# 10. An Artisan and the Røros Copper Works: Børre Hansen Langland

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## Introduction

This chapter explores an aspect of the local technological context within which Røros Copper Works operated. Large industrial activities such as Røros and Falun gave rise to new technological environments, often on an artisanal scale, which in turn had development effects. One element of this was watch and clock making, which was an important dimension of manufacturing and industrial change throughout Europe. Watch and clock makers were in the «orbit» of both the Røros and Falun copper enterprises, and connected these environments to a wider European «industrial enlightenment» in which clock making played a key role. The industrial enlightenment, to follow Joel Mokyr, was a Europe wide, largely 18th century, cultural shift which turned people's attention towards new production and productivity opportunities, based on the progress in scientific knowledge («propositional knowledge») and production skills («prescriptive knowledge»). According to Mokyr this shift happened in Europe and not elsewhere, and foremost in Britain, where such «useful knowledge» was strong. Central to the industrial enlightenment were skilled artisans and mechanics, the pool of which was larger in Britain but was found throughout Europe. Industrial progress happened through

the combination of different knowledges, and its growth is also associated with the increase in meeting places – such as scientific societies, informal groups, coffee houses, exhibitions and many more – where the different relevant knowledges, of the *savants* and the *fabricants,* could be communicated, fused and developed (Mokyr, 2004, 2009). Clock makers, Mokyr holds, were among the artisans and mechanics on whose workmanship «technological progress depended» (Mokyr, 2009, p. 110).

Here we explore the life and work of a local farmer, Hans Børre Hansen Langland (1732–1820), who was linked to the Røros Copper Works, and who not only became a rather prolific clock maker and metal-working artisan, but left an important diary record of his work. Langland was formally connected to Røros by virtue of the fact that he lived close to it. Both of Røros and Falun enterprises enjoyed privileged rights to exploit natural and human resources in their localities. The Røros Copper Works was granted royal monopoly rights to copper ores, water, forests and labour inside the so-called «circumference» (a circle area of approximately forty-five kilometers around the Old Storwartz mine.). The Røros company vigorously fought to maintain and even extend these rights into the 19th century (see chapter 4 by Henrik Thommesen). Falun Copper Works enjoyed similar rights, but its governance structure and organization, of far older provenance, were different and inputs, such as charcoal and transport for smelting, were provided by several self-sufficient and independent metal making works («bruk»; see Nordin 2020, p. 12). Around each of the copper works grew sizeable communities and distinct trade patterns. In the second half of the 18th century Røros Copper Works employed around 1400 workers in the mining and refining processes, and a further 1000 farmers who also performed obligatory work for the copper enterprise. Copper production required large supplies of wood for constructing the mine shafts, fuel for heating the shafts' rock walls before hacking out the copper ores, charcoal for smelting the ore and so on. Local farmers worked as charcoal burners, forestry workers felling trees and chopping wood, and they transported charcoal, firewood and timber, copper ores and other materials to and from the mines, smelting works, forests, etc.

Artisanal activities were common, because farmers manufactured at least some of their own tools and equipment. As the Røros Copper Works developed other artisanal activities emerged in the area, notably clock making. The production of clocks and watches has long been recognized as important for the evolution and progress of industrialization. Clocks had complex gearing – a mechanism that was used in many other industries including textiles. It has long been argued that the tool making skills of clock and watch makers played a key role in making tools and machinery for a range of other industries, as well as mechanical and scientific instruments. Many of the Industrial Revolution's mechanics came from a background in clock making, and «[t]he importance of watch-making for the textile industry cannot be overstated» according to Allen (Allen, 2009, p. 204). Yet the world of clock making and machine making for industries such as textiles, were in many respects very different. The scales were far apart, with no easy transition from highly precise production of small parts and fine tools using malleable metals, to making large items and machinery of iron.[1] Although clock making in industrial districts was widespread, questions about how exactly horology contributed to the development of other industries are far from fully answered.

To address such concerns, one approach is to focus on the knowledge field of horology. Was horology a field where science and technique met – a field of the new industrial enlightenment that swept over Europe, and above all Great Britain, in the late 17th and 18th centuries? What was the relevance of the knowledge field for other forms of useful knowledge? Connections between horology as a knowledge field with other fields can be sought in several ways; for example by looking at the career paths of individual clock makers, clock makers' prosopographies, or investigating meeting places, such as learned or technical societies, where different knowledges – residing in different people and occupations – would meet and knowledges might be exchanged or fused. These changes in technological capability

1 Gillian Cookson cautions that although they were much in demand in the early phases of the Industrial Revolution, their role during what she has dubbed «the age of machinery» was less important after the development of machine tools. She notes that «the essential innovations in machine-making tools, notably to the lathe and the planer, were the work of engineers such as Wilkinson, Bramah, Maudslay, Clements, Roberts, Whitworth, Fox, Nasmyth and Murray, none of whom was connected with clockmaking». From Cummins and O'Grada (2019), p. 17.

were complemented and fostered by demand changes – the consumption of time pieces was growing, and reached new segments of society. The factors influencing such demand have been sought in the social and economic order of the day – from the aim to increase labour discipline via time control, to emulation and consumers' desire for luxury consumption (Thompson, 1967; Berg & Clifford, 1999). As a result of these changes distinct clock making regions or districts developed in many countries in the early modern period, but clock making also grew in regions that were industrialising on other bases.

Even though Røros was a remote region it was not exempt from these developments. Hans Børre Hansen Langland lived in Ålen, on a remote farm in the southern Trøndelag region of mid-Norway. However the district was known for a number of excellent clock and watch makers. He lived at the family farm, Langland, together with relatives and other people, about sixteen in all. Langland was primarily a farmer, but combined farming and working with the Røros enterprise with making and selling a broad variety of items, among which were clocks and watches. Combining farming with other work was common in Scandinavia, most often with fishing, forestry or small scale manufacturing. Langland was directly connected to the copper industry because he was obliged to undertake work for the Røros Copper Works, since the farm was inside the circumference and transported copper ore, wood and other forest products for the mine. Most of this work was delegated to family and others, while Langland himself organized it. Transport was seriously difficult and dangerous, due to the climate and fragile transport network, and his diary reports on deaths due to drowning or other transport accidents. Nevertheless, this was a major source of income for Langland and his household, perhaps more so than for other farmers in the region. During the 18th century the Røros Copper Works was expanding production and new, large copper ores were found and exploited. The Mugg mine, Christianus Sextus and large parts of the Storwartz field were all in operation during the period, with impacts not only on the Røros Copper Works' owners and officials, miners and farmers alike, but also communities further afield (for instance, horses from Sogn, 400 kilometers away, were bought by the Røros Copper Works). One important question is what the impacts of the Røros Copper Works

were for the region. Here we explore this by looking at the relations between the Røros Copper Works and Langland: what happened in terms of transactions, exchanges and societal changes?

