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The front cover shows a detail from the dial of a longcase clock by Francis Henderson at Gosford House in East Lothian, Scotland. Photo James Nye. This issue contains an illustrated report of the AHS Study Tour to Scotland, held in May this year.

Materials expertise and networks: The case of Johann Conrad Fischer (1773–1854)

Artemis Yagou*

The late eighteenth and early nineteenth centuries constituted a transitional period when new, dynamic forces of industrialisation were unfolding all over Europe. At the same time, this was a period of increased physical mobility, in which portable clocks and watches were highly sought after. Watchmaking depended on the interactions and interrelations of many different domains and practices, including the production of steel, a material crucial for making reliable springs and other watch parts. Johann Conrad Fischer (1773–1854), a metallurgist from Schaffhausen, Switzerland, provided quality steel to Swiss, French and English clock- and watchmakers. Fischer's case illuminates aspects of the wider technical system surrounding watchmaking.

Introduction

In the long eighteenth century, watches were the most complex artefacts of their time, with the exception of scientific instruments.[1] Given that scientific instruments were meant for scientists, scholars and other elite groups, watches were the most complex artefacts used by the wider public. Watches were products intertwined with mobility: the need to tell the time while on the move had triggered advances in materials and technology that enabled the creation of smaller and more accurate timepieces. Ongoing miniaturisation led to the construction of portable clocks, initially in the form of table-top or carriage clocks, and later pocket watches. The latter combined portability with precision, while the design of dials and watch-cases communicated visually the instrument's reliability and the user's status. Nevertheless, the function and precision of portable timepieces remained serious challenges; these had to be addressed by makers, eventually leading to further technical innovation.

Johann Conrad Fischer (1773–1854), a metallurgist from Schaffhausen, Switzerland, was a personality whose trajectory was connected to many aspects of watchmaking, especially to steel production.[2] Fischer's career has been described as 'full of contrasts': he had 'one foot in the age of the domestic system and the other in the modern world of great industries'.[3] This essay presents Fischer's watchmaking-related activities, with the

*The author (artemis@yagou.gr) is a historian of design and technology. She is Research Associate at the Research Institute for the History of Science and Technology of the Deutsches Museum (Munich). Her main research interests are design history, the cultural history of technology, museums, horology, construction toys, and Greek material culture (eighteenth to twenty-first centuries). She has published widely, including the book *Fragile Innovation: Episodes in Greek Design History* (2011) and the edited volume *Technology, Novelty, and Luxury* (forthcoming, 2022). Her personal website is www.yagou.gr

1. Morgan Kelly and Cormac Ó Gráda, 'Adam Smith, Watch Prices, and the Industrial Revolution', *Quarterly Journal of Economics*, vol. 131, issue 4 (2016), 1727–1752, p. 1729.

2. Max Ruh, 'Fischer, Johann Conrad', *Historisches Lexikon der Schweiz* (HLS), version of 10 February 2017, https://hls-dhs-dss.ch/de/articles/007246/2017-02-10/ [accessed 23 December 2021].

3. W.O. Henderson, *J.C. Fischer and his Diary of Industrial England 1814–1851* (London: Frank Cass & Co. Ltd., 1966), p. 10. See also W.O. Henderson, 'Johann Conrad Fischer, A Swiss Industrial Pioneer', *Zeitschrift für die gesamte Staatswissenschaft*, vol. 119, issue 2, April 1963, 361–376, p. 372.

aim of illuminating the wider sociotechnical system of watch production and trade in the late eighteenth century and the first half of the nineteenth century.[4]

Materials expertise

Fischer was a versatile and prolific individual; primarily a metallurgist,[5] he has also been described as a craftsman, inventor, entrepreneur and diarist.[6] Born into a family of coppersmiths, he was destined to follow the same profession as his forefathers; his life was firmly rooted in the 'old world' of artisans and guilds.[7] Fischer attended grammar school, where he received a good general education, including Greek and Latin, and he started his apprenticeship at the age of fourteen. While an apprentice, he advanced his education by learning French and English, as well as mathematics and physics with the distinguished teachers Christoph Jezler and Melchior Hurter; the former was a pupil and friend of the mathematician Euler, while the latter was an expert on physics for military applications. It is thought that these two teachers had a significant impact in opening up the horizons of the young man.[8]

According to the census of 1766, a few years before Fischer was born, the town of Schaffhausen had about 5000 inhabitants, of which 770 were craftsmen; these, together with their families, constituted the main part of the population.[9] The town was protected

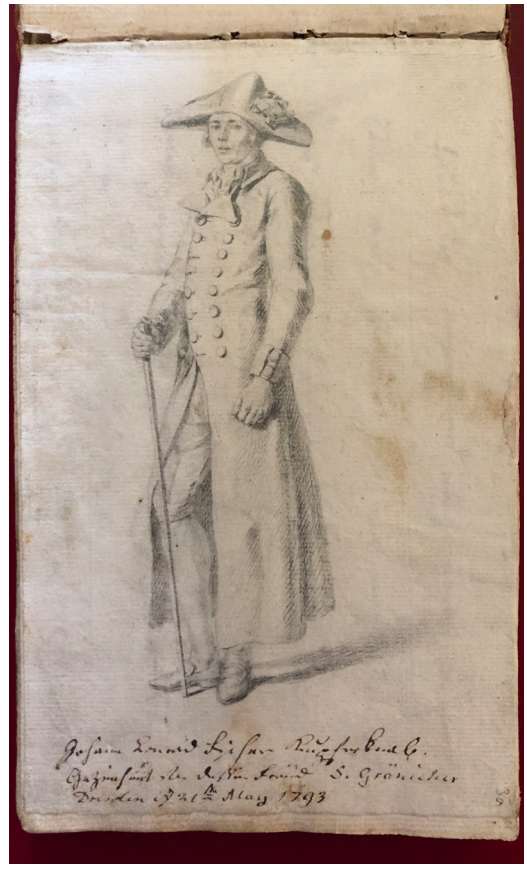

Fig. 1. Johann Conrad Fischer as a young journeyman, sketch by S. Graenicher in Fischer's notebook, Dresden, 1793. GFA 1/144.35, photo by A. Yagou.

