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## Accounting and Performance Monitoring in Tuscany: Larderello, 1836-1858

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### Abstract

This paper examines the use of accounting for performance monitoring in a new industrial environment, the manufacture of boric acid in Tuscany during the middle decades of the nineteenth century. We provide a background context showing the growing significance of Tuscan boric acid as a source of borax for use in the industrialisation of Britain and France, and how the supply of this product came into the hands of François-Jacques Larderel. However, because of the method of financing employed, Larderel was forced into fixed-price supply agreements with his financial backers, which influenced the nature of the accounting system and its use as a means of performance monitoring. We also reflect on possible sources of inspiration for the system utilised from 1836.

**Keywords:** boric acid, Larderel, 1849 rules, piecework, paternalism, Payen

### Introduction

In the first half of the nineteenth century Tuscany was in the early stages of industrial development. Many of the inhabitants, especially those living outside the main cities and towns or ports, were uneducated (British Parliamentary Papers C.165, hereafter BPP C.165) and hence securing a workforce for industrial activities was not easy, especially in less populated areas such as the inhospitable hills of the Colline Metallifere. Utilising a mixture of archival sources<sup>1</sup>, official papers and secondary works, we examine the development of, and role played by accounting in the growth of the boric acid industry, more specifically in the business which ultimately became known as Larderello. Today, the town of Larderello which grew up around the business is best known for being the place where the first geothermal power station in the world was developed during the early twentieth century, but our focus here is on earlier developments, namely those during the lifetime of François-Jacques Larderel, who died in 1858.

This paper has two key aims. First, to add to studies of industrial accounting in a non-Anglo Saxon context and, second, to examine the utilisation of accounting for performance monitoring in an early industrial context. In relation to the first aim, the advancement of comparative international accounting history as a research area, especially in relation to early industrialisation, requires additional studies of the utilisation of accounting in countries outside of the traditional Anglo-Saxon axis. Such studies of developments within the Italian states prior to the unification of the country in 1861 are, however, few and far between. This study therefore enhances our understanding of developments in Tuscany by adding to that provided by Antonelli *et al* (2006). Like that study, our analysis of Larderello focuses on an industry that lies outside the traditional focus of research into industrial accounting during industrialisation, with its dominant focus on major industries such as coal, iron and steel and shipbuilding. The industrial activity conducted by Larderel up to 1858 was quite different to that carried out in such industries but, nevertheless, Tuscan boric acid, as we show below, played an important role in western industrialisation during the first half of the nineteenth

century. With the domestic market for boric acid and borax, even within the Italian states, being virtually non-existent, the entirety of Larderello's output was exported, forming an important aspect of the economic and trading activities of Leghorn and the wider region.

However, developing a business in an environment in which industrial activities are largely unknown is never a simple matter. Creating a workforce out of a populace used to agricultural pursuits in all countries has necessitated the development of appropriate surroundings (e.g. factories) and systems for overseeing effective performance by those employed (e.g. Bentham's panopticon). While recognising that the development of accounting can have, and has had, important social and economic impacts in specific contexts, through an examination of the way in which the Larderello accounting system was used to monitor personnel, not just individual workers but also 'factory' managers, this paper adds to our understanding of the way contextual circumstances influenced accounting. With the cultural, social, legal, political and economic circumstances existing in Tuscany in the first half of the nineteenth century being widely different from those existing contemporaneously in the Anglo-Saxon world, this raises the issue of the extent to which such factors influenced the development of accounting systems. While we are unable to examine all such factors in a single paper, by adding to previous work, it is hoped that this study of accounting developments at Larderello will provide a firmer basis for future work and insights into such issues.

The paper is structured as follows. In the first section we set the scene by examining the growing importance of boric acid during the industrialisation of France and Britain in the period between c.1820 and 1858. This is followed by a consideration of developments in its supply, in particular the methods by which the growth of the boric acid industry in Tuscany was financed and the role of merchants therein. Output and quality issues at Larderello are then considered, followed by an examination of the actions taken to establish a labour force and the rules by which the business was regulated from 1 January 1850. This discussion makes clear the significance of the role of the accounting system in monitoring output and performance, the system itself and its suitability for performing such tasks being examined in the following two sections. We conclude with some observations on the possible origins of the accounting system, the contribution of this paper and avenues for future research.

### **Industrialisation and the growth of demand for borax and boric acid**

In the late eighteenth century, with increasing industrialisation, countries in western Europe imported borax, a compound of boron, for use in various industries, including metal smelting (where it was used as a flux), the manufacture of pottery (used in glazes), in glass manufacture and in the textile industries (used as a bleach and for cleaning). Before the 1820s the main source of borax, or tincal as it was also known, was from the east, especially India and Tibet, although other sources included Peru, Ceylon and Lower Saxony (Malte-Brun 1822, 623). Before being used in industry, however, the raw or natural borax usually had to be further refined, something which during the early nineteenth century increasingly came to be done in the country of use.<sup>2</sup> Since refined natural borax was expensive, chemical manufacturers in many countries increasingly sought ways of producing synthetic borax. The breakthrough was made in France where pairings such as Anselme Payen and Cartier on the one hand, and (Guillaume-)Edouard Buran and Houtou-Labilliardière on the other, succeeded in producing synthetic (or artificial) borax through combining boric (also known as boracic) acid and soda (Allen 1906; Payen 1841b, 322-323; *Journal de Pharmacie et de Chimie* 1828, 176). However, it was not until the end of the 1820s and subsequent joint work by Payen and Buran that their experiments generated a fool-proof method of producing commercially viable synthetic

borax on a regular and large scale.<sup>3</sup> Such efforts were encouraged and protected in France by increasingly heavy rates of duty on imported borax<sup>4</sup> whilst imports of boric acid, which only began in 1817<sup>5</sup>, were subjected from 27 July 1822 to a nominal rate of duty of just 25 centimes per 100kgs.<sup>6</sup> The impact of the different rates was to lead to an increase in boric acid imports into France between the late 1820s and late 1850s (see Figure 1).

As in the French case, not only did British imports of boric acid grow consistently from the end of the 1820s, when businesses like Messrs. Howards began to take an interest in it as an alternative to imported tincal<sup>7</sup>, they continuously exceeded those of natural and refined borax (see Figure 2) despite the fact that, unlike in France, they did not enjoy favourable treatment prior to the complete abolition of all duties in March 1845.<sup>8</sup>

[Insert Figure 1 about here]

[Insert Figure 2 about here]

While the growth of industrialisation in both France and the UK, together with the levels of customs duties and changes thereto, go some way to explain the growth of the boric acid trade depicted in Figures 1 and 2, changes on the supply side were fundamental. The boric acid used in the French and British synthetic borax industry came almost entirely from a single source, Tuscany. Thus, in 1853, 99.88 per cent of the boric acid imported into the UK came from this source, whilst in most other years it exceeded 90 per cent. A similar picture holds for France, although in some years Tuscan imports fell away to almost nothing! We will now turn our attention to the supply side.