### *The source diary*

The key source we have for answering such questions is Langland's diary. For most of his adult life Langland wrote a diary, or *Journall or Diarium* as he called it. On its first page he writes that he kept the diary «to draw up what I make in my Profession, so I can see whether I am debtor or creditor, owe or shall receive, and if someone owes/orders [unclear in ms.] something whether it is completed or not». A large part of the diary has survived – 130 pages – spanning the last half of the 18th century.[2] The diary falls into two parts. First there is an account section, which lists what he sold, to whom, prices and payments received, and second, a more discursive part which is more diverse and includes descriptions of daily tasks – dominated by farming – weather observations, and reflections and comments on innovations, scientific discoveries and world events. The diary was written over a long period, from 1754 to 1809, beginning when Langland was twenty-seven years old and ending when he was seventy-seven, thus covering fifty-nine of his eighty-nine years of life.

## The technology of time pieces[3]

When Langland entered the field of horology, he entered a field with a long history, characterized by small and major innovations and often co-existing with older techniques, such as sun dials. Some ancient time pieces were extraordinarily complex and sophisticated; they could keep unequal day and night hours and different hours according to the season, while the Chinese Su Sung water wheel of 1094 featured an escapement and balance weights. Mechanical clocks are believed to have existed from about the 13th century and became more numerous and elaborate during

2 The original diary is held by the Statsarkivet in Trondheim, Privatarkiv 46. We are using the transcribed version of the diary, created by Trond Bjerkås, and we follow the pagination in the two parts of the transcription. References to the diary are given to the relevant part of the diary – Diary I or Diary II. All translations from Norwegian to English are by the authors.

3 This section draws on Cipolla, 1967, and Landes, 1983.

the 14th century: astronomical movements were added to the movement of time, such as globes and spheres. Large clocks were made to adorn public buildings; they were expensive, mostly made of iron, and often installed on churches, monasteries and town halls. Perhaps the most famous in Scandinavia is the 14th century astronomical clock in Lund in Sweden. The Hansas installed one in Bergen in 1480–1481, and in the 16th and 17th centuries town clocks appeared in other Norwegian cities (see Ingstad, 1980). These public clocks required attendance because they were imprecise and needed frequent adjustments. As Cipolla (1967) notes, precision may not have been a priority – it was thought unnecessary to add a minute hand to the hour hand on clocks for a long time. Typically, clocks lost about fifteen minutes a day, and it was common that the clock makers were tasked with adjusting the clocks two or three times a week. The older technology, sun dials, did not disappear but remained, and were at times used to reset the mechanical clocks. Although lack of precision continued throughout the middle ages, some astonishing feats were achieved: the 1350 clock on Strasbourg cathedral included

> a moving calendar and an astrolabe whose pointers indicated the movements of the sun, moon and planets. The upper compartment was adorned with a statue of the Virgin before whom at noon the Three Magi bowed while a carillon played a tune. On the top of the whole thing stood an enormous cock which, at the end of the procession of the Magi, opened its beak, thrust forth its tongue, crowed and flapped its wings (Cipolla, 1967, p. 44).

The arrangements of the clocks were linked to religious beliefs, and to astronomy and cosmology, but also to practical tasks. According to Bartolomeo Manfred in 1473, referring to the public clock in Mantua, it showed the right time for «phlebotomy, surgery, dress making, for tilling the soil, undertaking journeys and for other things very useful in this world» (cited in Cipolla, 1967, p. 42).

While medieval clock makers «added wheels to wheels» – to the extent that they could not be counted (Cipolla, 1967, p.46) – rather than improving the escapement mechanism on which precision really depended, much of early modern innovation focused on this mechanism. The energy source of clocks was gravity and weights – slowly descending suspended weights (and counter weights). This was linked to clogs – toothed wheels – rotating

with the descent of the weights. The rate of rotation was controlled by the escapement mechanism, often of a verge and foliot type. The verge was a vertical rod, with two small metal pallets fastened to each end, set at right angles to each other and engaging with a toothed wheel. One pallet halted briefly the movement of the clog, then the other pallet released it. This mechanism moved the hands that showed the time, and also made the audible tick-tock sound of the clocks. The foliot was a horizontal bar with weights near the ends, and by moving the weights in or out along the bar the speed of the clock could be adjusted. A common arrangement was to have two of these sets inside a clock – one moving time, the other had some audible feature – the striking of a bell every hour for example. By «adding wheels to wheels», or sets, time pieces could have many different functions – showing hours, minutes, and seconds, playing tunes, showing celestial movements, etc.

An alternative to this system came in the mid-16th century, in which the escapement was regulated by a spring, rather than a foliot. It was the slow unwinding of a steel spring that moved the mechanism, and no longer the foliot with weights, and gravity. Verge escapement was also used in smaller time pieces – portable clocks and pocket watches – which became more numerous in the late 15th early 16th centuries, although poor precision remained a problem. Many were luxury items, highly decorated and expensive, involving new skills and artisans, including goldsmiths and jewelers, in their production.

The verge escapement mechanism was also used in pendulum clocks (introduced by Christiaan Huygens in 1656) but was often replaced by anchor escapements after 1666. A string of other innovations followed. One problem was that changes in temperature caused the metal to expand. Solutions were sought in the gridiron pendulum of the 1720s, the mercury pendulum of 1726 and the self-adjusting pendulum bob of the 1730s. The same was a problem in watches, and the measures introduced to solve it included bi-metallic use, compensation curbs on the spring and so on. Another key area where innovations were made concerned the friction at the escapement and irregularities of the train. Numerous experiments were made in the late 17th and 18th centuries and resulted in a variety of measures to reduce friction. The introduction of the balance spring, in the

mid-17th century, increased precision considerably – «to, say, five minutes». Adding minute hands became more common, but were at first numbered in Arabic numbers whereas hours were in Roman. Second hands began in the 1690s, and Arabic numbers were abandoned in late 18th century (Landes, 1983, pp. 128–29). Springs were also used in clocks, replacing weights or pendulums.

Clock and watch making grew through the 18th and into the early 19th centuries resulting in a huge variety of time pieces, catering for all market segments. The innovation of the repeater introduced more complexity. From the 1750s repeaters could be prompted to mark the hours, quarters and minutes by different sounds. It is thought that a famous London maker, John Ellicott, was the first to produce minute repeaters during the second half of the 18th century. During the 19th century, following the improvements made by Abraham-Louis Breguet, the minute repeating mechanism became much more common but was still to be found only in the best watches as it was expensive to make. To actuate the repeating mechanism meant pulling a cord (the pull repeater), pressing a button or, in the early versions, by both pushing and depressing the pendant (the top) of the watch.[4] As we shall see, repeaters, and datum clocks, avance clocks and moon clocks, were all included in Langland's production range.

