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**Evading constraints? 200 years of uncontrolled pollution
by the Swansea copper industry.**

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6,540 words

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Chapter One

Introduction

During the nineteenth century, the West Glamorgan region of South Wales had a world-leading position in the smelting and refining of non-ferrous metals, particularly copper. All smelting produced pollution but copper smelting was the dominant activity and became the dominant polluter. Constraints on this toxic nuisance were largely ineffective. Early complainants had to resort to litigation or the goodwill of the copper masters for compensation. Litigation was unsatisfactory, often costing more than was recovered and attempts at injunctions were expensive and often failed.¹ Legislation was considered by Government in 1862 and 1878 but was only partly brought into effect in 1906. It was claimed that technology could solve the problem but the solutions had only limited success. The problem was only finally solved with the slow decline and eventual closure of the copper smelting industry during the 1920s. The legacy has been described as 'one of the most polluted landscapes in the world'.²

Swansea, popularly known at the time as 'Copperopolis', was a centre for smelting copper, zinc, lead, tin and nickel. The cluster of works from Llanelli through Swansea to Neath produced up to 90 percent of UK copper, representing about 50 percent of global copper production in the mid-nineteenth century.³ The global use of copper expanded dramatically during the nineteenth century; it was estimated that Swansea processed over 250,000 tons of ore in 1856.⁴ Chris Evans states that, although Swansea copper production

¹Great Britain, Parliament, House of Lords, *Noxious Vapours Commission. Report of the Royal Commission on Noxious Vapours.* (1878), Minutes of Evidence, p 55, questions 1,850-1. Page out of order online, (is screen page 549).

²Quoted in Edmund Newell, 'Atmospheric Pollution and the British Copper Industry, 1690-1920' in *Technology and Culture*, vol. 38, no. 3 (1997), p. 655. from B.W. Clapp, *An Environmental History of Britain since the Industrial Revolution* (London, 1994), p. 27.

³R. O. Roberts, 'The Development and Decline of the Copper and Other Non-Ferrous Metal Industries In South Wales' in *Transactions of the Honorable Society of Cymmrodorion* (1956), p 78.

⁴House of Lords, *Noxious Vapours Commission.* (1878), Minutes of Evidence, p.426, evidence of Hussey Vivian, Question 10,911.

continued to grow through the rest of the century, its share of an even faster expanding world production had fallen to 12 percent by 1900.⁵

Copper smelting involves driving off many impurities. In mid-century, one ton of Swansea copper was typically produced, depending on its copper content, from three to five tons of ore and seven to eight tons of coal. The lost tons comprised roughly equal weights of solid slag and copper smoke,⁶ a cocktail of noxious, toxic smoke comprising gases and particles. The mid nineteenth century was the time of maximum production and therefore maximum pollution. There were opportunities to manage the pollution by imposition of best technical practice and by equitable developments in litigation. The authorities and the industry failed to grasp those opportunities. The parliamentary enquiries in 1862 and 1878 on the release of noxious vapours were thorough and balanced. The main industry brought under control was the alkali industry but copper escaped on both occasions. Alkali pollution was capable of remedy which was fairly inexpensive and technically feasible. Remedies for copper were seen by the smelter owners to be too difficult both technically and economically.

This dissertation seeks to test some of the claims made by the smelter owners to the parliamentary commissioners for exemption from control, with particular focus on the evidence to the 1878 Commission of Henry Hussey Vivian (1821-94), a leading copper master and innovator. He was also MP for Glamorganshire from 1857 to 1885 and Swansea District until 1893 when he became Baron Swansea.⁷ It will consider the range of evidence given by all sides in the context of the political, economic and legal environments within which the industry operated. In considering the justification for resisting pollution control, it will be instrumental to consider the causes of the industry's decline. Vivian claimed it was far less profitable in 1878 than for any of 35 years before.⁸

⁵Chris Evans, 'A World of Copper: Introducing Swansea, Globalization and the Industrial Revolution' in *Welsh History Review*, vol. 27, no.1 (2014), p 90.

⁶House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 423-4, questions 10,899-905, evidence of Hussey Vivian.

⁷William Davies et al, 'Vivian, Henry Hussey (1821 - 1894), first baron Swansea, industrialist and patentee of metallurgical processes'. *Dictionary of Welsh Biography*, (1959).

