The order rendered the arcanists responsible for the two parts of the *arcanum*; it further stipulated that the arcanists had to write regular reports to the board, including written information about changes to their recipes. The arcanists’ obligations thus comprised quality control and chemical analysis of raw materials; surveying the production of porcelain paste and glazing, including “careful observation of the use of the correct proportions [of ingredients], which are based on multifarious experiments reported in the recipe book”; design of plans for the construction of furnaces; surveys of the pigment laboratory; “the performance of useful experiments on particular materials used for the composition of paste and pigments and for the structure of furnaces and muffles,” and reports about the latter; and surveying the workers in these technical areas.⁸⁴

In the months before, Bergling had started a series of new experiments

related publications are Martin Heinrich Klaproth, “Mémoire chimique et minéralogique” (the issue of the academy’s *Mémoires* was backdated to 1786–87); and Martin Heinrich Klaproth, “Chemische Untersuchung des Uranits.” Klaproth’s “uranium” was presumably a lower-grade uranium oxide.

80. Klaproth, “Mémoire chimique et minéralogique,” 171–72.

81. KPM archive, XVII.12, fols. 54 [48]–59 [53].

82. KPM archive, XVII.12, 58 [52]. “Uranium yellow” (*Urangelb*) is mentioned in a table of porcelain colors from 1838 by the manufactory’s director, Georg Friedrich C. Frick; see Köllmann and Jarchow, *Berliner Porzellan*, 323 (color number 28 in the table).

83. GStA PK, I. HA Rep. 151 Finanzministerium, Abt. IC, Nr. 9469, fols. 64–71.

84. GStA PK, I. HA Rep. 151 Finanzministerium, Abt. IC, Nr. 9469, fols. 67–68.

to become acquainted with the making of porcelain paste and the quality control of its ingredients.⁸⁵ He had performed wet quantitative analyses of porcelain earths stemming from different deposits. On 6 January 1791 he finished his first report on the wet chemical analysis of four samples of porcelain earth from the deposits of Morl, Beidersee, Ströbel, and Passau.⁸⁶ He also performed wet quantitative analyses with feldspar, quartz, and a few additional stones, which he reported a couple of weeks afterwards.⁸⁷ Thus the would-be arcanist Bergling was learning by doing, but he also received instructions from external chemical experts.

The proportions of the components of raw minerals stemming from different natural deposits, or from different parts of the same deposit, are never exactly the same. Yet knowledge about the chemical composition of the ingredients of porcelain paste was crucial for successful manufacture. The wet quantitative chemical analysis of minerals—one of the most recent chemical methods—yielded the most exact knowledge in this respect. Around 1790 at the very latest, it became a significant technique involved in the manufactory's quality control of materials. Thus, one of the most advanced areas of chemical science became implemented in manufacture.

Bergling performed his analyses of porcelain earths and stones with Klaproth and another savant, the mineralogist and mining official Dietrich Ludwig Gustav Karsten (1768–1810).⁸⁸ In June 1793, after the old arcanist Manitius had retired, he was formally promoted to the position of arcanist, with an annual salary of four hundred Thaler. Now he was the manufactory's most important technical expert, knowledgeable in chemistry and responsible for indispensable technology. The two parts of the manufactory's *arcantum*—the making of the paste and the pigments—were unified, as Heinitz had intended. And the minster's man in charge of the unified *arcantum* was a reliable person who actually forwarded his knowledge to the board. In spring 1795 Bergling wrote a comprehensive inventory, in the form of a table, of all pigments and substances used in the laboratory, which demonstrated that the laboratory had considerably improved fol-

85. For further details concerning these experiments, see Klein, "Chemical Experts."

86. KMP archive, XVII.12, fols. 66 [60]–67 [61]. The Royal Prussian Porcelain Manufactory obtained its "porcelain earth" (a mixture of kaolin and quartz) mainly from deposits near the town of Halle (deposits of Morl, Beidersee, Brachwitz, and Sennewitz), and further from Silesia (mined around Ströbel) and from the town of Passau, which had previously been its main supplier. Its feldspar stemmed from Silesian deposits; see Siebeneicker, *Offizianten und Ouvriers*, 99.