By the mid-18th century there were clock and watch making production sites in Geneva, London, Paris, the Blois, the Black Forest, the Jura, in Preussen where the King promoted production in Berlin, in Russia close to Moscow, a factory was established in Lisboa and Christopher Polhem started his Stjärnsunds Manufakturverk in the Dalarna in Sweden, a short distance from the Falun Copper Works (Stora Kopparberget), and relatively close to Røros.

## Langland's production of time pieces: types and quantity

Although living in a remote area, Langland thus worked in a complex technical field and a geographically extended context in which innovation was ongoing and technological sophistication was increasing. His work

4 This draws on Wikipedia, retrieved 15 April 2020, https://en.wikipedia.org/wiki/Repeater_(horology). The quarter repeater strikes the number of hours, and then the number of quarter hours since the last hour. The mechanism uses two chimes of different tones.

should be seen in this wider context, and itself exhibited some complexity. Eight types of clocks can be identified. They are:

(1) *«Vekker» – alarm clock*. These were probably *longcase clocks with alarm* function. They did not strike at the hour, and they most often had just one hand, at times two. The cheaper ones had to be wound up every day, the more expensive, every two days and towards the end of the 18th century eight days clocks became common. Langland sold alarm clocks of different sizes, prices, and intervals between winding up, such as an alarm clock «which runs for 8 days».

(2) The second type is the *«Viser»* or *«Visarverk»*, a *clock without strike*, which solely showed the time – there was no alarm function nor did they strike at the hour. This type was relatively cheap, and among the first of the floor-clocks that were widely used in the region. Langland made such clocks to different sizes and prices. They required winding up every twenty-four hours, every three days or every eight days. There are entries such as «Small longcase clock 3-days», «8-days longcase clock», «A small longcase clock which is wound up every 24 hours».

(3) A third type is the *«Repeter-ur» – repeater, clocks with repeat function* striking at regular intervals. The strike of the clock can be triggered, and the strike for the last hour, hour and quarter hour, and minutes (minute repeater) repeated. These were complex mechanisms, used in watches from the late 18th century, but also used in floor clocks. One way to activate the repeat mechanism was, for example, by pulling a string to let the user know what the last full hour had been. It allowed, as Erik Ødegaard puts it, the man of the house to pull a rope running from the clock to his bed, and in that way get to know how many hours the clock had struck last time.[5] Examples from Langland's list are many – he sells, for example, «Repeater clock with cuckoo», or in most cases just «repeaters».

5 Correspondence with clock maker Erik Ødegaard, May 2020.

(4) There are «*Slagur*» – *clocks with strikes*, striking at regular intervals, often at the hour. Such clocks were usually made as longcase clocks in the South Trøndelag district, but not exclusively so. Energy was imparted by weights, often a pendulum. Springs were commonly used in the table clocks with short pendulums, and in wall clocks with short or longs pendulums. They required winding up, some every twenty-four hours, most every eight days. Langland lists many of these clocks, for example «8-days clock that is driven by springs» and a «Cabinet clock» with a dog on it.

(5) A fifth type is «*Lomme ur*» – *pocket watches*, small timepieces of a size that allowed them to be carried. The power source in portable time pieces was often a torsion steel spring, which would drive a balance wheel or verge escapement mechanism, and which had to be wound up at intervals. There is some uncertainty whether or not Langland made and sold pocket watches, but he undoubtedly repaired several.

(6) «*Datum ur*». These are longcase clocks with a plate or panel for thirty-one days, which showed the date, and requiring a hand solely for this purpose.

(7) «*Avancer ur*» are *avance clocks* often referring to pocket watches which had a mechanism to change the speed, to make the clock run faster (avance), or to slow it down (retard). In Langland's case these clocks may have been smaller clocks, which could be regulated to run faster or slower.

(8) «*Maane ur*» – or *moon clocks*, were most probably floor clocks that showed the 29.5 days phases of the moon on the half-moon shaped upper part of the clock face.

It is not easy to determine the type of time piece that Langland's terms refer to, and thus the kinds of time pieces he made and sold. And understanding his output is complicated by the fact that, in Norwegian there is no clear distinction between clocks and watches – a clock («klokke» or «ur») can refer to both. Langland uses the word pocket watch («lommeur») but not consistently – at times «ur» refers to pocket watches. For the most part the material at hand does not offer any clear insight into the detailed

mechanisms of his time pieces – apart from occasional instances where details such as «springs», «round glass face» and «lacquered plate» appear that throw some light on the matter. We return to this issue below.

Using the diary and available literature we can estimate how many time pieces Langland made during his life: the total would be in the region of 380. Langland listed and numbered his time pieces in the diary, but the series is broken where pages are missing. The first clock noted is no. 16, the last is no. 320. But drawing on occasional mentions of clocks elsewhere in the diary, and historical literature, 380 seems to be a good approximation. This suggests production of about five clocks per year over his working life, around nine during the last ten years when he probably worked together with his son-in-law Ingebrigt Jonsen Grønli.[6]

Clocks were and are complex mechanisms, built up of a large number of parts of varying sizes and materials. In Langland's case, and according to the diary, the tools for clock making as well as the clock's constituent parts, were largely made by him – while some were procured. In other words, the construction of clocks was a combination of making and buying parts and assembling them. Langland probably made the cases for the clocks himself, since he noted only in some instances that the case was not included. And likewise with weights – they were at times excluded from the sale. Most of the weights he made were of cast iron but some he made of copper, which Langland had easy access to from the Røros Copper Works' smelting works Dragås, nearby, and from drivers of copper ore passing the Langland farm on their way to and from Dragås (Ingstad, 1980, pp. 388–89). Langland also bought weights from Dragås – twelve in March 1770 for instance – from where he also bought iron and steel (Part II, pp. 8–10). The wheels of the clocks were sometimes bought, as in March 1767 when Langland received «some brass wheels» from «Ole Tomte in Sweden», adding a despondent «not of the best brass» (Del II, p. 2). That Langland also made tools for metal working, as well as for farming, textiles, wood and clock work, is mentioned in a reference letter to the Royal Norwegian Society of Science in Trondheim in support of Langland's application for a prize (Aas, 2019,

6 Two clocks not in the diary are: clock no 3, exhibited in the Ålen Museum, probably made in 1760, and no 7, from 1760, mentioned by Ingstad (1980) p. 389. Langland's working life is reckoned to have started in his mid- twenties and lasted until he was about 80 years old.

p. 48). Langland made toothed wheels for clocks, and the tools with which to make them: in March 1760 he sells «an instrument [made] by me to cut up the wheels for the clock with strikes» to a Swedish musician, for which he was paid upwards of twelve rigsdaler. (The large majority of Langland's clocks with strikes cost from fifteen to twenty rigsdaler, while a cow cost about five.) Of other inputs Langland purchased, glass, clock hands, files, and chains were brought from Christiania (now Oslo); iron and iron rods, brass, steel, springs, files and chains from Røros, and inputs were also bought further north. He refers for example to «brass and tin that I bought in Trondheim», in the autumn of 1765 or 1766, and to getting brass from Levanger in March 1769. The range of inputs was wide, including also gold coating, grinding stones, hemp rope, oil, and many more items (Diary I, p. 112; Diary II, pp. 1–11).