⁸House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 448 evidence of Hussey Vivian, question 11,439.

There is no dispute in the historiography about the reasons for the early dominant position developing. R. O. Roberts produced an extensive paper on the industry in 1956.⁹ Edmund Newell produced a more recent comprehensive review in 1990.¹⁰ From the outset, the region had advantages over other possible sites. It had a suitable seaport, a wide range of local, easily extracted, plentiful, high quality coals and an existing workforce skilled in non-ferrous metal smelting. The nearest major source of copper ore in Cornwall could be efficiently shipped in and mixed for optimum production with other British ores.

The Swansea copper industry came to be dominated by Cornish mining families such as the Vivians and the Grenfells who ran integrated enterprises of Cornish copper mining, shipping, Welsh coal mining, smelting and processing, often described as the first vertically integrated industrial concerns. Cornish ores had a relatively low copper content and high sulphur content. This meant that waste was a high proportion of the output, both as slag and as significant generation of oxides of sulphur in the flue gases, leading to high quantities of sulphurous oxides, the precursor to acid rain. There were also relatively high levels of arsenical and fluorine compounds in Cornish ore leading to further toxicity and acidity in the flue gases. Smelting and purifying such ore was a complex, highly skilled set of processes which became known as the 'Welsh Method'. Crucially, this method relied on ores with a material sulphur content for a number of the production stages. As British ore production waned and failed to keep up with demand from about 1830, the industry led by Welsh and Cornish expertise sourced ore in Cuba¹¹ and Chile but kept its processes and the necessary use of sulphurous ore. Welsh smelters argued that they could produce copper from any ores. That in some ways was their business model; unique skill and knowledge enabling them to create high quality copper using a wide range of ores.¹² As Edmund Newell points

⁹R. O. Roberts, 'The Development and Decline of the Copper and Other Non-Ferrous Metal Industries In South Wales', pp. 78-115.

¹⁰Edmund Newell, ' 'Copperopolis': The Rise and Fall of the Copper Industry in the Swansea District, 1826–1921' in *Business History*, vol.32, no.3 (1990), pp. 75-97.

¹¹Chris Evans. ' El Cobre: Cuban Ore and the Globalization of Swansea Copper, 1830–70' in *Welsh History Review*, vol. 27, no. 1 (2014), pp. 15-8.

¹²R. O. Roberts, 'The Development and Decline of the Copper and Other Non-Ferrous Metal Industries In South Wales' pp. 85-9. and Chris Evans, 'A World of Copper' (2014), p 87.

out in his comprehensive review of the Swansea copper industry, this required large-scale production and heavy capital investment, creating barriers to entry.¹³

Historians' analyses of the long decline from dominance in the mid nineteenth century to the eventual cessation of copper smelting in 1921 have engendered debate over the reasons for the decline. In its heyday, the industry was very profitable.¹⁴ R.O. Roberts' paper on the sources of and the return on capital for the smelting industry¹⁵ is a good source for the high levels of wealth generated over time. G. W. Roderick lays some blame for the industry's decline on the gentrification of the industrialists and their use of high profits in good years outside the industry rather than reinvesting in modern methods.¹⁶ The Vivian family come in for specific criticism for this, with Hussey Vivian famous for his lavish lifestyle. Newell disagrees with this and points towards the changing economics of the technology which allowed efficient smelting at the ore mine sites, reducing Swansea's advantage as a coal source.¹⁷ Newell also refers to effects of changes in excise duty and rules in the 1840s and the oligopolistic cartel actions of the Swansea copper masters manipulating the markets in ore and finished metal as possible incentives to foreign miners to smelt their ore locally.¹⁸ In his evidence to the 1878 Commission, Hussey Vivian perhaps predictably blames the fiscal reasons rather than the actions of the coppermasters.¹⁹

The 1878 Commission considered potential remedies to mitigate the pollution from copper smelting. Evidence from the coppermasters will be compared with that from other witnesses as well as other external sources. The second chapter will consider litigation and arbitration. The common claim was for compensation against demonstrable damage and

¹³Newell, 'Copperopolis': pp. 76-7.