4. The present article is not meant to provide a comprehensive account of Fischer's life or work. The abbreviation GFA [Georg Fischer Archive] refers to the holdings of the Corporate Archives of Georg Fischer Ltd., managed by the Iron Library (Schlatt, canton of Schaffhausen, Switzerland), https://www.archives.georgfischer.com resp. https://www.eisenbibliothek.ch/en.html [accessed 23 December 2021].

5. Rudolf Gnade and Karl Schib, *The Metallurgist Johann Conrad Fischer 1773–1984 and his Relation with Britain* (Schaffhausen: Georg Fischer Limited, 1947).

6. Henderson, *J.C. Fischer and his Diary*. See also Heinrich Buess, 'A Swiss Manufacturer Sees the Industrial Revolution in England', *British Journal of Industrial Medicine*, 18 (1962), 47–51.

7. His grandfather Christoph Fischer (1691–1770) and his father, also named Johann Conrad (1721–1811), were both coppersmiths and wine merchants. His father had received advanced education and travelled extensively in Europe; he also worked for five years at the Royal Mint at Woolwich, see Max Ruh, 'Fischer, Johann Conrad', *Historisches Lexikon der Schweiz* (HLS), version of 19 January 2005, https://hls-dhs-dss.ch/de/articles/028584/2005-01-19/ [accessed 23 December 2021]. Fischer wrote down relevant biographical data and composed a family tree in 1851 and 1854, GFA 1/91 and GFA 1/144.32.

8. Gnade and Schib, *The Metallurgist*, pp. 9–11. The potential for education in Schaffhausen was augmented by the existence of a municipal library housing a wealth of important books. Hanspeter Marti, René Specht, André Weibel, 'Die historischen Buchbestände der Stadtbibliothek Schaffhausen', in Urs B. Leu et.al. (eds), *Handbuch der historischen Buchbestände der Schweiz, vol. 2: Kantone Luzern bis Thurgau* (Hildesheim/Zurich: Zentralbibliothek Zürich, 2013), pp. 273–302.

by fortress walls, which shut the town off from the outside world and symbolised its political conservatism.[10] Despite the strongly protectionist nature of the crafts guilds, their members were aware of the importance of contact with others. Upon completing their apprenticeship, young craftsmen had to travel to Europe as journeymen before returning to the safety of their local guild to practise their profession. In this context, following his apprenticeship, Fischer embarked on a journey which lasted almost three years, from 1792 to 1794, and took him through Germany, Denmark, Sweden, England and France (Fig. 1). The diary he published about the journey in 1794 chronicled only the part from Copenhagen to Sweden and back. During this trip, he visited London for the first time and worked there for an engineering fitter.[11] After his return to Schaffhausen, he acquired the status of master coppersmith; the cast lion that Fischer made in order to reach that goal is currently exhibited in the Museum zu Allerheiligen in Schaffhausen, in the section dedicated to guilds. He continued working with his father, then subsequently on his own; in 1802 he moved from the ground-floor workshop of his home in the town centre to a new workshop in the nearby valley of Mühlental (Fig. 2).[12] This was a significant transition from an elementary, home-based manufacturing unit to a more substantial facility, in a location where waterpower was easily accessible and in abundance. Furthermore, as the Mühlental was outside the town walls and thus beyond the guilds' sphere of influence, Fischer could work there with more independence and freedom.

As a metallurgist, Fischer was constantly experimenting with new materials, and he became particularly proficient in working with cast steel to produce bells and other items; he is credited with developing steel for watch springs (*Uhrenfederstahl*) in the early 1810s.[13] The use of springs had enabled the fabrication of timing devices that were smaller and more portable than earlier, weight-driven clocks. Watch springs were typically made of cast or crucible steel (also known as Huntsman steel), a material that had been perfected in the 1740s by Benjamin Huntsman (1704–1776), a Quaker from Lincolnshire.[14] Crucible steel was of substantially better quality than blister steel, which was produced by the cementation process and had significant limitations, especially an uneven distribution of carbon.[15] High-quality crucible steel was produced by melting blister steel in ceramic crucibles. This process served to homogenise the composition of the steel, notably its carbon content, and allowed it to achieve a cleaner microstructure since the slag inclusions (waste minerals) floated to the top of the liquid bath and were skimmed off.[16] Indeed, 'the crucible process provided […] an unrivalled material: absolutely homogeneous in its carbon content and clear of foreign matter.'[17]

9. Karl Schib and Rudolf Gnade, *Johann Conrad Fischer 1773–1854* (Schaffhausen: Georg Fischer Aktiengesellschaft, 1954), p. 18.

10. Gnade and Schib, *The Metallurgist*, p. 8. On the history of the town, see also Karl Schib, *Geschichte der Stadt Schaffhausen* (Thayngen-Schaffhausen: Karl Augustin, 1946).

11. Gnade and Schib, *The Metallurgist*, p. 10

12. Henderson, 'Johann Conrad Fischer', p. 365.

13. Hans Boesch, *Die Unternehmungen von Johann Conrad Fischer* (Schaffhausen: Naturforschende Gesellschaft, 1951), biographical table attached to the end of the publication.