## Repairs and alterations

Langland also had a repair business. The diary has a list *On reparation of clocks*, for two periods, 1762–1771 and 1778–1799, missing pages accounting for the break. There are seventy-eight repairs and renovations noted for these twelve years – varying from one to twenty-three per year. Among the customers in 1770 were the Director at Røros, Peder Hiort, who had his pocket watch repaired, the Provision Accountant Fyhn whose time piece had «new hands» put on, while he repaired «the spring» for Mines Accountant Støp and carried out repairs for the «Head of Mines» in 1779. There is a certain cluster of pocket watches early on, they accounted for twenty-one of the forty-seven repairs in the first period, falling sharply to two during the second.

Langland also made alterations, such as adding alarm functions, for instance to John Koch's clock (clock without strike) in 1765, and to one that Johannes Skomager had bought from him a couple of years earlier, and he added a «spindle» in Smelting accountant Bredahl's clock in 1770.

Some technical details emerge: the use of springs (in 1765 he repaired a clock with strike «which is run by springs» for Peter Abildgaard) and increasing number of hands on the clocks. He sold a clock with three hands (no. 46) in the mid-1770s, and two clocks with strikes (no. 257) with

«date-hour-minute and seconds hands» about twenty years later. His own clock from 1767 (no. 62) played psalms, although it is doubtful that he made its most complicated key parts himself. We also find a number of different types of wheels, replacements of parts and so on.

One of the clocks Langland repaired was a «3 stroke clock with a cuckoo» for Mines Accountant Busch in 1770. The origin of the cuckoo clock is unclear but often associated with its development from the 1760s in the Black Forest district in southern Germany; although it is thought that its origin goes much further back. Five years earlier, in 1765, Langland sold a clock (no. 22) with moving parts, a small cabinet clock «on which a dog lay and winked the eyes», to Henrich Bull, and some years later, two cuckoo clocks, no. 83 and no. 86 (in 1773 and 1774 respectively).

Swedish time pieces had an impact. The clock adorning the church in Røros was made at the Swedish Stjärnsund Manufactory in 1784, and cheap Swedish-made time pieces were sold to the district in large numbers (Ingstad, 1980, p. 15). Presumably most, if not all, the pocket watches Langland repaired had been made by Swedish artisans. The Mora clock making district was not far from the border, and some of his customers were Swedes: for instance he repaired a pocket watch for a Svend Simen Hammerin, hat maker «in Stockholm», in 1764, and for a Nils Tørensteen «in Sweden» in 1770. Langland sought out time pieces made in Sweden; the repeater (not numbered) he sold to Skancke in 1791 was «Exchanged with a Swedish clock and 10 rd between».

It is likely that Langland did not make all the time pieces he repaired, as in the case of pocket watches. Yet a number of renovations and repairs concerned clocks he made; at least eight family names in the list of repairs appear also in Langland's list of sales.

## Varied production

In addition to time pieces Langland had general small scale manufacturing outputs, comprising a wide range of products. Among them two products stand out: first, spinning and winding equipment – according to Ingstad, 1980, he made 400 spinning wheels between 1754 and 1777 – and second, signets (of steel or brass) of which he also made in large numbers – seventy-seven between 1770 and 1783 (Ingstad, 1980, p. 389; Aas, 2019,

p. 47). Yet a cursory glance at his accounts reveals at least another thirty products. Many related to the use of tobacco: pipe mouthpieces made of elk antlers and small tobacco boxes, but there are also other products including needles, buckles, axes, locks for rifles, locks and keys, saws, table legs, vises, knife shafts, spectacles, spindles, guns and pistols, a chest with iron fittings and lock, padlocks, sheep scissors, ink holders, candlestick holders, a fiddle, a number of other tools and household items of different kinds, and sundials.

## The organization of sales and repairs

Sales and repairs involved travel, since immediate local demand was limited. Over time, Langland's sales area expanded and came to include customers from across the South-Trøndelag region – and from the Mjøsa district in the south to Nordland in the north, a distance of 700 km, and from the Romsdal region in the west to the Swedish border, a distance of approximately 170 km. While it was mostly Langland who had to travel to his customers, for instance to install his clocks, there were alternatives. During Easter 1767 he travelled 25 km to Nordaunet, to «Hægsett to set up his clock with strike that he had from me», and went on a much shorter journey, to «Sælboe for reparation on a clock at the Mines accountant's and at Major Brønlund's» (Diary II, p. 26; Ingstad, 1980, p. 390), but what emerges from the diary is a fairly wide and intricate network of people who carried orders and payment (for clocks and many other wares such as food, materials, and so on) between the maker and the consumer. This included family members but also others: for instance, the clocks Langland had sold to Hiort in 1770–71 and subsequently repaired were «sent with Haagen Nyhus» back to Hiort. Many of Langland's customers sent Langland new orders on behalf of others. The relationships sometimes seem rather complex. The Head Accountant Bredahl, at the Dragås Smelting Works appears frequently and he carried money, held payments owed to Langland, and generally helped with transactions. For instance in 1770, when Langland repaired a clock for the Mines Accountant Busch in April payment arrived two months later, «from Bredahl». Langland used agents who sold for him. One would be Ellev Clementzen (in 1768), Bredahl another. Similar arrangements may have been organized with customers elsewhere,

possibly with the clock maker Billing in Trondheim who bought three of the same type of clocks from Langland in the early 1790s, possibly acquired in order to be sold. Payments to Langland were made in different ways, by cash, instalments and exchanges in kind. In 1795 Langland sold Director Aas a repeater (no. 227), which was «to be paid for with an alarm clock» adding a rueful «not done». Langland accepted or sought metals as payment – one of many instances is from 1768 when Johannes Skomager paid for his time piece «in iron and brass».

On the left, a clock by Langland from 1774. On the right Langland's clock No. 3, exhibited at the Ålen Museum. Photographs by Hans Westberg Aas.