¹⁴R. O. Roberts, 'The Development and Decline of the Copper and Other Non-Ferrous Metal Industries In South Wales', p. 97 and House of Lords, *Noxious Vapours Commission*. (1878), p. 474, question 11,967.

¹⁵R. O. Roberts, 'Enterprise and Capital for Non-Ferrous metal smelting in Glamorgan, 1694-1924' in *Morgannwg transactions of the Glamorgan Local History Society*, vol. 23, (1979) pp. 48-82.

¹⁶G. W Roderick, 'South Wales Industrialists and the Theory of Gentrification: 1770-1914' in *Transactions of the Honorable Society of Cymmrodorion* (1987), pp. 78-9.

¹⁷Newell, 'Copperopolis', p. 94.

¹⁸Newell, 'Copperopolis', p. 85.

¹⁹House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 426, question 10,912.

private nuisance. Public nuisance could be dealt with by injunction which was expensive for the litigant and potentially drastic for the defendant. The third chapter will look at the technologies available. There were a number of methods in existence for capture of the worst toxins in flue smoke, particularly arsenic and sulphur and its acidic derivatives. Much was made of the relative efficiency of the various methods. The Press published effusive stories that the problem had been solved when that was not the case. The fourth chapter will consider legislation. The parliamentary enquiries of 1862 and 1878 were undertaken with a view to create law limiting the production of noxious fumes. In both enquiries, copper smelting was accepted as a major cause of serious pollution. Neither resulted in legislation which affected Swansea's copper trade. A cynical view would be that a powerful independent oligarchy misrepresented the options, persuading the government that in 1862, with a thriving industry, there were no effective remedies and by 1878, with an industry under stress, that the remedies were not affordable. This dissertation generally agrees with that view, while laying out the case for both sides.

Chapter Two

The Problems of Litigation

Many claims for damage from industrial pollution were dealt with informally or through arbitration, particularly in straightforward cases where a property was close to a works and the effect on vegetation was obvious. As chimneys became taller, which had the effect of diluting the pollution but spreading it wider, dispute resolution became more difficult.²⁰ The situation was made complex by the ephemeral nature of the smoke. It was often difficult for the claimant to identify the exact source of the pollution in a highly concentrated industrial area like Swansea. Smoke from many chimneys and works merged into a general cloud of pollution. Claimants had to decide which firms, and how many, to claim against and for economic reasons sometimes banded together resulting in multiple claimants and defendants. There is evidence in the parliamentary enquiries of a complex system of arbitration working in some alkali fumes disputes, using an arbitrator trusted by both sides, assessing damage, apportioning shares to be paid by factories and shares to be received by claimants.²¹ The evidence is also that such schemes fell apart over time perhaps as polluters dropped out or claimants increased.

Resorting to litigation has always been an expensive, time consuming and uncertain experience. In the case of smoke pollution this was certainly true. Most actions were civil claims for compensation for private property damage. In some cases injunctions were sought at assizes against public nuisance, a claim more difficult to prove and potentially putting manufacturers out of business. Newell describes success rates in the eighteenth and nineteenth centuries at about 25 percent.²² Two well-known cases held in the Swansea region illustrate the difficulties. *David v. Vivian (1833)* was a case brought by 11 small

²⁰Ronald Rees, 'The South Wales Copper-smoke Dispute, 1833-95', in *Welsh History Review* vol. 10, nos. 1-4 (1980-81), p. 484

²¹House of Lords, *Report from the Select Committee of the House of Lords, on Injury from Noxious Vapours; together with the proceedings of the committee, minutes of evidence, appendix, and index.* (1862), p. 184, question 1,964 is arbitrator's evidence & p. 208, questions 2,220-2 are manufacturer's evidence.