14. Leslie Paton, 'The Iron and Steel Available to the Horological Masters of the Past', *Antiquarian Horology*, vol. 15, no 1, September 1984, 47–51; Charles F. Hummel, 'English Firms Producing Tools Used by the Dominy Craftsmen', *Winterthur Portfolio*, vol. 2, Winter 1965, 27–46, p. 30; Gnade and Schib, *The Metallurgist*, pp. 14–18; Berthold Schudel, *Johann Conrad Fischer, Ein Schweizer Pionier der Stahlindustrie 1773-1854* (Schaffhausen, self-published, 1921), p. 17.

15. Chris Evans, 'Steel in Britain before and after Benjamin Huntsman: Manufacture and Consumption in the Eighteenth Century', in Philippe Dillmann, Liliane Pérez and Catherine Verna (eds.), *L'acier en Europe avant Bessemer* (Toulouse: Presses universitaires du Midi, 2011), pp. 285–298.

16. Michael L. Wayman (ed.), *The Ferrous Metallurgy of Early Clocks and Watches – Studies in Post Medieval Steel* (London: British Museum, 2000), pp. 143 and 145–146.

17. Evans, 'Steel in Britain', p. 296.

Fig. 2. An illustration of the original Fischer home workshop in the old town of Schaffhausen (centre) and the workshop established in 1802 at the Mühlental valley (top), Schaffhausen City Archive J 40/0226 MzA KG S. 237.

Huntsman was a clockmaker; he was therefore keen to have high-quality steel for components such as watch springs whose properties had to be uniform and predictable.[18] The precision and reliability of watches depended a lot on the properties of the spring material. Making good watch springs was a very difficult task that was intertwined with the level of expertise in steel manufacturing, 'since it is the quality of the steel which determines the amount of elastic power in the springs'.[19] William Blakey wrote in 1780 that 'an ordinary watch spring is a small thin strip from 12 to 22 inches long, bent in such a way that it has enough elastic energy to make a balance oscillate 540,000 times in 30 hours.'[20] The uses of steel in clocks and watches meant that it had 'to be fashioned very precisely and to have very specific and quite demanding tasks to perform'.[21] Gradually,

> rapid developments in clock and watchmaking produced movements where the drive springs were given ever more arduous tasks, and where the ability to bear high stress uniformly made a homogenous and clean, inclusion-free steel a necessity. No other steel usage had such a demanding specification, and thus it is no surprise that the European crucible steel process was originally developed for the manufacture of clock springs.[22]

Furthermore, given the need for smallness and lightness, watches had to be made to ever tighter specifications; miniaturisation required not only strength, but also precision and uniformity, advantages offered by crucible steel.[23]

Furthermore, high steel quality was a prerequisite not only for the springs themselves, but also for the necessary tools: makers of clocks and watches had to

> get from a watch material dealer round and square steel rods of sufficient sizes for all kinds of watchmaker's work. The round steel serves for arbors, broaches, drills, screws, turning arbors and other similar tools; that of square section for flat, pointed and rounded chisels, punches, screwdrivers, sink cutters etc. Flat steel of different widths and thicknesses is used for springs, clicks, verges, plates for escape wheels or balance cocks, etc.[24]

Clearly,

> the improvements in steel technology were very much market-driven, and in no small part by the clock and watch makers' requirement for more reliable, homogenous, and ultimately stronger steel.[25]

18. Evans, 'Steel in Britain', p. 296.

19. William Blakey, English translation by M.L. Wayman, *The Art of Making Watch Mainsprings, Repeater Springs and Balance Springs*, in Wayman, *The Ferrous Metallurgy*, 113–138, p. 114. Original text: *L'Art de Faire les Ressorts de Montres* (Amsterdam: Marc-Michel Rey, 1780), available at http://gallica.bnf.fr/ark:/12148/bpt6k61161354 [accessed 23 December 2021]. Another English translation is available at http://www.watkinsr.id.au/Blakey.pdf [accessed 23 December 2021]. The methods used in the eighteenth and nineteenth centuries to make watch springs are also described in *How to Make a Verge Watch*, http://www.watkinsr.id.au/berthoud.html [accessed 23 December 2021], incorporating translations by Richard Watkins and E.J. Tyler of two texts: Ferdinand Berthoud, *Essai sur l'Horlogerie* (Paris: Jombert, Musier and Panckoucke, 1763), and Jacob Auch, *Handbuch für Landuhrmacher* (Ilmenau: Voigt, 1827), 2005.

20. Blakey, *The Art of Making*, p. 114.

21. P.T. Craddock and M.L. Wayman, 'The Development of Ferrous Metallurgical Technology', in Wayman, *The Ferrous Metallurgy*, 13–27, pp. 21–23.

22. Craddock and Wayman, 'The Development', p. 25.

23. M.L. Wayman, J. Lang, J.H. Leopold and J.L. Evans, 'Clock, Watch and Chronometer Springs', in Wayman, *The Ferrous Metallurgy*, 53–83, pp. 53–55; P.T. Craddock and M.L. Wayman, 'Driven by Clockwork: The Role of Clockmaking in the Development of Sixteenth- to Nineteenth-Century European Ferrous Metallurgy', in Wayman, *The Ferrous Metallurgy,* 107–112, pp. 110–111.

24. *How to Make a Verge Watch*, p. 95; description of spring preparation on pp. 137–138.