### **The development of boric acid production in Tuscany**

The Maremma region of south-western Tuscany extends from the Tyrrhenian Sea to the northern mountains of the Colline Metallifere where, in 1778, Hubert Franz Höfer, a chemist at the court of the Grand Duke of Tuscany, discovered the existence of boric acid within the *soffioni* (natural hot springs) at Monterotondo. Subsequently Paolo Mascagni discovered solid boric acid (sassolite) in the lagoons of Montecerboli and Castelnuovo (Wisniak 2005, 489-490). These discoveries assisted the development of the synthetic borax industry in Europe, although it was not until the 1820s/1830s that the boric acid industry in Tuscany really took off, its early development being plagued by technological problems and disputes over business relationships and land ownership.

### ***Ownership of the soffioni and lagoons***

The early history of the industry is shrouded in confusion, being punctuated by disagreements, law suits, renegotiated contracts and such like. At the heart of the problem was the complex system of laws governing land and mineral ownership in Tuscany. Mapping the land began during French control of Tuscany (c.1799-1814) and was subsequently completed by the Tuscan authorities, which also undertook 'the valuation of the lands, [and] the repartition of the land-tax' between 1819 and 1834 (BPP C.165, 9). While the land was owned by the Grand Duke of Tuscany it was often leased on a perpetual basis to individuals, for which they paid an (often, small) annual ground rent in return for

an obligation to cultivate the land and to build thereon (BPP C.165, 11). With the lagoons and potential production sites spread over a wide area<sup>9</sup>, covering some 200 square kilometres between the villages of Volterra and Massa Marittima (Società Boracifera 1937, 1), many individuals became interested in their potential development, resulting in legal disputes over their ownership. Even so, one man came eventually to control the bulk, though not all, of the lagoons, François-Jacques Larderel (from 1836, Francesco de Larderel, Count of Montecerboli).<sup>10</sup>

In 1812<sup>11</sup> Tastoni, Fossi, Franchini and Griemard leased lagoons at Montecerboli and Monterotondo, establishing a small chemical factory in the latter place to produce boric acid and refined borax which, in 1815, came under the control of Enrico Brouzet. In the same year Brouzet joined forces with the chemical manufacturer Dr. Giuseppe Guerrazzi to commence borax production on an industrial scale at Monterotondo. This attempt, however, ultimately proved unsuccessful despite technological developments introduced by the engineer Antonio Ciaschi.<sup>12</sup> In 1818 the Community of Pomarance agreed to lease the lagoons of Montecerboli to Brouzet for the small sum of 200 lira per annum. However, he failed to sign the agreement by the deadline of 30 April and the lease was taken up instead by Larderel for 205 lira per annum on behalf of two wealthy merchants of Livorno, the widow Chemin and her son-in-law Francesco Prat. Larderel had come to an arrangement with these merchants whereby they would own the lagoons and market the product while his own business, 'Fratelli Lamotte and Larderel', formed with his three cousins in 1814, would oversee production. As a result, a new company was formed on 1 June 1818, La Società widow Chemin, Prat, Lamotte and Co., although relations between the two businesses were not always completely amicable (see below under finance) so, on 5 October 1822 a new, 15-year partnership was created, La Società Widow Chemin, Prat, Lamotte & Larderel.

In 1834 as the end of this partnership drew near Larderel attempted to buy out his partners by entering into complex financial arrangements with various parties (see below under finance) thereby gaining full ownership of the lagoons. However, Larderel was unable to fully separate himself legally from his former partners, who continued to retain a share in the business. Desirous of severing his links with his former partners once and for all, in June 1838 Larderel agreed to sell the lagoons to the French aristocrat, the Viscount de Sercey, whose intention was to sell them on to a newly established 50-year limited partnership, the Société D'Hesecque et compagnie. Attempts to implement this agreement were negatively impacted by concerns over Larderel's title to the lands, the substantial mortgages outstanding thereon and problems relating to the financial agreements undertaken c.1834. Larderel and de Sercey finally agreed the sale of the lagoons on 7 September 1839, the former receiving a total of 2,372,000 francs and a third share in the Société D'Hesecque (Scardozi 1992, 39). Nevertheless, problems over ownership rights continued to dog the company throughout its short-lived existence, from its registration in Paris on 1 April 1839<sup>13</sup> through to its liquidation on 29 May 1847 (Scardozi 1992, 44).

In 1846, with the business proving less successful than anticipated, the lagoons were sold to Federico Arpin & Co., in which both Larderel and de Sercey held a share. In 1847, following Arpin's death, Larderel took over complete ownership of the lagoons, buying out de Sercey's shares at half their face value (Cronologica 1702-2004). A new company, Francesco de Larderel & Co. was established on 29 May 1847, albeit with a high level of indebtedness. Once again, unable to fund the purchase of the lagoons from his own resources, Larderel entered into a commercial and financial relationship with the Anglo-Livornese merchants, Thomas Lloyd & Co.

## **Finance**

To both gain a foothold in the boric acid industry and eventually full ownership of the lagoons and business he had been largely responsible for developing, Larderel was forced to engage in financial arrangements with others, generally involving reciprocal supply arrangements whereby he would supply the output to his financial backers at a pre-determined price. In 1818 finance had been provided by the widow Chemin and Prat, and under a contract dated 30 December 1820, Lamotte and Larderel agreed to sell all of the boric acid production of the lagoons, at least 12,000 lbs per month, to the Società widow Chemin, Prat, Lamotte & Co. (Scardozi 1992, 32). The division of responsibilities, with Prat in charge of the sales operations and managing the warehouse and commercial operations in Livorno, while Larderel and Lamotte oversaw production (Mori 1967, 390), became a source of dispute, with Lamotte and Larderel accusing Prat and the widow Chemin of retaining the commercial profits for themselves, while Prat accused Larderel and Lamotte of delivering acid to customers without it passing through the Società's Livorno warehouse (Scardozi 1992, 32ff). In consequence, a new arrangement signed on 5 October 1822 led to Larderel joining the partnership and Prat giving up sole responsibility for the management of the business, though retaining control of the bookkeeping, correspondence and cash.

In the late 1820s financial problems unrelated to the boric acid enterprise led the widow Chemin and Prat to suspend payments and seek, unsuccessfully, to sell their shares in the business for 60,000 lira. In consequence, Lamotte took over the administrative functions of the business as from 23 March 1828 with Larderel deputising in his absence. In 1834 two agreements<sup>14</sup> were entered into by which Larderel sought to buy out his three partners, as from 8 January 1835. The boric acid business was valued at 3m. Tuscan lira with each of the other partners to receive 900,000 lira. However, 800,000 lira of the 2.7m lira purchase sum was to be held back, meaning that the widow Chemin, Prat and Lamotte retained an interest in the new business arrangement, being entitled to a share of the production (pro rata to their investment) at a maximum price of 14 lira per 100lbs. To enable Larderel to carry through this arrangement he borrowed money from a number of sources, not least, a Mr. Barberet, variously described as a merchant or banker of Lyon, and the British merchanting and banking business, Hepburn, Pillans & Co., each loan lasting 10 years (Scardozi 1992, 38; *The Chemist & Druggist* 1897, 975).<sup>15</sup> In return for receiving a loan of c.900,000 lira from Barberet, Larderel agreed to supply him with 370,000 lbs. of acid annually for 10 years at the very low price of 11 lira per 100 lbs. (Scardozi 1992, 38).<sup>16</sup> In return for the loan from Hepburn, Pillans & Co. of 480,000 lira at 5 per cent interest (Fratarelli Fischer 1992, 56), Larderel agreed to supply them with 21m. lbs. of acid (Scardozi 1992, 38) at a price 'somewhat above £41 (per ton)' (*The Chemist & Druggist* 19 June 1897, 975).<sup>17</sup> By virtue of these financial arrangements, Larderel was unable to sell, on his own account, any acid in France, America, Britain or the region of Hanover.