87. KMP archive, XVII.12, fol. 68 [62].

88. Karsten had first studied mining sciences at the Mining Academy of Freiberg from 1782 to 1786 and then continued his studies for one year at the University of Halle. In 1789 he became a mining assistant in Heinitz's Mining and Smelting Department and began teaching mineralogy in the so-called Mining Academy in Berlin; in 1792 he was promoted to the position of mining councilor. Karsten was both a well-known mineralogist and a technical expert in mining. For further details concerning these analyses and Bergling's related collaboration with Karsten and Klaproth, see Klein, "Chemical Experts."

lowing Bergling's and the inspecting committee's suggestions.⁸⁹ Heinitz's strategy of innovation and abolishment of personal secrecy was successful—at least for a few years.

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In 1795 the manufactory began to manufacture a new product: the so-called sanitary dishes (*Gesundheitsgeschirr*).⁹⁰ The paste for this new kind of porcelain was made from the same ingredients as the manufactory's true porcelain ("porcelain earth," feldspar, and clay) but contained a considerably larger proportion of clay than true porcelain. As it was fired at relatively low temperatures, it became possible to use hitherto unused space of the furnaces, which implied a more economic use of fuel. The sanitary dishes were thus cheaper than true porcelain, attracting new groups of consumers. As a result, the revenue of the Berlin Porcelain Manufactory increased significantly between 1795 and 1805.

The paste for the sanitary dishes was a co-invention of Bergling and a newly employed laboratory worker named Johann George Roesch (1767–1821). Roesch had followed a career path similar to Bergling, uniting knowledge coming from local experience and formal chemical education and training.⁹¹ He was first apprenticed to a painter of the manufactory, became a laboratory assistant in 1791, and was promoted to a laboratory worker two years later. In 1795 he became a vice arcanist, after returning from his travels to porcelain manufactories and potteries in Saxony, Thuringia, and Austria.⁹² Shortly afterward, he began to attend courses at the so-called Mining Academy of Berlin.⁹³ In spring 1797 the board hired yet another laboratory assistant, named Georg Frick (1781–1848), who was the son of an assayer in the Berlin mint. In the years to come, Frick received a formal chemical education and training similar to what Bergling and Roesch had, first at the "Mining Academy" and some years later at the newly established Bauakademie. When the arcanist Dr. Schopp died in June 1797, Roesch became his successor. However, on 26 August 1797 Bergling, too, died, unexpectedly.⁹⁴

The latter event clearly was a drawback for Heinitz's policy of deper-

89. KPM archive, XVII.12, fols. 76 [68]–79 [71].

90. The name referred to the fact that it was not glazed with lead compounds, which were poisonous. A similar product had been manufactured earlier in France. See Siebeneicker, *Offizianten und Ouvriers*, 36–37, 99.

91. *Ibid.*, 149, 486.

92. Travels had long been part of Heinitz's strategy for educating and training his technical officials, in addition to more formal training and education.

93. Referring presumably to Roesch, the chemist Hermbstaedt mentioned in his teaching report from 13 October 1796 to Minister von Heinitz that he had taught "one of the young arcanists of the Porcelain Manufactory"; GStA PK, I. HA, Rep 121, Nr. 7959, fol. 96.

94. KPM archive, V.6, fols. 15, 25.

sonalizing the *arcanum*. In December 1797 the minister entrusted a student of Immanuel Kant and chemist from the city of Königsberg with the second position of arcanist: Jeremias Benjamin Richter (1762–1807). Yet the savant Richter, who would soon become one of the best-known chemists in Europe, tried to turn back the wheel of Heinitz's reforms, claiming the right of personal secrecy. As Arnulf Siebeneicker has observed, the archive of the Royal Porcelain Manufactory contains countless orders to the savant arcanist requesting him to send reports to the board and forward information about his recipes, but he did not comply.⁹⁵ When the board offered additional financial compensation for his recipes, he accepted this, without actually changing his secretive conduct. Richter never communicated his knowledge to the board, and after his death in 1807 his recipes could not be found.