25. Craddock and Wayman, 'Driven by Clockwork', pp. 111–112.

Other items produced by crucible steel, apart from clock and watch springs, were 'cutlery, penknife blades, needles, pen nibs and buttons'.[26]

Fischer was the first who managed to produce cast steel on the Continent, something he achieved by his own methods; he is considered a pioneer.[27] In his diary, Fischer mentions the 'weldable steel invented by me, and also the thin rolled spring steel',[28] as well as the 'watch spring steel, made at Le Locle from rolled sheets of Schaffhausen cast steel'.[29] Throughout the period in which Fischer was active, namely before the introduction of the Bessemer method in the mid-nineteenth century, steel was thought of as a 'boutique good', made in small batches by known masters.[30] Undoubtedly, Fischer considered himself such a master. In a letter of 12 January 1811 to the Japy firm in Beaucourt (France), Fischer writes about the 'unanimous agreement of manufacturers of springs for watchmaking' regarding the superiority of his steel compared to that of Huntsman.[31] This comparison, which resurfaces many times in Fischer's correspondence of 1811–1816, is a clear indication of the international nature of steel production and the related rivalries in development and supply. In another letter, he claims: 'my steel is particularly sought after for the springs, having been found superior to the English steel for this use'.[32] In a letter of December 1816, the silversmith Peter Bruckmann of Heilbronn (Baden-Württemberg) also praises the quality of Fischer's steel in comparison to English steel.[33] Competition must have been intense in this domain: attempts by other producers to sell inferior steel under Fischer's name made him think that he would have to stamp his ingots.[34]

Although the processes of invention were generally shrouded in secrecy,[35] dissemination of materials expertise did take place not only in personal meetings and correspondence but also through lectures and publications. In 1821, Fischer published an article based on a lecture he had given in July 1820 to the Swiss Society for Natural Sciences in Basel, about his experiments with adding silver to steel in order to produce a material similar to the so-called Wootz steel for swords and blades.[36] In this article, he refers to the Wedgwood scale, which he used for the measurement of temperatures, as well as to the related 'interesting researches by Mr Faraday'.[37]

26. Craddock and Wayman, 'Driven by Clockwork', p. 108.

27. Henderson, 'Johann Conrad Fischer', p. 366; Kenneth C. Barraclough, *Steel Making before Bessemer,* vol. 2, *Crucible Steel: The Growth of Technology* (London: The Metals Society, 1984), pp. 125 and 206–208.

28. Gnade and Schib, *The Metallurgist*, p. 20; Karl Schib (ed.), *Johann Conrad Fischer 1773–1854. Tagebücher* (Schaffhausen: Georg Fischer AG, 1951) [subsequently referred to in the footnotes as *Tagebücher*], p. 72.

29. Gnade and Schib, *The Metallurgist*, p. 21; *Tagebücher*, pp. 84–87.

30. Chris Evans and Alun Withey, 'An Enlightenment in Steel? Innovation in the Steel Trades of Eighteenth-Century Britain', *Technology and Culture*, 53 (3), 2012, 533–560, p. 533.

31. Letter of 12 January 1811 by Fischer [in French], GFA 1/144.15, p. 2.

32. Letter of 17 March 1811 by Fischer to Mr Erhard Doree of Neuchâtel [in French], GFA 1/144.15, p. 11. See also letter of 2 April 1811 by Fischer to Mr Peyer of Mandach (Switzerland) [in French], GFA 1/144.15, p. 11; letter of 3 September 1811 by Fischer to Mr Pechinet Malguiche [in French], GFA 1/144.15, p. 22; Schib and Gnade, *Johann Conrad Fischer*, p. 84.

33. Letter of December 1816 by Peter Bruckmann [in German], GFA 1/97. For other positive appraisals of Fischer's steel, see: Gnade and Schib, *The Metallurgist*, pp. 30–31 and 36; Henderson, 'Johann Conrad Fischer', p. 367. This quality may also be attested by the fact that the London Royal Mint, which Fischer visited in 1825, made part of its dies of Schaffhausen steel; the same material was used by the mints of Paris and Munich. Ursula Kampmann, 'Eine Visitenkarte aus Stahl' [A Business Card Made of Steel], https://bookophile.com/a [accessed 23 December 2021].

34. Schib and Gnade, *Johann Conrad Fischer*, p. 84.

35. Gnade and Schib, *The Metallurgist*, p. 18.

36. Johann Conrad Fischer, 'Notice de quelques Essais sur l'alliage de certains métaux avec l'acier fondu', *Bibliothèque universelle des sciences, belles-lettres, et arts: Sciences et arts*, vol. 18, pp. 73–78; Craddock and Wayman, 'The Development', pp. 23–-24; Evans and Withey, 'An Enlightenment in Steel?', p. 548.

37. Fischer, 'Notice', p.75.

Evidently, he was closely following scientific developments that could prove useful to his work. Much later, in 1851, Fischer also wrote a supplementary memorandum to clarify the manufacturing process of the objects he exhibited at the Great Exhibition in London.[38] These publications connect the hands-on, experimental facets of his work to the social and communication aspects discussed in the next section.

Networks

Much of what we know about Fischer comes from his own letters and, especially, from his diaries.[39] Those he wrote during his several visits to England are of particular interest, because there he visited numerous industrial sites and manufacturing facilities. In these 'industrial "grand tours"',[40] he met many distinguished personalities of industry and science, including James Watt Sr (1736–1819), James Watt Jr (1769–1848), George Augustus Lee (1761–1826), and William Thomas Brande (1788–1866).[41] He systematically took advantage of his acquaintances in order to build his network of connections. For example, in 1825, Charles Gaspard de la Rive, a Swiss physician who had studied in Edinburgh and specialised in mental illnesses, provided Fischer with a letter of recommendation that enabled the latter to meet Michael Faraday (1791–1867).[42] This was the first of several meetings that Fischer and Faraday had over the decades, in which they shared views on technical and scientific topics. During his trips to England he also visited Huntsman facilities in Attercliffe and elsewhere, and met members of the Huntsman family.[43]