In 1838 Larderel decided to pursue a different way forward. The establishment of the Société D'Hesecque was an attempt to increase the capital available to the business by engaging wealthy French aristocrats. Although registered in Paris in May 1839 the company's headquarters were moved to Florence in September of that year. Under the terms of the company's formation Larderel would retain control of the production operations over its 50 year lifetime, supplying all output to the company at a price of 14 lira per 100lbs. In respect of the outstanding loans, that with Barberet seems to have been offset by him being given shares in the Société D'Hesecque, Scardozi (1992, 44) noting their subsequent sale to Larderel c.1846/47, while in 1843 the company was paying interest of 30,000 lira per annum to free themselves 'from the constraints of the English contract' (Scardozi 1992, 40).

With the liquidation of the Société D'Hesecque in 1847 Larderel again took ownership of the lagoons but, once again, only through borrowing heavily. With debts of more than 5.5m. lira (Scardozi 1992,

29) Larderel negotiated a sales agreement with Thomas Lloyd & Co., agreeing to sell them 18m. lbs. of acid, i.e. the entire output for the next six to seven years, at a price of 32 lira per 100lbs. (Scardozi 1992, 44). The continuing need for finance resulted in further agreements being made with Lloyds in 1850 also for 18m. lbs. (effectively covering the output for the years 1854-59) and in 1851 for 32m. lbs. (effectively covering 1860-69). In 1851, before the end of the first agreement, Larderel was permitted to increase production but only after agreeing to a reduction in the price received to 25 lira per 100lbs. and in 1854 a second increase in output was only allowed on condition that he stopped refining borax in Livorno (Scardozi 1992, 44).

### **Marketing**

During the early stages of the development of boric acid production sales were conducted by the partnership of the Widow Chemin, Prat, Lamotte & Co. although from time to time, and contrary to their agreement, by Fratarelli Lamotte & Larderel. Up to 1822 much of the acid was sent to Lord Levy & Sons in London (Scardozi 1992, 32) but some clearly found its way to Paris and the Payen works at Grenelle. The product was shipped from Livorno where, despite many English merchants leaving during the Napoleonic era, some continued to play an active role following Napoleon's downfall. When the partnership of Widow Chemin and Prat got into financial difficulties in the late 1820s, new arrangements had to be found for marketing the acid and in 1831 commercial relations were established with the Anglo-Livornese merchants John and Thomas Lloyd (Nicolini 2007). It is probably through this connection that the loan secured from Hepburn, Pillans & Co. in 1835 was arranged, since the Lloyds were to hold the register of the coupons into which the loan was divided (Scardozi 1992, 38). It has been suggested (Scardozi 1992, 29, 44) that for many years the Lloyds were desirous of obtaining a monopoly of the marketing of Tuscan boric acid, something which they finally achieved under the arrangement made with Larderel on 3 August 1847 and which, with subsequent agreements, were to last through to the end of the 1860s.

### **The development of production at Larderello, c.1818-1858**

#### **Quantity**

Like Guerrazzi and Brouzet, Larderel and Lamotte found that producing boric acid was no simple matter. Costs were high, not least due to the heavy and increasing expenses associated with the use of rapidly dwindling local supplies of wood to heat the evaporating pans used to crystallise the acid. In 1827 Larderel hit upon the idea of using the steam from the *soffioni* to provide the necessary heat and, despite some initial teething problems, by 1830 the construction of masonry domes to give effect to this improved method of evaporation and drying had been fully implemented (Società Boracifera di Larderello 1937, 6). Nevertheless the production process, from the initial collection of the waters to final evaporation and drying (for a brief description, see BPP C.165, 37; for a longer one with illustrations see Payen 1841b, 251-254), remained a long drawn out one, taking 72 hours in the mid-1830s. Further technological advances, such as the development of Adriane boilers in the early 1840s (Ginori Conti 1933, 13), which reduced the time needed for evaporation to just 12 hours, enabled an increase in output (see Figure 3) and a fall in production costs, though they had still not been fully introduced by the early 1850s (Scardozi 1992, 44).

[Insert Figure 3 about here]

Some of the increase in production was achieved by expanding both the number of production sites ('factories') as well as the number of domes in operation, which varied as between factories. De Larderel (1851, 9) noted that production had initially been focused on lagoons near Montecerboli (later known as Larderello) which formed the most important production site in the mid-1830s (Payen 1841a, 254-255). Larderello remained the centre of the company's operations even though, by the early/mid-1840s, Sasso had become the largest factory, producing 16,000 kgs. per month to Larderello's 11,000 kgs. (*Encyclopédie Technologique* 1847, col. 429). By 1851 nine 'factories' were in operation, five in the area around Pomarance (including Larderello) and four in the Massa-Marittima, with 400 boilers in operation day and night (de Larderel 1851, 10).

### **Quality control**

Increasing levels of production created their own problems, not least the issue of the quality of the product. The waters of the *soffioni* and lagoons naturally contained about 0.3% boric acid, though after evaporation, and particularly following the introduction of the domes, the resultant crystals contained around 7% acid. Unfortunately the crystallised product also contained impurities which negatively impacted on the acid's commercial value and led to litigation such as that taken by the Lloyds in 1834 (Nicolini 2007).<sup>18</sup> Experts appointed by a magistrate agreed that the acid contained more than 20% of impurities, but while two of them judged the acid to be of good quality (despite the trade of that period placing a limit on impurities of 10%), the third considered it poor. In April 1836 a fourth expert found the acid to be really poor, noting that the Lloyds had the right to refuse to accept it and were due compensation, necessitating the appointment of a fifth expert to determine the amount.

The ongoing dispute over quality may be one factor which explains the activities of Anselme Payen in Tuscany in the mid-to-late 1830s (1841a, 248fn.1).<sup>19</sup> A share prospectus for the Société D'Hesecque notes that Payen, who was one of the nominated members of the Paris oversight committee listed in the company's Acte de Société (article 23), was charged with establishing plant at the lagoons to effect the procedure which he had perfected with his former partner, Buran, of a simple and economic way of purifying the acid<sup>20</sup> and to use his presence in Tuscany in the interests of the company.

Key factors in determining output levels and the quality of the product were the nature of the workforce, how it was incentivised and how its performance was monitored. We now examine these in turn.