How can we assess the quality of Langland's production? As for time pieces, his early work appears for the most part to have been relatively simple. The earliest clock we know of is no. 3 from 1760, exhibited at the Ålen Museum. From observation it appears well made, but fairly simple, as was the first clock listed in the diary, an alarm clock (no. 16), in 1765 (Aas, 2019, p. 37). Yet in the same year he also made the clock with a dog with moving eyes. In 1769, at around thirty-six years old and possibly ten years into his career, he finished what is regarded as his masterpiece, clock no. 62. This is a floor clock which played Norwegian religious tunes.[7] Langland made improvements and alterations to his clocks and introduced new types and

7 Vår Gud han er så fast en borg, and Den store hvite engleflokk (Ingstad, 1980, p. 393).

attributes. He made an 8 days clock with strike «which repeats» with three hands (no. 46) in 1766–67, and less ambiguously a repeater («with cuckoo», no. 83) in 1773. Repeaters were much more complex than alarm clocks, and these became a major product in the later period, from about 1788. Datum clocks appear in the diary from 1790 (no. 186); «[t]he first with date hand [datum viser] on the outside of the plate» he notes, which suggests that earlier versions had been made. Avance time pieces equally introduced new features; these were smaller time pieces or pocket watches, where the speed could be advanced or slowed. They appear in the diary in 1792 (no. 197), and reappear in 1799 when he sold three (nos. 262–64). The sales of moon-clocks are listed in the diary from 1801 when a clock maker Elgström in Trondheim purchased one, for twenty-six rigsdaler. According to the reference enclosed with Langland's application for the prize announced by the Royal society in 1802, the moon clocks showed the phases of the moon, thus adding a new dimension to Langland's production (Aas, 2019, p. 102). Langland undoubtedly innovated: iron substituted for wood; copper and brass were introduced; the clock faces changed shape and became covered with glass; decorations perhaps more elaborate (including use of gold); new features were added; the mechanisms became more complex, and his product range expanded. He may not have been at the frontier of clock making, but the frontier seemed close by: in 1788 Langland met «general von Krogen», who was party to the Danish Crown Prince Frederik and Prince Carl of Hessen's visit to Røros. Krogen «showed me his watch ['ur'] which cost 200 rd, and wound up by itself» – for Langland, undoubtedly an impressive novelty (Diary II, p. 48).

The first production set therefore comprised a wide range of products made of metal and wood, the second, repairs and production of increasingly complex time pieces. The range of skills were complementary, and covered numerous fields – metallurgy, precision mechanics, different treatments of wood and metal, tempering of wood and metals, and so on. Langland seems to have been highly praised locally, and his products from both product groups were in high demand and sought after by wealthy, high ranking and influential people, as well as farmers, artisans and others. Possession of these skills implies a process of learning, and the attainment of new knowledge. How did that happen? What were the sources of knowledge?

## Links to family and the district

Hans Børre Langland achieved some fame and recognition by his contemporaries. A visitor to Norway in the years 1773, 1774 and 1775, Gerhard Schøning, wrote:

> Among the people at large here (allmuen) there are some artists who deserve the name of master in their craft, even though they have not been taught therein, but in particular one deserves in that respect, a Bør Hansen to be mentioned, living on the farm Langland, who is a clock maker, signet maker, turner, smith, where of he altogether has been his own teacher.[8]

That Langland altogether was solely self-taught, or autodidact, seems somewhat misleading. True, there is no evidence that he received formal schooling or was apprenticed. And it is reasonable to assume that he, as a farmer, most often made the many tools and implements that were used in farming the land, as was common in the Scandinavian countries. Furthermore, it appears that many people could make their own clocks, of the simpler kind that were in use, «in their sitting rooms». Lastly, learning-by-doing and experience are important elements in increasing capability. Even so, and given his expressed quest for furthering his knowledge (see below), Langland's case deserves further scrutiny.

The tradition of sons following in their fathers' footsteps was widely practiced, and common also in the clock and watch making regions. Ingstad mentions the families Eggan, Morseth, Dahlen, Røe and Langland (Ingstad, 1980, pp. 386–390). Langland taught his nephew to make clocks and his son-in-law who continued the production series after Langland's death.[9]

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8 Cited in Aas, 2019, p. 37: «Blant allmuen findes der en del kunstnere som fortjener navn av mestere i deres haandtering, skjønt de deri ei ere blevne opplærte, men i sær fortjener i den hensigt en Bør Hansen at nævnes, boende paa gaarden Langland, der er uhrmager, signetstikker, dreier, smed, hvori altsammen han har været sin egen læremester». From Schøning, G. (1778). «Reise giennem en Deel af Norge, i de Aar 1773, 1774, 1775... beskreven af Gerhard Schøning» (Ingstad, 1980).

9 See Ingstad (1980, pp. 386–392). According to Ingstad, his son-in-law, «Later… continued this activity and made several good clocks. Yet he never came close to Børre Langland's number of clocks. When his time pieces nevertheless have higher numbers – one of his last was number 452 – it is because he continued his father-in-law's series» (Ingstad, 1980, p. 393).

Yet there were important connections and sources of knowledge in the regional environment that went beyond the family. Despite limited specialization, clock making districts did develop in Norway, one encompassing Ålen where Langland lived. Indeed, the region was the first to develop significant production of clocks, from around 1800 until the 1870s. Of equal importance was the neighbouring valley Gauldal. It is held that the larger area, from Røros to where the river Gaula runs into the Trondheim fjord, produced more clock makers than any other district in the South Trøndelag region (Ingstad, 1980, p. 386). The question is if this district fostered, through proximity and interaction, both production and technological change.

From the Ålen hamlet came one of Langland's contemporaries, the builder Svend Aasen, who also made some clocks, and other well-known clock makers from the region were Jørgen Larsen Raaen who combined working as a smith for the Røros Copper Works with clock-making, and Amund Jacobsen Røe, Jørgen Larsen Raaen and Lars P. Tørres who, like Langland, combined it with farming.[10] Yet this was a far cry from the transition to specialized clock and watch making centres, with masters, apprentices and division of labour, found elsewhere in Europe during the course of the 17th and 18th centuries in cities such as London, Paris, and Geneva, and in districts such as the Jura (see Cipolla, 1967, p. 53). In Stockholm, clock makers were numerous and wealthy enough to form guilds in 1695 and in Copenhagen in 1755. But for Langland, as for Norwegian clock makers more generally at the time, watch and clock making mainly remained a part-time job primarily carried out in the countryside.

Nevertheless the relations between these makers in a distant European district involved transfers of knowledge. Of the clock makers mentioned above, Jørgen Larsen Raaen had learnt clock making from a Swedish tramping clock maker and from Langland; Lars P. Tørres appears to have been a pupil of Raaen and taught clock making to his son Svend Larsen, who in turn taught his grandson (Ingstad, 1980, p. 387).

10 See Ingstad (1980, p. 385–392). Ingstad writes that Raaen was a smith at «the works» (verket), here taken to mean the Røros Copper Works.

Flows and exchanges of knowledge continued, and may well have taken place also through sales of clocks to other clock makers, as in the early 1790s when Langland, by then an established horologist, sold three «moon clocks» to the clock maker Billing in Trondheim. In the last 1795 transaction (no. 219), he included in the sale: «oil, powder, key, steel wire» and the bill came to just above eleven rigsdaler, but, he noted that Billing «has paid 9 rd in glass». He also sold a moon clock (no. 281) to the clock maker Erik Elgstrøm in Trondheim in 1801.