Fischer was also well connected to various makers in the Swiss and French Jura, and he provided them with his rolled steel production, which was particularly appropriate for files, springs, razors, knives and gun barrels.[44] Already from 1809 he was supplying weldable cast steel to the Japy firm in France. The Japy horological industries had been established at Beaucourt, in the Franche-Comté region of France, by Georges Frédéric Japy (1749–1812) and were later managed by his sons.[45] Like Fischer, Japy the elder came from a family with a long artisanal tradition and, at the same time, was exposed to broader educational resources.[46] The Japy concern produced clocks (especially carriage clocks), watches, and various types of hardware.[47] Around 1835,

> some 50,000 rough movements (ébauches) were exported from France to Switzerland annually, most of these presumably by the Japy factory in Beaucourt, to be worked up there into finished watches (Fig. 3).[48]

38. Schib and Gnade, *Johann Conrad Fischer*, pp. 73–75 and Plates XXII–XXIII. See also: Gnade and Schib, *The Metallurgist*, pp. 39–44; Henderson, 'Johann Conrad Fischer', p. 367.

39. *Tagebücher*.

40. Mike Page, 'Swiss Steel Master Visits the Black Country', *The Blackcountryman*, Winter 2012, vol. 46, no. 1, 28–32, p. 28.

41. Henderson, 'Johann Conrad Fischer', pp. 373–375.

42. *Tagebücher*, pp. 209, 213 and 804. This letter survives in the archives of Faraday (Letter 257), Frank A.J.L. James (ed.), *Correspondence of Michael Faraday*, Volume 1 (London: Institution of Electrical Engineers, 1991), p. 371.

43. Henderson, *J.C. Fischer and his Diary*, p. 64–65; Barraclough, *Crucible Steel*, pp. 129–130.

44. Henderson, *J.C. Fischer and his Diary*, p. 4.

45. H.L. and H.L Tardy, *Dictionnaire des Horlogers Français – Seconde Partie* (Paris: Tardy, 1972), pp. 325–326.

46. Japy's personal library included works by ancient Greek authors, the *Encyclopédie* of Diderot and D'Alembert, and other important books of the Enlightenment. Bruno Jacomy, *Une Histoire des Techniques* (Paris: Éditions du Seuil, 2015), p. 284.

47. Charles Allix, *Carriage Clocks. Their History and Development* (Woodbridge: Antique Collectors' Club, 1974), pp. 129–149; Eduard Saluz, 'Das Japy-Imperium. Aufstieg und Niedergang eines Familienunternehmers', *Klassik Uhren* 2/2006, pp. 9–11.

48. David S. Landes, 'Watchmaking: A Case Study in Enterprise and Change', *The Business History Review*, Spring 1979, vol. 53, No. 1, p. 16. See also Eugène Jaquet and Alfred Chapuis, *Technique and History of the Swiss Watch from its Beginnings to the Present Day* (Boston: Boston Book Art and Shop, 1953), p. 88.

Fig. 3. Unfinished watch movements (*ébauches*) by the Japy firm, around 1800, Musée des Arts et Métiers, Paris, Inventory nos 01286-0001, 01286-0002, 01286-0003, 01286-0004, 01286-0005 and 01286-0006, © Musée des arts et métiers-Cnam, Paris, photo by P. Faligot.

Fischer had a close relationship with the Japy firm for several decades; it was one of his best customers. Fischer also took up the task of setting up steelworks for Japy, although the available information on this matter is quite contradictory.[49] Despite some conflicts and financial problems with one of Japy's sons in 1828, eventually settled in court in favour of Fischer, the collaboration continued.[50]

On 9–10 January 1814, in the margins of the War of the Sixth Coalition between Napoleonic France and other European powers, Tsar Alexander I (1777–1825, reigned 1801–1825) visited Schaffhausen and specifically Fischer's workshop, where he surveyed the production process.[51] Understandably, the visit acquired great importance for Fischer. A few days later, Fischer wrote to J. Jaques Lavousé of Geneva

49. It is unclear whether Fischer established one or more steelworks for Japy in the late 1810s and early 1820s; the locations mentioned in the sources are La Roche and Badevel. Schib and Gnade, *Johann Conrad Fischer*, pp. 83–84 and 95–98; Henderson, *J.C. Fischer and his Diary*, pp. 4–5, 9 and note 22 on p. 21; H*undertfuenfzig Jahre Georg Fischer Werke 1802/1952* (Schaffhausen: Georg Fischer, 1952), p. 39.

50. Schib and Gnade, *Johann Conrad Fischer*, pp. 96–100.

and the Japy brothers that two representatives of his would visit Montbéliard (France). He asked them to meet the representatives and inform them of the price of their products,

> especially as far as watchmaking is concerned and samples to be shown to the Emperor, who has a determined preference for the mechanical works. But all these should be finished [products] and ready for use, for example watches and pendulum clocks.[52]

There is no evidence of any successful outcome of this initiative. Fischer was keen to enable the connection with Russia, but was not an entrepreneur himself; in fact, he was characterised by a comparative lack of commercial initiative. A metallurgist at heart, he was primarily concerned with solving related problems through constant experimentation.[53] In later years, it was Heinrich Moser (1805–1874), son of a Schaffhausen clockmaker and himself accomplished in the profession, who took advantage of the Russian market. Moser became active there and made a fortune by exploiting the local demand for watches; his watch factory, established in Le Locle (western Switzerland) in 1829, supplied even the easternmost provinces of Russia.[54] There appears to be no evidence of any collaboration between Fischer and Moser.[55]