### **Creating and retaining a labour force**

The area where the *soffioni* were to be found has been described as 'one of terrible violence and confusion ... among bleak and solitary mountains' (BPP C.165, 37). The wild nature of the terrain meant that few people lived there due to the inherent dangers such as death from falling into the boiling waters of a lagoon or losing a leg by stepping into a smaller pit (BPP C.165, 38). With the Tuscan authorities operating a laissez-faire approach to industry, it was up to entrepreneurs to make provision for securing and maintaining a workforce. A government statement from the mid-1830s noted (quoted in BPP C.165, 31-32):



Our trade exists without prerogative or privileges; without corporations of arts or trades; without any interference with wages; without special taxes on buildings devoted to manufactures; without any fetters upon contracts or sales; without any code of discipline or coercion in the relation between master and workman; without any inspection over the interior of manufacturing establishments, except those regulations demanded by the public health and public security.

Though precise numbers are unclear, employment in the boric acid industry was not large. It has been suggested that the original workforce in 1818 comprised c.15 mountain-peasants from the Tuscan-Emilian Apennines (Cronologica 1702-2004). The offer of inducements such as high wages, accommodation<sup>21</sup>, the right to cultivate land (BPP C.165, 38 fn.\*) and provision of other amenities, helped to attract workers, accounting records showing 36 persons directly employed at the domes of the eight operating factories in May 1836 (ASPGC E1272). In 1840 the accounts (ASPGC E1453) detail 136 persons, ranging from the general manager, bookkeeper, warehouseman and five factory managers at the top of the organisational structure, through production workers (44) and carters (15) to smiths, bricklayers, carpenters, a stonecutter, with peasants and labourers at the bottom. In 1850 the workforce has been put at 108 employees, their families constituting a population of 368 inhabitants living in the company villages (Bianchi et al n.d., 442)<sup>22</sup>, whilst almost twenty years later, Tabarrini (1868, 5) notes that the population of the seven localities was almost 1000 people.

Creating an industrial workforce from a population used to agricultural pursuits, as in other countries, was a challenge in the early stages of industrialisation. A staunch catholic, much influenced by the context prevailing in post-revolutionary France, in which all citizens acquired unalienable rights which had to be safeguarded at all costs (Bianchi et al. n.d., 443), Larderel adopted a paternalistic outlook, both to his workers and those who lived in the townships which were close to and/or developed around the factories. In 1832 he built a chapel at Montecerboli which was extended in 1842 and again in 1854-56 (Cronologica 1702-2004). In the early 1840s each factory had a doctor and a surgeon, whilst at the centre of operations, which from 1846 became known as Larderello, a pharmacy distributed medicines free of charge to both workers and the poor of the region (*Annales du commerce extérieur: Toscane* 1843, 14, in *Annales du commerce extérieure: Italie 1844/62*). An elementary school for children of both sexes provided free education for workers' children (Cronologica 1702-2004) while workshops were provided at each factory for children to pursue their hobbies (de Larderel 1851, 12). In 1849 a Mutual Aid Society was established to provide pensions for widows, the elderly and orphans.

Due to such developments Larderel became renowned for his paternalism but, as Scardozi (1992, 45) points out, this 'was not only a reflection of the dominant agrarian and sharecropping mentality, but a form of work organization, which responded to the particular difficulty of controlling labour in scattered "factories"'. In pursuit of such control, in December 1849 Larderel issued a set of rules (*Regolamento Generale Dello Stabilimento Dell'Acido Boracico*).<sup>23</sup> Reflecting the fact that all members of society had rights and obligations these rules, which came into effect on 1 January 1850, applied not only to the firm's management and workers but also those living within the area covered by the company's operations (Bianchi et al n.d., 441).

### ***The General Rules, 20 December 1849***

In 1849 Larderello was a 'company town' (Lungonelli and Migliorini 2003, 16-17), an instrument by means of which Larderel attempted to find a solution to the problem of the perverse effects of industrialisation in a previously largely uninhabited region. The provision of housing, healthcare,

children's schools, recreational associations, etc. attempted to foster non-antagonistic social relations and create a strong, ideological link between the employer, the factory, its workers and the local society. The 1849 rules (ASPGC N183) set out general obligations applicable to all, in particular the necessity for good conduct and regular attendance at work, it being specifically noted that 'adopting behaviour that is moral, religious and civil, sets an example to one's inferiors'. The rules indicate the organisational structure of the business (see Figure 4) and urged key personnel such as the bookkeeper (*computista*), the warehouseman (*magazziniere*) and the factory managers (*ministri*) to fulfil their duties efficiently and without interfering with those of others. Ultimate responsibility for ensuring adherence to the rules lay with Larderel or, in his absence, the General Manager (Luigi Beneducci), amongst whose duties were to inspect all factories regularly as regards both work and administration in general and overseeing the employees. The bookkeeper's role was to keep all of the administrative books related to the manufacture of the product and all associated upstream expenses, in as many separate accounts as there were things or persons concerned and involved with the administration of the factory. The records were to be kept in good condition, clearly legible and backed up by the related paperwork, with all registers and documents diligently conserved. Each month, in conjunction with each factory manager, the bookkeeper was required to carry out checks and conduct calculations, compiling and sending to headquarters the general accounting statement. Once a year he was also required to draw up and send in an annual general report.

[Insert Figure 4 about here]

The duties of the Larderello warehouseman involved not simply recording the receipt, storage and shipping out of the acid but of all goods entering and leaving the warehouse, e.g. all materials, tools and equipment received and sent to the factories or to Livorno. The registers were to be kept diligently and promptly in a manner which would not delay the carters, vehicles and persons that either delivered or shipped out the goods. The warehouseman was required to ensure that the acid entered the warehouse dry and pure and, where this was not the case, he was to keep it separate from the other produce. Every Friday he had to send to Livorno a note of everything that he had sent out or received during the week, indicating the day and the name of the carter. On the first and sixteenth of every month he was required to draw up and send the manufacturing statement and the general report of all events in the factories, based on reports received from the respective factory managers. The warehouseman was also required to keep a register concerning the status and movement of the factory personnel. Once a month he was required to deliver all documentation to the General Manager for accounting purposes. Additionally, the warehouseman was required to assist the General Manager and, in his absence, take over his duties.

Each factory had its own manager, responsible to Larderel or the General Manager, who was required to oversee manufacturing operations and determine any requirements, proposing such improvements and enlargements he deemed useful and necessary. The factory manager supervised the work, being obliged to keep a register of, and account for, all the materials and items he received. Daily operations were entered in a register and weekly reports drawn up. Upon receipt of the acid produced, the manager would immediately record this in the register and the record books provided to the workers of each dome or boiler. Every Sunday he was required to draw up and send to the General Manager a report concerning production and all events that had occurred. He was to keep rigorous checks on everything and, on 1 January of each year, was required to draw up an inventory of everything in the factory.

Individual workers were responsible for carrying out production, as well as maintaining in good condition the lagoons, domes and boilers at which they worked. General working procedures were outlined in the rules, including an obligation to inform the factory manager in the event of any

malfunctions. Fines were used to encourage workers to adhere to 'Religious, Moral and Civic observance', any sums collected going to the coffers of the Mutual Aid Society which oversaw assistance to widows, orphans and the needy in general (Bianchi et al n.d., 442).