There is a deep irony in this story: the student of Kant—the most famous representative of the German Enlightenment elite—claimed personal secrecy, whereas Bergling, Roesch, and Frick, who had an artisanal background, supported Heinitz's effort to depersonalize the *arcanum*.⁹⁶ Seen from a broader perspective, however, Richter's attitude was a mere episode. In the long run, Heinitz's initiative to transfer the *arcanum* to the manufactory's board and to establish more formal training in chemistry and mineralogy for laboratory workers and arcanists bore fruit. The culminating point of this evolution was the establishment of a distinct research and teaching institution of the manufactory in 1877, the *Chemisch-technische Versuchsanstalt*.⁹⁷

Conclusion

The German arcanists were surrounded by an aura of secret knowledge, partly derived from alchemy, and some of them were also recognized as alchemists or chemists. Until 1787, the arcanists and laboratory workers of the Royal Prussian Porcelain Manufactory kept their knowledge a personal (or private) secret. The subsequent depersonalization of the *arcanum* was a complex process spurred by a whole bundle of forces. The Enlightenment discourse about scientific openness and transparency certainly helped abolish personal secrecy. But there were additional causes for this change, apart from Enlightenment ideals, which I have tried to lay bare in this article.

Personal secrecy of individual experts was often perceived as a risk, as knowledge could be easily lost in the case of conflicts, for example, or the experts' premature death. In the particular context of the eighteenth-century German state administrations and royal manufactories, personal se-

95. Siebeneicker, *Offizianten und Ouvriers*, 149–50.

96. On this issue, see note 2.

97. Siebeneicker, *Offizianten und Ouvriers*, 81–82, 161–62.

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crecy was further contested for a variety of additional reasons. Leading officials regarded it as a hindrance to the organization of manufacture through the administration; in Prussia, this problem was reinforced by the principle of collective decisions. What is more, reform-oriented officials identified private secrecy as an obstacle to the implementation of refined chemical expertise through the arcanists' and laboratory workers' formal chemical teaching and their systematic collaboration with external chemical experts. The values of chemical science further coincided with these officials' conception of a reliable, knowledgeable expert official who would be instrumental in the improvement of manufacture and reform of state administrations.

The royal porcelain manufactories were manufactories in the modern economic sense of involving a high degree of division of labor. The arcanists and laboratory workers holding key positions within this system were experts crucial for the entire labor process and the quality of the luxury goods. I argue that attempts to integrate these experts in both the modern manufactory and the state administration became one of the major driving forces for abolishing personal secrecy. Personal secrecy had different consequences when it was implemented in a modern socioeconomic system, on the one hand, and in individual enterprises of projectors (e.g., at the courts) on the other hand. In the case of conflicts, or the experts' unexpected death, crucial knowledge was lost in both cases, but for a manufactory and state administration the consequences were more dramatic. The problem was aggravated when the recruitment of experts was difficult, as was the case in the Berlin Manufactory, where Heinitz tried to establish new ways of teaching along with a new type of knowledgeable and reliable "expert official."

What is important to note here is the fact that the arcanists and laboratory workers of the royal porcelain manufactories were not individual artisans but rather "expert officials" who held key positions within a system of division of labor organized by the state. The ideal technical expert of a minister like Heinitz was no longer the itinerant individual projector or alchemist, who boldly advertised his secret personal knowledge, but rather a more humble, disciplined figure.⁹⁸ He would be knowledgeable, reliable, and ready to provide long-term service to the state. The "expert official" was willing to subordinate himself in the system of a royal manufactory, to cooperate in committees involving different types of experts, and communicate his knowledge to the manufactory's board and the minister. At the same time, he would absolutely protect his knowledge from outside competitors and everybody harmful to the state. Clearly, the privilege of personal secrecy was a significant obstacle to all these values.

I would further argue that the external experts of the manufactory,

98. Hence, the terms *projector* and *alchemist* took on a negative meaning in the eighteenth-century context discussed here.

too—among them the chemists and mineralogists M. H. Klaproth, D. L. G. Karsten, and S. F. Hermbstaedt—were not just Enlightenment savants who would have mobilized rhetorical means in order to control the *ouvriers* and rationalize labor on the basis of preexisting knowledge.⁹⁹ These men were teachers of the manufactory’s technical experts, but they also cooperated with them in the laboratory, producing new forms of combined knowledge from the bottom up. Combined natural and technical knowledge was a feature of all Renaissance and early-modern experts. In the eighteenth century, however, ministers like Heinitz sought to make practical use of mathematics and the sciences in ways that were more independent of individuals, more sustained, and more easily organized and controlled by the state administration. To these belonged the establishment of formal technical teaching institutions, long-term inspection committees, and the writing down of recipes and of experimental reports.

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99. See note 2, and for the hybrid artisanal-scientific expert, see Klein, “Artisanal-Scientific Experts.”

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