At the beginning of the nineteenth century, travel and trade suffered serious disruption because of the Napoleonic wars and the related Continental System. In 1814, Fischer managed to make his second trip to England, twenty years after the first one; during that period, many developments had taken place in the metallurgical industries. On his trip, he

> visited a whole series of arms manufacturers, tool and steel dealers, cutlers and watchmakers. His watch spring steel, made at Le Locle from rolled sheets of Schaffhausen cast steel, aroused particular interest.[56]

He also purchased rough castings and various fine finished objects, with a view to examining them in greater detail on his return home.[57] According to Fischer's diary, on 24 August 1814 he visited Samuel Fenn (1767–1821), a London-based maker of watches and watch tools.[58] Fenn, who is described in the diary as

51. Some time after his visit to Schaffhausen, the Tsar sent a precious ring to Fischer as a token of his satisfaction. Franziska Eggimann, 'Der Ring des Zaren – eine 200-jährige Geschichte', *Ferrum* 86 (2014), pp. 125–129. See also Henderson, 'Johann Conrad Fischer', footnote 5 on p. 367. During his reign, the Tsar had attempted a limited and eventually unsuccessful modernisation of Russia. https://www.britannica.com/biography/Alexander-I-emperor-of-Russia [accessed 23 December 2021].

52. Letter of 23 January 1814 from Fischer to J. Jaques Lavousé and the Japy brothers [in French], GFA 1/144.15, pp. 51–52.

53. Gnade and Schib, *The Metallurgist*, p. 38.

54. His father Erhard Moser (1760–1828) had been the town clockmaker (*Stadtuhrmacher*), and his brother Georg Michael Moser (1797–1871) was also a watchmaker, active in Paris and Nemours. The latter's namesake Georg Michael Moser (1706–1783) was another member of the Moser family who had been active in London many decades previously as a goldsmith and émailleur, and became a founding member of the Royal Academy. One of his cases for a watch made in collaboration with watchmaker William Webster is currently exhibited at the Museum zu Allerheiligen in Schaffhausen. Serge Paquier, 'Moser, Heinrich', *Historisches Lexikon der Schweiz* (HLS), version of 2 February 2010, translated from French, https://hls-dhs-dss.ch/de/articles/030370/2010-02-02/ [accessed 23 December 2021]; https://www.royalacademy.org.uk/art-artists/name/george-michael-moser-ra [accessed 23 December 2021].

55. In fact, in the early 1850s, they had serious disagreements over the development of railways in Schaffhausen. Schib and Gnade, *Johann Conrad Fischer*, pp. 174–175.

56. Gnade and Schib, *The Metallurgist*, p. 21; *Tagebücher*, pp. 84–87; see also Schudel, *Johann Conrad Fischer*, p. 9.

57. *Tagebücher*, pp. 169–175; Gnade and Schib, *The Metallurgist*, p. 21.

58. Granville H. Baillie, Ilbert Courtenay and Cecil Clutton (eds), *Britten's Old Clocks and Watches and their Makers. A History of Styles in Clocks and Watches and their Mechanisms*, Ninth Edition revised and enlarged by Cecil Clutton (London: Bloomsbury Books, 1986), p. 441; Granville H. Baillie, *Watchmakers and Clockmakers of the World* (London: N.A.G. Press Ltd, 1966), p. 107.

a 'trader of tools and steel', appreciated the rolled steel presented to him by Fischer, a type of steel not available in England at the time.[59] Fischer notes about that visit: 'On the way home, I called on the watchmaker's tool dealer Fenn in Newgate street, who was also very pleased with the rolled steel leaves for watch springs shown, and confessed that they do not have anything like them in England. The relatively high price of portable watch springs is also proof of how laborious their production is there, as a single spring costs almost as much as a dozen of the same quality in Locle or Fleurier' (both watchmaking centres in western Switzerland).[60]

During the same trip, Fischer also met the cutler Edward Stammers, who initially 'doubted whether Fischer's steel would make watch springs, but eventually agreed to use it for some springs ordered by the watchmaker Berola'.[61] 'Berola' must be Joseph Anthony Berrollas (1775–1852), active at various London addresses in the first half of the nineteenth century. He was an ingenious watchmaker, who patented a repeater in 1808, a warning watch in 1819 and an alarm watch in 1827.[62] Improved materials were of great interest to Berrollas, as he systematically sought to work in collaboration, in order to conceive and develop original, hybrid ideas, with special emphasis on 'user-friendliness'.[63]

Various documents preserved in the Corporate Archives of Georg Fischer Ltd. are testaments to Fischer's contacts and collaborations with firms in numerous towns and cities in Switzerland, France and Germany. For example, on 13 January 1816 Fischer addressed a letter to Girerd and Dubreuil of Lyon, who are mentioned in different sources as ironmongers (*quincailliers*) and wholesale merchants,[64] trying to promote his 'laminated steel for the springs'.[65] He mentions that he is not sending specimens for that material but references, more specifically the names of J. Jaques Lavousé of Geneva [alternative spellings: Lavouse, Lavouze or Lavousi], Lesquereaux of Fleurier, and the brothers Ch. and L. Lorimier of Locle. A catalogue of Swiss watchmakers includes Lavousé without reference to his specialisation; in the same catalogue, Charles and Louis Lorimier are both mentioned as practising the profession of case-fitter (*maître monteur de boîtes*), while Lesquereux [sic] is described as '*maître horloger*'.[66] Fischer's steel for watchmaking uses was therefore well-known and used by a range of practitioners, who could testify to its high quality. In May 1825, he also visited the factory of Vincenti and Rogier in Montbéliard, where all kinds of machines were made and used for the production of watches.[67]

Over several decades he continued his

59. *Tagebücher*, pp. 82 and 87. Two steel files for clockmaking and watchmaking made by Samuel Fenn around 1824 survive in the collection of the Winterthur Museum (Delaware, USA); they were used by the Dominy family of clockmakers and cabinetmakers in East Hampton, New York. Charles F. Hummel, 'English Firms Producing Tools Used by the Dominy Craftsmen', *Winterthur Portfolio*, vol. 2, Winter 1965, pp. 27–46.