The general rules clearly indicate the central role played in the administrative system at Larderello by the accounting system and we now turn our focus to this.

### **An overview of the accounting system**

As with the archives of many businesses those of Larderello are incomplete. Production and cost records survive only from 1836, while financial accounting records exist from 1841. Despite their incomplete nature and some of the surviving records being in French while others are in Italian, it is nevertheless possible to determine that the accounting system from the early 1840s was one which integrated financial and cost information.

### **Financial accounts**

Chronologically speaking the first surviving financial account book is a ledger, '*Grand Livre No. 2, 1841-47*' (ASPGC E2295), kept in French, comprising 405 folios. Each account, such as share ownership, various types of cost (e.g. experimental, transport, brokerage, stores, office, workers, postage, management fees), is set out in credit (*doit*) and debit (*avoir*) form on facing pages. Of particular interest are the accounts for 'manufacture of borax in Paris', 'Borax' and 'Boric acid'. Other accounts are kept under the names of individual creditors and debtors, as well as there being one for each of the factories. Expenses are detailed analytically, entered on a financial basis, but there are no closing entries at the end of each financial year. One omission from the ledger is the cash account, possibly reflecting the existence, from 1836 on, of separate cash books (*libri di cassa*) (ASPGC E1449-1451), recording daily receipts and expenditure.

Over time there is an increase in the level of analysis within the ledgers (*libri mastro*), both as regards movements in creditor balances and expenses. That for 1850-1858 (ASPGC E2298), for example, contains additional accounts for new products such as 'purified acid' (*acido depurato*), from which it is possible to obtain the industrial profit, which is then debited to the profit and loss account, highlighting that expenses rather than costs weighed on the period. Moreover, from 1848, reflecting the severing of the previous links with France, the ledgers are kept in Italian, but there is still no evidence of any closing entries being made. The surviving journals (*libri giornale*) for the period 1842-1844 and from 1853 onwards (ASPGC E1405) record operations chronologically using the double entry method.

### **Cost accounts**

A basic feature of the accounting system used from c.1836 onwards is the factory books (divided into factory 'administration' books and factory 'general accounting' books) and the *Saldaconti*. A uniform method of accounting and costing was applied to all factories but, whereas the financial accounts were initially kept in French, from 1836 the factory books and those concerned with production were always kept in Italian, even though their balances were then reported in the general ledger.<sup>24</sup> Each factory kept its own production record, the factory 'administration' book, in which the manager recorded the total daily output, together with the manufacturing, transport, construction, maintenance and various (general) expenses incurred. Examples of such books survive for all factories from 1840 (e.g. *Fabbrica di Montecerboli* (ASPGC E1202)) with each page, entitled

*'Prospetto della fabbricazione e spedizione dell'acido boracico e delle spese occorse nel mese di...'* (statement of the manufacture and dispatch of boric acid and expenses incurred in the month of ....), being devoted to the results for a single month (see Table 1). The row totals therefore provide the total daily cost of production while the column totals yield the monthly figures for the production and cost of the factory under various headings, as per the factory 'general accounting' book.

[Insert Table 1 about here]

While the factory 'administration' books were kept at the factories, the factory 'general accounting' book, a form of duplicate record, was kept at the company's headquarters in Larderello. The earliest surviving example, the *'libro di contabilità generale'* (ASPGC E1272) is for the period 16 April 1836 to 31 December 1839. The book contains a separate monthly summary of the output and expenses of each dome at every factory entitled *'stato del prodotto delle fabbriche dell'acido boracico e delle spese tutte, occorse per l'amministrazione nel mese di...'* (state of the product of the boric acid factories and all expenses incurred for administration in the month of ...). The information recorded (see Table 2) includes the names of the factory, its manager, and the production workers associated with each dome. While the factory 'general accounting' book records expenditure under the same headings as used in the factory 'administration' books, it differs in that it directly shows the output together with the production and other costs linked to each individual worker (see Table 2). Although the name used for these books changes through time (e.g. *'Amministrazione Generale'* (General Administration) 1840-42 (ASPGC E1273), *Amministrazione della fabbricazione dell'acido boracico'* (Administration of the boric acid factory) 1843-45 (ASPGC E1276)) the format remains the same. Though not kept using the double entry method these books, which bear the signatures of senior management, in particular the general manager and cashier, a director, and the book-keeper, clearly belong to the double entry system of accounts, forming the basis for entries in other books.

[Insert Table 2 about here]

The third element of the cost accounting system was the *Saldaconti* (firm accounts) which relate to the whole firm and provided the link with the financial accounting system. Unlike the factory books, each *Saldaconti* only records entries in monetary terms and uses the double-entry method. The first book dates from 1840 and relates to the general administration of Boric Acid (ASPGC E1453). The book commences with the 'General Administration' account, presenting the cash receipts (cash account contra-entry) in the credit section and the cash on hand at the end of every month in the debit section, and there are also accounts for each managerial/administrative staff member and each worker.<sup>25</sup>

A separate page in the *Saldaconti* is devoted to each factory recording the monthly expenditure on the credit side of the account and the factory's revenue, from the sale of the boric acid produced in that month, on the debit side. During the Société d'Hebecque era production was valued at the pre-determined contract price of 14 lira per basket of 100lbs., the warehouse in Livorno being debited with these factory revenues. At the foot of each page was determined the balance, representing the profit or loss for the factory.<sup>26</sup> The remaining pages of the *Saldaconti* contain the general manufacturing accounts relating to acid production, recording monthly expenditure on the credit side and the value of the boric acid manufactured, again valued at the pre-determined contract

price, on the debit side. At the end of the financial year the balance of this account therefore represents the profit from acid manufacture.

Each *Saldaconti*, therefore, provides direct information on:

- personnel costs;
- individual factory performance;
- the profitability of each line of production; and
- the overall output position.

Whereas the *Saldaconti* for 1840 and 1841 (ASPGC E1453-E1454) include information relating to both employees and factory data relating to manufacturing operations, that for 1845-47 (ASPGC E1455) and subsequently contain only personnel data, the factory data being recorded in the factory 'administration' books. The *Saldaconti* therefore made possible the tracking of the company's staff, both in qualitative and quantitative terms.

At the company level, quarterly financial statements were drawn up such as that for the second quarter of 1840 (ASPGC E2819), where each page contains data on the quarterly performance of a factory. The summary ends with the '*prospetto della contabilità generale*' (statement of general accounting) in which the expenses are separated into: manufacturing and transport; factory construction and maintenance; and general administration expenses. Also detailed are warehouse movements, divided into receipts and deliveries.