The Ålen-Gauldalen clock making district was not far from the significant clock making district of Mora-Dalarna in Sweden. Products and people moved across the Norwegian-Swedish border. As already mentioned, many cheap pocket watches (presumably from the Mora district), were bought by people in the Røros region, and are probably among the several pocket watches Langland repaired. This may have entailed a process of «learning-by-repairing» and, taking a Swedish time piece as part payment (referred to above), possibly reverse engineering.

People close to Langland visited Sweden. Svend Aspaas was sent to Sweden to study bridge construction and machine making as well as «the uses of slag» – a residue of copper production, which suggests Falun Copper Works as his destination (Dahle, 1894). People moved between the clock making districts, and finally, Langland himself travelled in Sweden. On the 12th of November 1767 Langland set out for Sweden with the aim «to be better schooled in the art of clock making». In his diary is a description of the route he followed, mostly on foot, the people he met and walked together with, and more. His journey took him first to Røros. From there to Älvdalen across the border, a distance of about 270 km, then a further 170 kilometers to Falun. He returned to Norway and Ålen seven months later, on 9th May 1768. We do not have detailed records of where Langland went, or what he did on his way. The tramping artisan was a well-known phenomenon in 18th century Europe – tramping was indeed obligatory for advancement in many trades – and has been recognized as an important vehicle for the diffusion of technologies across large parts of Europe (Mathias, 1979, ch. 2). Against this background, and given Langland's stated aim for his travels, it seems likely that Langland visited the Falun Copper Works, and, as he moved across Scandinavia's most sophisticated

clock making district, also the most important clock maker of them all, the Stjärnsunds Manufactory in Hedemora.

Although we cannot trace any specific process of apprenticeship or other formal training for Langland, he lived in a region that was distinctly active in clock making and a wide variety of metal based trades and must therefore have been exposed to the relevant skills and knowledges that were involved. Farming was itself a skill based activity, and involved the manufacture of tools and implements. Langland was therefore exposed to the skills of the new industrial enlightenment by virtue of his location; the regional location and links to the Røros Copper Works meant that he was by no means isolated in terms of knowledge.

## Links to Røros Copper Works, and Stjärnsunds Manufactory

Langland had close links to the Røros Copper Works and, via the Stjärnsunds environment, to Falun. From early on in his clock making career, one important segment of customers were the directorship and management at the Røros Copper Works, particularly dominant during the early years 1765–1772. To this was added another influential, local elite group – titled people in high positions. Later on the range of customers was wider and included people of lower status. Some of Langland's high ranking customers, and the products they bought, included the following:

No. 28, a clock with strike for Provisions Accountant Vilhelm Fyhn, 15 rigsdaler, in 1765.
No. 33, 8-days alarm for Head of Mines Henning Flor, 7 rigsdaler, in 1765.
No. 34, an alarm for Mines Accountant Bernt Hartz, 7 rigsdaler, in 1766.
No. 38, an alarm for Leutenant Geertzen, 7 rigsdaler, in 1766.
No. 46, 8-days clock with strike for Magistrate Peder Christian Tyrhol, 19 rigsdaler, in 1766 or 1767.
No. 50, a clock with strike for «a priest in Nordland», in 1768.
No. 85, a clock with strike «with case» for Mines Accountant Hartz, 18 rigsdaler, in 1774

No. 204, «a repeater with four hands» for Mines Accountant Støp, 20 rigsdaler, in 1792.
No. 208, «a repeater» with three hands for «Inspector Arneberg», probably Ulrich Frederich Arneberg, Inspector for the northern district (Dahle, p. 232), 17 rigsdaler, in 1793.
No. 220, repeater for Provisions Accountant Hejde, 18 rigsdaler, in 1795.
No. 221, a repeater for «Mr. Director Knoph», 18 rigsdaler, in 1795.

Selling to employees of the Røros Copper Works connected Langland to skilled and highly educated people – knowledgeable in techniques such as mechanics, metallurgy, accountancy, and copper production. While the owners of the firm lived in Trondheim, the directors, managers and administrators were largely residents of Røros. This was an important group, composed of relatively wealthy customers with large social and economic networks. They sent their time pieces to Langland for repairs, bought his clocks and a range of household articles, in particular linked to textiles.

Peder Hiort (1715–1789) who first was Provisions Accountant, then Mines Accountant, and finally, in 1772, Director at the Røros Copper Works was an important node in Langland's network. Langland came to his house, repaired the household's time pieces, sold him clocks and also household equipment (such as textile winding and spinning implements) and some tools, as when Langland sold a vise to «Mechel the servant of Hiort at Røraas» (Diary I, p. 15). He purchased or was partly given a smithy or equipment for a smithy by Hiort (Diary II, p. 11).

Langland lived close to Dragås, one of Røros Copper Works' smelting works, where copper ore was smelted, and raw copper (gahr-copper), produced. Dragås was a large and important establishment in the Ålen area, employing between thirty and forty people up until 1760. Børre Langland's father, Hans Bjørnsen had worked as a mason during its construction, and Langland's father-in-law as a smith there. Langland sold many of his products to people linked to Dragås, for instance to Henrich Olsen Dybdahl (Smelting Accountant from 1727 to his death in 1765) and his household: between 1754 and 1777 he sold thirteen spinning wheels and two alarm clocks, and repaired a clock without strike (Aas, 2019, p. 81).

Langland sold and repaired time pieces for Dybdahl's successor Bredahl and his household – pocket watches and a clock without strike and, in 1768, he «put a new spindle in a clock» for Bredahl. On 2 May 1767 Langland writes about repairs on a pocket watch belonging to Mons Bredahl, in a passage which incidentally illustrates how payments were made by combining payment in cash and in kind. It appears that Langland had bought shot from Bredahl, who then claimed that Langland owed him money for this. But according to Langland the quantity of shots he had purchased from Bredahl was less than Bredahl claimed. Moreover, Bredahl had written that Langland also owed him for shots he had bought the previous year: «that I owe him 12 s [shillings] for 1766». Langland injects his reparation of Bredahl's watch into the equation – the repair would cover the twelve shillings he owed: «I should have paid that with the reparation of his pocket watch …», somewhat magnanimously adding that «he must have forgotten» (Diary II, p. 3). The diary suggests that payment or part payment in kind happened regularly.