60. *Tagebücher*, p. 87.

61. Henderson, *J.C. Fischer and his Diary*, pp. 25–26.

62. Baillie, Courtenay and Clutton, *Britten's Old Clocks*, p. 370. See also Granville H. Baillie and Brian Loomes, *Watchmakers and Clockmakers of the World* (London: N.A.G. Press Ltd, 1976), p. 21. Detailed illustrations of inventions by Berrollas are included in Isaak Brown, *Die neuen und neuesten Erfindungen und Verbesserungen in der Uhrmacherkunst* (Munich: Callwey, 1981) (first edition Quedlinburg and Leipzig: Basse, 1854), pp. 27–31, 49–52 and 103–104. One of Berrollas' alarm watches from around the period when Fischer met him is nowadays kept in the collection of the British Museum, Catalogue number 1201.1392.

63. David Buckden, 'An Impoverished Innovator. Joseph Anthony Berrollas (1775–1852)', *Antiquarian Horology*, vol. 38, no 2, June 2017, 248–254.

64. J. de la Tynna, *Almanach du Commerce de Paris, des Départements de l'Empire Français et des Principales Villes du Monde* (Paris 1809), p. 718, and Henderson, *Johann Conrad Fischer*, p. 24, respectively.

65. Letter of 13 January 1816 by Fischer (possibly to Girerd and Dubreuil of Lyon) [in French], GFA 1/144.15, p. 60.

66. Sylvie Béguelin et Hugues Scheurer, *Répertoire raisonné des Horlogers Neuchâtelois du XVIIIeme et XIXeme Siècle, Volume III, Inventaire des Horlogers à partir des Sources Notariales* (Neuchâtel, La Chaux-de-Fonds, 1993), n.p.n.

67. *Tagebücher*, 201–203; Gnade and Schib, *The Metallurgist*, p. 28; http://www.patrimoine-pays-de-montbeliard.fr/index.php?id=253 [accessed 23 December 2021].

Fig. 4. A portrait of Fischer in advanced age (artist unknown, no date), GFA 1/90, photo by A. Yagou.

metallurgical work, constantly experimenting and aiming for improvements in his products. At the same time, he maintained a very active public profile by offering his services in various capacities, including as the first 'town president' (mayor) of Schaffhausen (1831–1835), as Artillery Inspector for the Schaffhausen canton, subsequently promoted to Artillery Lieutenant-Colonel, and finally as the canton's Director of Mines, a post that he occupied for half a century.[68] In 1846, he visited again the Fenn workshop on Newgate Street, London, where he met the nephew of the former owner. According to Fischer, Fenn the younger was initially sceptical and reserved, but gradually became much friendlier; the two men exchanged views on steel production.[69] A few years later, in 1851, aged 78, Fischer made his last trip to England (Fig. 4). He contributed to the Swiss section of the Great Exhibition, where he exhibited 'ingots of meteor steel and articles made of the same';[70] his steel bars received an honourable mention.[71] Fischer was astonished by the massive technological and

68. Gnade and Schib, *The Metallurgist*, p. 11–12; Schib and Gnade, *Johann Conrad Fischer*, pp. 135–94; Ruh, 'Fischer, Johann Conrad' (version of 10 February 2017).

69. *Tagebücher*, pp. 577–578.

70. *Official Catalogue of the Great Exhibition of the Works of Industry of all Nations* (London, 1851), p. 303. 'Meteor steel' was the name used for a nickel steel alloy developed by Fischer following extensive metallurgical experiments. Gnade and Schib, *The Metallurgist*, pp. 25–27.

71. Henderson, *J.C. Fischer and his Diary*, p. 42; see also Marc Graf, 'Johann Conrad Fischer und die Weltausstellung 1851', *Ferrum* 66 (1994), pp. 39–42. The Japy firm, with which Fischer remained in close contact, also participated in the Great Exhibition. Some of the Japy exhibits survive in the collections of the National Museums Scotland. Harry Gilmore, 'Meeting on 27 May', *Antiquarian Horology*, vol. 21 no. 6, Winter 1994, p. 513; J. A. Neale, 'Meeting on 19 October', *Antiquarian Horology*, vol. 21 no. 6, Spring 1996, p. 422.

social changes that had taken place in England, but also expressed critical views on the status and living conditions of the workers.[72]

Patterns of transition

While Fischer was deeply embedded in the traditional structures of craft guilds, his activities also exemplify the transitional nature of his times towards the modern industrial world. The range of his experience made him realise that

> for a Swiss manufacturer in the new industrial age the key to success lay in concentrating on the production of specialized goods and in exploiting the markets of the Continent.[73]

Possessing a solid background in his craft, he systematically pursued new paths and continuously expanded his knowledge and connections. Watchmaking was one among the wide range of interests Fischer held. His efforts for the improvement of steel complied with a more general pattern: they were market-driven, directly emanating from the needs of clock- and watch-makers, who were in turn spurred on by the wishes of consumers themselves.[74] Our incomplete knowledge of his involvement with watchmaking could be enhanced by respective information from his partners' side, especially Japy and other French and Swiss clock- and watchmakers.[75]