### **Piecework and performance monitoring**

Following his first attempt c.1835 to gain full control of the lagoons via loans linked to fixed-price supply contracts, Larderel's main concern was to maximise production while minimising costs, thereby keeping profits as high as possible. The accounting system aided this approach by providing information on output, costs, the performance of individual employees and managers. By 1841 it is clear that it was being used to monitor the performance of factory managers, their monthly reports on acid production, expenses, cash movements, etc. being the subject of exchanges with Larderel, especially concerning output. On 30 January 1841, for example, the manager Sogliani apologised for the unsatisfactory nature of his report, declaring that he would do his utmost to ensure increased production in February despite noting that it would be a short month (ASPGC E300). Reporting on his visits to each factory, in letters dated 5 and 6 April 1841 Sogliani notes that March had been a good month for production at 202,027 lbs. (expenses 10,257.14 lire) and he expected the coming months to be likewise. On 13 October 1841 Antonio Pezzati, Larderel's secretary, wrote to the manager of the Montecerboli factory acknowledging his note on the production workers, and urged him to ensure that production was 'more active' and higher next month.

Production remained a major concern of top management even after the introduction of the December 1849 rules which required factory managers to report on output weekly. On 2 August 1851 letters were sent to the managers of the Castelnuovo and Sasso factories complaining about the July production level, and in November 1851 the former was urged to make his 'best efforts to ensure that production increases' (ASPGC E2261). Factory managers were subsequently required to supply forecasts of estimated production for the following month and chastised if production trends were not in line with expectations (ASPGC E2803). Poor performance could lead to managerial changes being threatened, the manager of Serrazzano, Giuseppe Pacini, being told in a letter dated 22 March 1853 to improve output or Larderel would be forced to replace him (ASPGC E2261).

A key feature of encouraging performance was the use of the piecework payment system, which was in place at least as early as 1840 (ASPGC E1202). Workers at each dome were paid on a joint

production basis according to a fixed rate, the December 1849 rules indicating the motivation behind this method: payments to all employees would be 'calculated on the quantity of production, so that their work will be addressed to increasing output'.<sup>27</sup> Letters written to the managers of the factories on 25 February 1853 (ASPGC E2261) set out the rates to be paid for the coming year, that for Castelnuovo indicating that the manager would receive:

6 lire for every 1,000 lbs ... and for the workers of the dome San Giuseppe 18 lire percent, [dome] San Ottaviano  $16\frac{2}{3}$  lire. For San Eugenio, a dome not currently in production, to Sommi father and son will be paid not less than 80 lire per month.

The varying rates of pay reflect the fact that domes were not homogeneous production units, output depending as much on factors such as size, location and the state of the weather, as on the effort of the workers. These factors may also explain why there is no evidence of any incentive bonus system being used. As previously noted the amount produced was recorded against the individual dome workers' name in a box at the bottom of each page of the factory administration book (but not in the factory general accounting book). The accounts for 1836 show that the number of workers varied from 1 to 2 per dome, with payment being per dome.<sup>28</sup>

One aspect of the monitoring of managers involved year-on-year comparisons. In March 1842, for example, comparisons for January and February were made with those for the same two months in 1841 (*Comparativi di produzione acido borico 1839-1906*) while in a letter dated 6 July 1853 the general manager, Beneducci, reported to Larderel that production was not so bad and in the first half of the year had been going better than last year. However, in October and November 1853 the managers of the Lustignano, Serrazzano and Monterotondo factories received letters pointing out unfavourable comparisons between the current year's output and those of 1851 and 1852.

Although output levels were the major focus of attention, product quality could not be ignored, with many recommendations on this topic being made to factory managers, the warehouseman and Inspector Beneducci from the early 1840s onwards. It was the poor quality of the product which led at the end of October 1854 to Bertini being removed as manager of Castelnuovo. Despite previous complaints as to his performance, in particular his ability to effectively oversee the workers and the quality of the product, the factory's performance had not improved. Seemingly in an attempt to soften the blow to the Bertini family, the letter of 11 October 1854 also notes that his son, Torello, would be given employment at the factory.<sup>29</sup> Through the accounting system, management would have been able to determine the financial position of each worker and his family, such action reflecting Larderel's paternalistic outlook.

### **Some reflections on the accounting system and its potential origins**

Even before the introduction of the rules of December 1849 Larderel clearly saw the need to link organisational structure and the accounting system at Larderello in order to regulate the firm's operations and monitor factory performance. From at least the mid-1830s the accounting system enabled costs to be observed from two perspectives: at the level of the dome and the factory. The former made workers visible to factory managers, who were themselves rendered visible to top management through weekly and monthly reports. With production units spread over a large geographical area the accounting and reporting system played a fundamental role in the control of operations. However, while managers could inform the General Manager if they observed poor worker performance and make proposals, they did not have the power to dismiss workers. Incentives to maintain and/or increase output were provided to both factory managers and workers through the use of a piecework payment system, with the Larderello accounting system enabling

performance to be monitored. As we have seen, it was clearly used in this way. But from where did it originate?

With no detailed accounting records surviving prior to 1836, it is unclear whether the extant records mark the start of the system or are merely a continuation of a pre-existing system. However, it is worth noting that many of the series of account records dating from either 1836 or 1840 contain the reference 'n.1' (*numero 1*) suggesting the commencement of a new series of books. However, once again, whether this simply reflects the beginnings of a new ownership regime or a break with former accounting methods is unclear. As Larderel had overseen production activities since 1818, if the surviving records represent a new system, this raises the question of what caused the change. A possible explanation is the move to fixed price contracts linked to the loans taken out by Larderel from the mid-1830s. Prior to this time, although Larderel was supplying the whole of the output to the Società widow Chemin, Prat, Lamotte and Larderel partnership, the price was not pre-determined. Nevertheless, even in this earlier era, Larderel's incentive to maximise profits through obtaining the highest level of output at minimum cost would still have operated.

Whether the system commenced before or in 1836 there still remains the question as to its origin. Within Tuscany or the Italian states more widely there was little by way of an accounting literature to help guide businessmen in keeping cost accounts in the first half of the nineteenth century. Moschetti (1610) had described a very simplistic accounting system for a manufacturer (Melis 1950, 673-681) but it was to be c.1840 before any other works mentioning costing were to appear (Cerboni 1889): a work by Papale entitled *Metodo di tenere in conti a partie doppie per comodo di una fabbrica qualunque* (Method of keeping double entry accounts for any factory) was published in Messina by Nobolo in 1839; and between 1838 and 1843, in Venice, Antonelli published the *Enciclopedia del negoziante, Gran Dizionario del Commercio, dell'industria, del banco e delle manifatture* (Merchants Encyclopedia, Grand Dictionary of Commerce, Industry, Banking and Manufacturing). In his accounting text of 1850, *Elementi di amministrazione e contabilità* (Elements of Accounting and Administration), Villa mentions costing, referring to an 1848 work by the Frenchman, Chevalier, but it is not until the 1870 edition of Villa's text that there is a part (Section IV) dedicated to '*Dell'industria e delle amministrazioni agrarie, manifatturiere e commerciali*' (Concerning agricultural, manufacturing and commercial administration).