Dragås Smelting Works appears to have functioned as a clearing house for Langland's sales. His clocks were frequently forwarded from Dragås to customers in the area and beyond, and Bredahl organized the financial side of these transactions: the customer paid Bredahl for the purchase, and Bredahl forwarded the money to Langland, at times before having received the payment from the buyer. The frequency with which Bredahl makes payments to Langland on behalf of others suggests that Bredahl did something other than the wide spread practice of fetching and bringing for each other that existed in the local economy. These were largely informal arrangements, as was it seems, Bredahl's role as agent for Langland. Without doubt, the Dragås Smelting Works was an important node in Langland's network by facilitating transactions and connecting Langland to numerous people spread across wide areas.

The Røros Copper Works itself appears as a customer of Langland in the Diary; in 1765 Langland repaired «a clock for 6tie mine» (Christianus Sextus), and he sold an «8-days alarm» clock (no. 47) to «The King's Mine», in 1766 or 1767. Yet among the many links between Langland and the Røros Copper Works, the works stands out as a source of supply of raw material and production inputs. It was of major importance, as the location

of clock-making enterprises in copper districts in Scandinavia suggests. Between 1767 and 1792 Langland purchased from Dragås shots, confolium (probably a spirit), paper, pens, quick silver, tin, iron plates, iron rods, steel, copper, brass and more (Aas, 2019, p. 82). He bought tin from the Director of the Røros Copper Works in 1768, and two years earlier brass and steel from «Røros» – presumably from the Røros Copper Works itself. In 1768 he bought a brass oven hood from Dragås and in 1771 he purchased steel and copper (Diary II, pp. 7, 10, 11).

Securing raw material for making clocks, but also signets (made of brass or steel), recurs frequently in the diary, and it took many forms. In 1769, a shoe maker paid Langland partly in brass, for a time piece (no. 48) he had sold him. He also bought brass and tin from further afield: from a trader in brass from Levanger residing in Trondheim, for instance. Some of this may have been difficult to procure. In 1771 he writes that he lent brass and copper to Ingebret – probably his son-in-law – and they purchased a copper pan from a tailor (Diary II, pp. 8, 10, 11).

The Røros Copper Works also sold Langland finished goods, such as cast iron weights for clocks: for instance the «12 clock weights» he brought from Dragås in 1770. Production tools and equipment also appear. Purchases from the copper works of semi-finished and finished goods raises questions about the extent to which the Røros Copper Works engaged in such production, since it is commonly held to have solely produced gahr-copper, a half worked up raw material.

## Transport for the copper works

The mines and smelting works of the Røros Copper Works depended for their operation on large quantities of raw material and intermediate inputs such as charcoal, copper ore and wood. Farmers in the district were engaged in such transport, as was Langland and his household. There are several entries concerning transport of timber and wood from 1768 to 1807 where Langland refers to felling trees in the «works-forest», and he entered the quantities they drove to the Røros Copper Works. In January 1775, for example, they drove ninety-three loads to Røros and twenty-one to Tolga, another of its melting works (Diary II, p. 37).

Transport also included driving copper ore from the King's mine, the Mug Schurffet and the Christianus Sextus mine, to the smelting works. The diary lists the quantities concerned, as when noted for 1769 «This year approached 4000 barrels ore to Dragås by Christmas» (Diary II, p. 29). The average number of barrels was 3600 a year between 1779 and 1787 and just under seventy-seven barrels for each of the years 1779, 1781, 1783 and 1789. It seems that most, if not all of it, went to Dragås. It has been estimated that the quantity Langland transported accounted for 1/47th of the total quantity used per year at Dragås.[11] Langland appears not to have transported wood and ore himself, but relegated the work to members of his household, relatives but also servants, and people Langland engaged to do this. We can read that on «2nd February 1770 in the evening our men went to the mine», meaning men employed by Langland, and that his «servant was in Halden and drove wood to the mine» in the spring of 1775 (Diary II, p. 100).

Transporting, or driving, was dangerous work – hampered by extreme weather conditions where snow, wind and floods blocked the transport routes, and caused death by drowning or freezing, such as in the winter of 1778 when two drivers froze to death as they were driving for the King's Mine (Diary II, pp. 9, 29, 30, 41).

But Langland's income from it was high: he earned 100 rigsdaler in 1762 and in 1763 (Ingstad, 1980, p. 385). 100 rigsdaler equals about 36,360 GBP, 402,700 NOK in 2019 money. (For that sum you could buy twenty to twenty-five cows according to Aud Mikkelsen Tretvik).[12] Two years later, in 1765, he earned seventy-three rigsdaler (Diary II, p. 22). This equals about 25,400 GBP, 281,188 NOK in 2019 money. The diary is incomplete, and given that Langland was obliged to transport for the Røros Copper Works, there is good reason to believe this work was carried on for many more years. Transport for the Røros Copper Works was an important and lucrative business for Langland, perhaps the most lucrative branch of his many activities, in a century marked by many conflicts between the Røros Copper Works and farmers who meant they were underpaid for transport work (see chapter 4 by Henrik Thommesen).

11 Diary Part II, p. 29; and see Aas, 2019, p. 33 for more detail.

12 See Aas, 2019, p. 32 with reference to Tretvik.

## Stjärnsunds manufactory

On his travels in Sweden in 1767 it seems certain that Langland visited the Stjärnsunds Manufactury in Hedemora (Dalarna), which was an important clock and watch making district in Sweden. Stjärnsunds had been established by Christopher Polhem (1661–1751) in 1760. Polhem, who later was Mining Mechanic at Falun Copper Works, was an important figure in the Swedish industrial enlightenment having visited many countries in Europe, backed by a travel stipend from the Swedish state.[13] Stjärnsunds began the large scale production of clocks in Sweden, but a wide range of metal goods were also produced, such as padlocks, tools of various kinds, household items and equipment for agriculture. Around 1750 Stjärnsunds produced thirty to forty clocks a year (Gjerkaas, 1990, pp. 70–72). While Polhem was abroad people who had worked for him raided the factory and stole equipment and completed clocks – perhaps diffusing horology to the wider district (Aas, 2019, p. 41).

Stjärnsunds acted as an important source of knowledge for artisans, and was frequently visited. Clock makers from the Mora district, it is claimed, «had as a habit to visit the factory to learn making floor clocks» (Kjønstad, p. 46). Langland had a more general ambition, «to be taught in the art of clock making». We have no detailed records of his travel, but he made a clock (no. 62) with his name on it and with the sign ∞ – the sign of infinity. This is as far as we know the only clock he made that bears this sign. But the sign can be found on some of the Stjärnsunds' time pieces. It has been asked if he in fact bought this clock from Stjärnsunds Manufactory while he was in Sweden (Aas, 2019, pp. 42), in which case the purpose may have been to make similar clocks himself. Reverse engineering, as it were. Another possibility may be that he himself made it, at Stjärnsunds. He was away from Norway for seven months. However, we can note that compared with clock no. 3, made before he went to Sweden, there are notable differences with his later clocks: the clock faces are no longer exclusively of wood (as in no. 3), but often of metal and they had detailed patterns, quite similar to the Stjärnsunds clocks. In other words, Stjärnsunds clocks may have been a