Furthermore, his persistent efforts to improve the materials he produced can be better evaluated by considering competition and other adverse conditions. In one of his letters, he mentions specifically how difficult it was to overcome a certain conservatism, 'the prejudices and the ridicule of the public, which is always in opposition with [sic] the introduction of novelties.'[76] A dedicated metallurgist, he was concerned with solving problems related to materials;[77] he continued investigating with great curiosity, experimenting until the end of his life.[78] Firmly grounded in the world of crafts and guilds, Fischer communicated with some of the most prominent scientists and industrialists of his time, as well as with powerful leaders.[79] His case vividly illustrates the transition from old forms of knowledge and production organisation to the new industrial conditions.[80]

According to the theoretical framework formulated by Hilaire-Pérez, technological evolution in the eighteenth century was 'rooted in the practices and in the cultural itineraries of artisans'.[81] Fischer's work appears to continue such traditions well into the nineteenth century. In particular, highly evident in his work were the fundamental creative processes of 'networking, exchanges, mixing', considered typical of eighteenth-century artisans.[82] His activities contradict 'the myth of the "lone inventor" to create a broader picture suggesting experimentation, demonstration, discussion, rivalry, discovery and capitalisation'.[83] In this vein, we argue that Fischer's case shows the considerable

72. Henderson, *J.C. Fischer and his Diary*, p. 44.

73. Henderson, *J.C. Fischer and his Diary*, p. 10.

74. Craddock and Wayman, 'The Development', p. 13.

75. See for example an account book of Japy Frères from 1809, confirming a steel delivery by Fischer. Adrian Knoepfli, *Mit Eisen- und Stahlguss zum Erfolg*, Schweizer Pioniere der Wirtschaft und Technik No. 74 (Meilen, Switzerland: Verein für wirtschaftshistorische Studien, 2002), p. 15.

76. Letter of 26 February 1816 by Fischer (possibly to Watt) [in English], GFA 1/144.15, p. 168.

77. Gnade and Schib, *The Metallurgist*, p. 38.

78. Gnade and Schib, *The Metallurgist*, p. 44.

79. Eggimann, 'Der Ring des Zaren'; Johann Conrad Fischer, *Meine Unterredungen mit Fürsten*, GFA 1/144.4.

80. Wolfram Fischer, *Wirtschaft und Gesellschaft im Zeitalter der Industrialisierung* (Göttingen: Vandenhoeck & Ruprecht, 1972), p. 290.

81. Liliane Hilaire-Pérez, 'Technology as a Public Culture in the Eighteenth Century: The Artisans' Legacy', *History of Science* 45(2), 2007, pp. 137–138.

82. Hilaire-Pérez, 'Technology as a Public Culture', p. 136.

significance for the industrial Enlightenment of craftsmen who combined high-level practical skills with mobility and openness. People like Fischer underpinned processes of 'hybridization of knowledge, taking place amongst small groups of industrialists (micro-milieux) or even individuals, linked to scientists and those scientifically trained'.[84] Although originating from an artisanal environment, such craftsmen were also trained in scientific subjects and participated in innovative activities.[85] They represent an 'intermediary and heterogeneous category',[86] clearly deserving more attention. In-depth study of their activities may shed light on the late eighteenth and early nineteenth centuries as times of 'articulations and transitions between modes of production',[87] as well as of continuities.[88]

Conclusion

The aim of this essay has been to illuminate the range of social, technical and cultural aspects that affected watchmaking in the late eighteenth century and the first half of the nineteenth century. One of the actors involved in the large and multifaceted technical system of watchmaking was the Swiss metallurgist Johann Conrad Fischer. His personal trajectory was complex, transnational, and characterised by continuous experimentation; Fischer's life opens up a fascinating window into the world of early modern manufacturing. Firmly established from a young age in the guild system of the conservative and relatively isolated Schaffhausen as apprentice coppersmith, he became exposed to and involved with new types of organisation of production. Although not a watchmaker himself, Fischer participated as a metallurgist in the wider technical system surrounding watchmaking, and contributed to it in many ways: not only through the production of high-quality steel, but also through his networking activities. His case shows how production and development in early modern, industrialising Europe were deeply embedded in the practices of craftsmen: their profound knowledge and constant improvement of materials, as well as their sustained communication with various experts through diverse channels. The case of Fischer represents a valuable node in watchmaking networks of invention and production, vividly demonstrating their complexity.

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83. Angus Patterson, 'Surpassing Midas: English Cut Steel, 1740–1830', *The Journal of the Antique Metalware Society*, vol. 25, 2020, 2–15, p.11. See also Chris Evans, 'Crucible Steel as an Enlightened Material', paper presented at the conference Steel in Britain in the Age of Enlightenment, University of Glamorgan, 7–8 December 2007.

84. Hilaire-Pérez, 'Technology as a Public Culture', pp. 137–38. Fischer's case has substantial similarities with the French 'artistes mécaniciens' of the Egypt expedition and with the mechanic and inventor Edme Régnier discussed by Hilaire-Pérez. See also James R. Farr, *Artisans in Europe 1300–1914* (Cambridge: Cambridge University Press, 2000), pp. 1–7.

85. Hilaire-Pérez, 'Technology as a Public Culture', p. 138.

86. Patrice Bret quoted in Hilaire-Pérez, 'Technology as a Public Culture', p. 138.

87. Francesca Bray, 'Liliane Hilaire-Pérez, La pièce et le geste. Artisans, marchands et savoir technique à. Londres au XVIIIe siècle', *Artefact* 4 (2016), https://journals.openedition.org/artefact/539 [accessed 23 December 2021].

88. Kenneth Warren, *Steelmaking before Bessemer*, vol. 1, *Blister Steel: The Birth of an Industry*; vol. 2: *Crucible Steel: The Growth of Technology* (book review), *Technology and Culture*, vol. 27, no. 3 (July 1986), 624–626, p. 625.