With little domestic literature available, a possible source of inspiration may have been France. Lemarchand (2016, 365) has suggested that in the late eighteenth and early nineteenth centuries, prior to double-entry bookkeeping being more widely diffused, 'accounting innovation in industry frequently seemed to be carried out by individuals who shared trade in common, and lived or had lived in regions where double-entry had long been practised'. Larderel and the other early partners in the boric acid business were either French emigrés or descendants thereof, and the Société D'Hesecque was comprised of wealthy French financial backers. As Zan (1994) notes, Italian financial accounting literature in the nineteenth century was strongly influenced by that of France but the extent to which French influence extended to the area of cost accounting is unknown. Given the links, both formal and informal, between Anselme Payen and Larderello from 1818 onwards it is possible to surmise a link to the accounting ideas of Anselme's father, Jean-Baptiste Payen. In 1817 Jean-Baptiste wrote a book on industrial accounting, based on his experiences of running his chemical business at Grenelle in Paris.<sup>30</sup> It was here c.1815 that Anselme became manager of his father's borax factory and where he conducted his experiments between 1818 and 1820 to produce synthetic borax using Tuscan boric acid. When Larderel travelled to France in 1819 to try to expand the market and learn the best ways of producing borax (Cronologica 1702-2004) it seems unlikely that he did not visit the Payen establishment in Paris.

The possibility of a link between the Larderello system and that of Payen is based purely on circumstantial evidence but there do exist some similarities between the outputs of the Larderello

accounting system and that described in Payen's *journal de comptes en nature* (Payen 1817, 42ff). For a later period, the book relating to the factory producing borax and other chemicals mirrors that of Payen's account *en matières*, with inputs listed on the left hand side and the outputs of different products on the right hand side. Furthermore, the architecture of the books within the accounting system as a whole contains echoes of those suggested by Payen (1817, 4). Nevertheless, there are important differences (at Larderello, for example, there is no attempt to allocate overheads and no depreciation is charged) and while these may simply reflect the specific nature of the Larderello business, which lies somewhere between Payen's second and third types of enterprise<sup>31</sup>, it can not be ruled out that Larderello developed his own bespoke system using his former background as a merchant and trader. Indeed, the Larderello case may echo that of the Manifattura Ginori (Antonelli *et al.* 2006) where cost calculation was found to be in advance of the literature in the first half of the nineteenth century, as has been found in the case of Britain (Boyns and Edwards 2013) and France (Boyns *et al.* 1997). At Larderello, as at Ginori the accounting system comprised cash accounts, ledgers and records relating to production, workers and the warehouses, enabling the determination of product cost through an analysis of production activities, i.e. the labour input, materials, machines and indirect factors. These clearly went far beyond the methods used in connection with the putting-out system employed in the Middle Ages examined by Saponi (1932) and Melis (1950).

Although we cannot be certain of the precise origins of the Larderello system, we have seen how it reflected the needs of Larderello for monitoring the geographically spread production units, and the financial and market relationships within which the business operated. If it did not develop out of any French connections, then the utilisation of a fully integrated cost and financial accounting system based on double-entry at Larderello prior to the emergence of a literature on the topic, as in Britain and France, suggests that there may have been multiple origins of cost accounting ideas. Any differences between the cost accounting system found at Larderello in the first half of the nineteenth century and those existing in firms in other countries may merely reflect the nature and particularity of its business relationships than to specific national or regional influences. However, further research is needed, both into the Larderello archive and more widely, if we are to better understand the precise relationship between the development of industrial accounting systems and economic/market factors on the one hand, and social, cultural, legal and political factors on the other.

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## Notes

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<sup>1</sup> When the initial research for this paper was conducted in the first half of the 2000s, the archive material resided in Florence (as Archivio Storico Piero Ginori Conti (ASPGC)) and the Italian co-author and the Florence archivist began to list the accounting and related material. However, since then the material has been moved to Enel's Historical Archive in Naples (as Larderello 1818-1962, Fondo Unico), and the listing currently utilised there simply uses document descriptions, not individual document reference numbers. To avoid significant repetition of such descriptions within the text, for those items allocated a reference number in Florence (e.g. ASPGC XXXX) we use these while cross-referencing to their current description as used in Naples within the



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references section of the paper. Where no reference number was allocated in Florence, we simply use the description.

<sup>2</sup> For some time before 1800 the Netherlands held a monopoly of refining natural borax using closely guarded methods.

<sup>3</sup> Payen (1823, 315-316) notes that he and Cartier founded the first large factory to produce all types of borax using Tuscan boric acid and that it was capable of producing 50,000 kgs. per year, twice the then consumption in France. However, Payen's claim to have been the first to manufacture synthetic borax was contested by Buran, a report to the French Society of Pharmacy in 1828 concluding that while Buran was undoubtedly the first to have manufactured octahedral borax in France, it was Payen who was the first to discover the chemistry behind it and publish and make known its method of manufacture (*Journal de Pharmacie et de Chimie* 1828, 176).

<sup>4</sup> In March 1791 the duty on unrefined borax was set at 6 francs 12 centimes per 100kg, subsequently being raised to 25 francs in February 1805 and 50 francs in February 1810. In April 1816, while the duty on unrefined borax was left unchanged, imports of refined borax were to be charged at the rate of 180 francs per 100kgs if entering via a French ship, or 191 francs 50 centimes if by a foreign ship or overland. In May 1826 a new category of partly-refined borax was introduced, the rates of duty on both this category and natural borax varying depending on whether it originated in India or elsewhere (the latter being charged at twice the rate for the former). The rates on refined borax remained at former levels though all rates were further amended in November and December 1851 and continued to apply beyond the period covered by this paper.

<sup>5</sup> On 15 June 1817 an advocate acting on behalf of Henry Brouzet approached the French customs authority to establish a right of entry for Tuscan boric acid (Guerrazzi 1836, XXI), with 'Guerrazzi, Brouzet, Baglioni & Co.' sending a shipment of 2,555kgs to France in that year (Cronologica 1702-2004).

<sup>6</sup> This rate remained in place until 16 November 1860 when boric acid imports were made duty free.

<sup>7</sup> Payen (1855, 238) suggests that the first borax refining factory using imported tincal was established in Paris in 1786, while Wisniak (2005, 492) indicates that in Britain the first appeared in 1798. A 'Prescription' book relating to Allen & Howard for 3 March 1799 to 22 November 1803 indicates that borax was one of the products they experimented with in their Plaistow (London) laboratory, the product becoming a staple of successor versions of the business for more than a century (*The Chemist & Druggist* 1914, 116, 121). From the 1830s Messrs. Howards began to acquire supplies of boric acid from Tuscany (*The Chemist & Druggist* 1897, 975) and by the mid-1860s, when it was the principal raw material used at their Stratford works, the business was described as being 'amongst the largest consumers' of Tuscan boric acid (Strauss et al 1867, 146).

<sup>8</sup> In 1803 only borax was dutiable, a distinction being made between refined and unrefined (or Tincal), with the former paying 8d. per lb, and the latter 4d. per lb. In November 1813 the former rate was doubled, whilst the latter was increased by only 50 per cent. By 1820 imports of boric acid were also being taxed, at a penal rate of 50 per cent ad valorem, but in 1823 this was altered to 4d per lb. In late August 1833 much reduced rates were introduced: refined borax 10s. per cwt., unrefined borax and boric acid, both 4s. per cwt. (i.e. less than 0.5d per lb.). These rates were further slashed in July 1842.