13 Herman Richter, *Geografiens Historia I Sverige Intill År 1800, vol. 17:1, Naturvetenskapernas Historia I Sverige Intill År 1800*, Uppsala: Almqvist & Wiksell, 1959, p. 133.

source of learning for Langland, through imitation. Imitation was frequent among European clock makers, and clock makers using another maker's symbol was not uncommon. Landes refers for example to how even steel spring makers – highly skilled craftsmen and not clock makers – sometimes signed as the maker of clocks they supplied springs to (Landes, 1983, p. 205). This was also the case with some of the time pieces Langland sold, for instance to Francis (or Frantz) Billing. Billing was an immigrant clock maker from Dublin who ran a clock making workshop in Trondheim. Ingstad writes that Billing made good quality time pieces, but that some of the clocks bearing his name in fact were made by Langland. In the diary four sales to Billing in the 1790s are noted; one repeater (no. 179) and four «moon clocks» (nos. 188, 194, 203, 219) (Aas, 2019, p. 102–103). As we have seen Langland took a Swedish made clock as part payment for a clock he sold, and in 1791 he wrote that a «Leutenant Lemmich got a Swedish clock with strike from me for testing» (no. 192). Of foreign sources that influenced his work British designs were strong, affecting above all the shape and decorations of the clocks, while German influences impacted clock making above all in the southern parts of Norway (Ingstad, 1980). An important point about Polhem is that he was not only a source of major clock making expertise, but was closely connected with the Falun Copper Works.

## Culture and institutions

The diffusion of knowledge from abroad is a frequent theme around Langland and the Røros Copper Works. Much of this came via a specific person at Røros. A recurring figure in the diary is the Director of Røros Copper Works Peder Hiort, who was a frequent customer of Langland's, and a man who Langland at times visited in his home. Hiort was educated at the Latin Cathedral School in Trondheim, then, from the age of 17, studied theology at Copenhagen University, graduating in 1737 (Norway did not have a University at that time). He was, however, deeply interested in scientific subjects, which he studied in the university library where he was also employed for some years. Kvikne holds that the library functioned as a meeting place for scientists and that Hiort became deeply influenced by Enlightenment ideas while there (Kvikne, 1945, pp. 12–33). Following his departure from Denmark in 1740, Hiort returned to Røros where he

built up a sizeable private library, containing literature on mining, history, geography and topography, medicine, theology and biographies (Kvikne, 1945, p. 142). He regularly had books from Denmark sent to him by a permanent supplier.

There was overlap between Hiort's and Langland's interests. The diary contains long descriptions and reflections on scientific matters. One section, headed *Astronomic Annotation*, deals with the planetarium Sphaera Movens, or the Leiden sphere, the first mechanical model showing the Copernican solar system, built in Rotterdam in 1670 and exhibited in the Academy library in Leiden in 1710.[14] Langland mentions Adrian Vroesen, who took the initiative to construct it, Steven Tracy, who carried it out, referring to the latter as «the artist Thrasius», and the mathematician Nicolaes Stampioen's contributions (who, incidentally, was also engaged in the measurement of longitude at sea – eventually accomplished by John Harrison by 1770).[15] Langland refers to «the last *Fontenelles* publication of 1738», and appears to have, or have seen, a copper plate engraving of the sphere from one of its pages. He gives many details about the sphere; the clock within which «runs for 9 days or even longer if one wants. It gives the months, days, hours and minutes. …and all the main planets and sub-planets around after the Copernican world order…» and more. His detailed description runs for several pages, ending with how the moon rotates, «but it always shows us the same side, and why is not so easy to say the cause» (Diary II, p. 12). This is followed by two pages on religion (the events of Easter), abruptly ended because pages are missing.

## The wider effects of the Røros Copper Works on Norwegian industrial change

The impacts of the Røros Copper Works on Denmark and Norway were significant. The sales of the Røros copper brought in enormous profits – after the King had had his tenth, the rest of the copper went to the firm's owners in Trondheim, who shipped it mostly to Amsterdam and Hamburg

14 See note 17 for Hojimaijers and Huib Zuidervaart.

15 About the Leyden sphere, see references to Hoijmaijers and Zuidervaart in Aas, 2019, p. 53.

where it was sold (see chapter 6 by Ragnhild Hutchison). According to Dan Christensen the value of the exports amounted to 30,000 rigsdaler a year (Christensen, 1996, p. 336). Export duties generated enormous state income, while the owners' earnings contributed massively to Trondheim's wealth and to its bourgeoisie, who were a driving force behind the establishment of the Royal Norwegian Society of Sciences in Trondheim in 1760. Two of the directors of the firm became members of the society, Peder Hiort, from 1768 until his death in 1798, and Erich Otto Knoph from 1789 (Christensen, 1996, p. 336). In Scandinavia, as in numerous other European countries, private and public organisations actively supported innovation (Bruland, 1998). One initiative was to give out prizes, which this society also did, another to publish and distribute information about scientific and technological developments, which in this case undoubtedly reached Langland.[16] On the 10th of November 1802 Langland submitted to the Society an application for a prize for a new cowshed of stone that he had built on the farm. Enclosed with the application was a letter of support setting out Langland's many achievements, among which that he had made «more than 150 signets to high-ranking people and numerous farmers».[17]

## Conclusion

Although Røros was a remote region, both in Norwegian and European terms, the career of Børre Langland suggests that it was in close touch with some of the main trends in the European industrial enlightenment in the 1700s. The Røros Copper Works was, for that time, a major enterprise, and had been for a considerable period. Around it emerged people such as Langland, closely involved with one of the most important emerging technologies of modernity, namely clock making, but also with a wide range of other fabricated metal products. Langland should not be seen as an isolated craftsman, but as someone connected at least informally, with much wider trends. He was literate, interested in politics, foreign countries

16 See Aas, 2019, pp. 57–65.

17 See reference in Aas, 2019, p. 48 to the letter of application «Premiesøknad» 1802. It is kept at the Trondheim University Library, Gunnerusbiblioteket, 1802. The letter was signed by the clock ringer Børre Olsen Saxvold, Peder Larsen Kirkhus, and the vicar Peder Tønder Feldtmann. A transcribed version is kept at the Langland farm.

and world events. His links with Peder Hiort gave him a connection to the main intellectual currents of the time, while his travels to Stjärnsunds Manufactory connected him to the frontiers of the technology. The European industrial enlightenment seems to have spread, via figures such as Langland, into remote Norway, connecting even this peripheral region with the main dynamics of European change.

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Translation of titles of mining positions:
Proviantskriver = Provisions accountant.
Bergskriver = Mines accountant.
Hytteskriver = Smelting works accountant.
Overstiger = Head of mines.
Hyttemester = Head of smelting works.
Bergmester = Mining inspector.