<sup>9</sup> The *soffioni* and lagoons were formed along three tectonic lines running through the Colline Metallifere.

<sup>10</sup> François-Jacques Larderel was born in Vienne on 17 November 1789 into a Dauphinoise family of gentlemen, subsequently ruined by the French Revolution (Frattarelli Fischer 2004). He then moved to Livorno with his family, one source putting this in 1799 while another indicates that it was during the reign of Napoleon's sister, Elise Baciocchi, as Grand Duchess of Tuscany (1809-1814) (de Germiny 1931, 156-157). In 1814 he was married to his cousin Paolina Morand, at which time almanacs describe him as a 'chincagliere' or seller of trinkets (Frattarelli Fischer 2004).

<sup>11</sup> Except where otherwise indicated the information in this paragraph is taken from 'Cronologica 1702-2004'.

<sup>12</sup> Ciaschi died in 1816 by falling into a lagoon which he had himself excavated (BPP C.165, 38).

<sup>13</sup> An announcement of the formation of D'Hesecque & Co. can be found in *Bollettino di notizie statistiche ed economiche d'invenzioni e scoperte Progresso dell'industria e delle utili cognizioni* for the 1<sup>st</sup> half of 1839.

<sup>14</sup> The first was dated 23 August 1834 with the widow Chemin and Prat, and the second 1 September 1834 with Lamotte (*Annali di giurisprudenza: raccolta di decisioni della Corte suprema di Cassazione* 1841, col. 680; see also Scardozi 1992, 36).

<sup>15</sup> George Hepburn and James Pillans, senior, had been partners in Grant, Hepburn & Co. of Trieste and, together with James Pillans, junior, in Grant, Balfour & Co. of Genoa, two of three mercantile firms based in Italy in which Isaac Grant was a senior partner in the 1820s. On 31 May 1831 both partnerships were dissolved (*The London Gazette for 1831* vol. II, 2392). Hepburn and Pillans then seem to have gone their own way, acting as bankers and merchants, and being represented in Livorno by the Anglo-Livornese merchants John and

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Thomas Lloyd (Cartiglia 1992, 533). Thomas Lloyd had joined his cousin John at Livorno in 1824, becoming a partner in the business in 1830. When John returned to Britain the business became known as Thomas Lloyd & Co. (Griffiths 2007, 86). The various Grant businesses continued to operate under new partnership arrangements but, in 1837, got into financial difficulties and were loaned £30,000 by Barings bank. In 1848 the Trieste business was closed and the Livorno and Genoa branches re-formed as Grant, More & Co. Due to debts owed to Barings, the Genoa branch was closed in 1865 and that at Livorno in 1866 (see note to Baring Archive HC12.2 House Correspondence – Italy).

<sup>16</sup> The low price reflects the fact that Barberet paid all the production costs on the amount which was supplied to him (share prospectus for the Société D’Hesecque, f.3). By virtue of Barberet being given shares in the Société D’Hesecque, the 120,000 kgs. to be sold to Barberet became the property of the company, and was to be purified and/or used to manufacture borax at the production sites by E. Buran & Co.

<sup>17</sup> This is taken from a letter written by Grant & Co., Livorno, to David Taylor & Sons, druggists of Mincing Lane, London, dated 14 March 1836. The letter also suggests that this amount was to be delivered in seven lots from 1<sup>st</sup> January, 1837 to the end of June 1839 and that a first tranche of 3m lbs. had already been delivered to Hepburn, Pillans & Co. and ‘resold to W. Lloyd (the refiner) at about £50.’ However, the first claim seems questionable given the then current annual output of about 1.75 m. lbs., unless large stocks were previously held at Larderello or Livorno.

<sup>18</sup> They had previously taken legal action in 1832 claiming that the Larderello partnership had violated its contractual arrangement by selling acid to other merchants thereby undermining the Lloyds’ exclusive arrangement for supplying the British market. With the courts suggesting a potential reduction of 13 lire per 100lbs of acid in the price received for acid supplied to the Lloyds, the Larderello partners agreed to stop this activity (Nicolini 2007).

<sup>19</sup> In this source Payen states that his visit was in 1835 though other sources indicate he was there in 1836 (Nasini 1930, 40; letter from the Larderello bookkeeper Pezzati, dated 11 May 1856, which refers to Payen signing the Larderello visitor’s book on 11 October 1836). It is, of course, not impossible that he made more than one visit especially given his subsequent connection with the Société D’Hesecque. Cronologica 1702-2004 suggests that Payen first began a chemical-physical analysis of the *soffioni* waters in 1832, visited the lagoons in 1835, and resided for a while in the Larderello village in 1838.

<sup>20</sup> Frattarelli Fischer (1992, 50) suggests that it was in 1838 that Payen began to apply steam to the purification of the acid at Larderello.

<sup>21</sup> At the beginning workers lived in huts but from around 1830 Larderel started to build small houses in which a family lived in a single room (Fondazione Michelucci, Comune di Pomarance, Il villaggio di Larderello, 2006).

<sup>22</sup> Cronologica 1702-2004 provides some (incomplete) data for 1850: 18 inhabitants at the Lagoni Rossi factory, 29 at Serrazzano, 73 (including 16 workers) at Sasso, 28 at Monterotondo...

<sup>23</sup> The establishment of these rules may, in part, reflect the recent political turmoil that had affected Tuscany and Livorno in particular during 1848 and 1849, part of wider uprisings across Europe. Despite Grand Duke Leopoldo signing the *Statuto* on 17 February 1848, riots occurred in Livorno in June 1848, Larderel being appointed a member of the emergency governing commission put in place to try to restore order (LoRomer 1987, 281-282).

<sup>24</sup> The difference in the language used is probably explained by the fact that those who kept the accounts at the factories were unable to write in French.

<sup>25</sup> Some of the workers, bricklayers and carters employed by the firm were casual workers, so it is difficult to identify precisely the permanent staff of the company. Nevertheless, the book does enable the identification of the various functions and the skills required at the time.

<sup>26</sup> In 1840 each factory showed a profit.

<sup>27</sup> In addition to rewards there were also to be ‘relative penalties for shortcomings and ... in the application of which I will be as fair as I am severe’ (quoted in Bianchi et al n.d., 442).

<sup>28</sup> The number of workers employed at each dome varied over time reflecting the technology of the time. The introduction of Adriane boilers after 1842, while reducing the length of the production cycle, actually increased the number of workers required per dome.

<sup>29</sup> It is not entirely clear how product quality was monitored since, although the factory sheets from 1836 on contain space for a measure of the percentage of acid, in the sample of sheets examined, this column was always blank!

<sup>30</sup> The book was entitled *Essai sur la tenue des comptes d’un manufacturier*. For more details, see Nikitin (1992, 373-383; and 1996).

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<sup>31</sup> Payen sets out the accounts for three types of business, the last two clearly based on his own chemical manufacturing experience: firstly, an individual who produces custom-made products from materials supplied to them; secondly, a manufacturer of a single product, *colle forte*, using a single boiler and one furnace; and thirdly an enterprise in which more than one product is manufactured using many boilers and furnaces.

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