²²Newell, 'Atmospheric Pollution and the British Copper Industry, 1690-1920', p. 670.

farmers who clubbed together to claim damages and public nuisance against the firm of Vivian at the time of Hussey Vivian's father, the sitting Member of Parliament. Vivian saw it as a threat to the industry. He engaged the leading London barrister of the day, Sir James Scarlett, on a retainer of 500 guineas.²³ He was against a local barrister from Merthyr in an extremely unbalanced battle. *The Cambrian* carried the case in detail²⁴ taking up seven columns sub-headed 'MOST IMPORTANT TRIAL'. Evidence was highly polarised. The plaintiffs and their witnesses described severe damage to crops and livestock as well as personal discomfort and illnesses. The defence rejected the notion of damage, calling contradictory witnesses, claimed the farmers were incompetent and detailing the costs Vivian had incurred to minimise damage, incorrectly claiming that all smoke pollution had been suppressed. Scarlett made much of the misuse of the claim of public nuisance, a criminal indictment, for the purpose of recovering civil damages. He also played on fears that the trade would be suppressed putting 90,000 out of work compared with protecting the interests of 11 farmers. He further referred to the strategic importance of copper, not least its use for sheathing the hulls of commercial and naval ships. The trial was held in Carmarthen to avoid the bias likely to be shown by a Swansea jury but the jury found Vivian not guilty. It seems that the majority of Swansea's population was delighted the threat to the town's livelihoods had been removed, despite the reality that the claimants were only looking for compensation and not to close down the industry. *The Cambrian* announced 'the greatest joy throughout this town and neighbourhood, which has been manifested by the ringing of bells and firing of cannon throughout the day'.²⁵ It was not explained who had commissioned the activities and whether they were spontaneous or orchestrated.

In another attempt by the plaintiff group, *David v. Grenfell (1834)*, they claimed just damages rather than injunction. Evidence was again highly contradictory from either side. The jury found for Mr David but could not apportion blame between pollution and agricultural mismanagement. Damages of one shilling were awarded.²⁶ In a telling

²³Carmarthen, March 6', *Monmouthshire Merlin* (9 March 1833), p. 3.

²⁴Carmarthen Spring Assizes. Most Important Trial. - Indictment of Messrs. Vivian's Copper Works, near Swansea, as a Public Nuisance', *The Cambrian* (16 March 1833), pp. 3-4.

²⁵It is with heartfelt satisfaction', *The Cambrian* (9 August 1834), p. 3.

²⁶Breconshire Assizes. Copper Smoke Trial', *The Cambrian* (9 March 1833), p. 4.

postscript to this case the manufacturers did not want the result to stand despite the derisory damages. An appeal was lodged in 1835 led again by Sir James Scarlett claiming a mistrial and the judgement was overturned. The appeal decision was subsequently revoked in 1836 when Scarlett's submission was found to have incorrectly described the evidence.²⁷ These two cases demonstrate the seriousness with which the coppermasters took the risks of successful litigation against them. In *Tipping v. St. Helens Smelting Co. (1865)*, Newell points to the legal significance of Tipping losing a claim for personal discomfort, following appeal to the House of Lords, making such claims 'virtually impossible' in Swansea.²⁸ These cases in total effectively closed off the practical options for legal redress against existing works. Newell quotes the following legal opinion from an 1894 case.

'The claimants will know that the Defendants will fight to the death [,] that success will cost them a lot of money and that failure will ruin them and they know that any jury will be very slow to find in their [the claimants] favour'.²⁹

That case, *Talbot v. Rio Tinto Copper Co Ltd (1894)*, resulted in victory for the plaintiff, a wealthy landowner. However, Miss Talbot eventually agreed to set her injunction aside and accepted a lump sum and annual payments. This followed considerable lobbying and public demonstrations from the local community and the workforce who would have lost their jobs.³⁰

Looking at the evidence from the parliamentary enquiries there is clear concern demonstrated by the committee members in both enquiries as to the suitability of the common law to deal with smoke and fume pollution generated by rapid industrialisation.³¹ The 1878 Commission commented:

'A man ... cannot (it is alleged) succeed in an action for damages or other legal proceeding, unless he can point out, and trace home the damage to, some particular offender. This becomes absolutely impossible where works are thickly congregated

²⁷Court of King's Bench, April 25th', *The Cambrian* (30 April 1836), p. 3.

²⁸Newell, 'Atmospheric Pollution and the British Copper Industry, 1690-1920', p. 671.

²⁹Newell, 'Atmospheric Pollution and the British Copper Industry, 1690-1920', p. 670.

³⁰The Rio Tinto Works at Cwmavon - Generous Conduct of Miss Talbot', *South Wales Daily News*, (26 June 1893), p. 6

³¹House of Lords, *Report from the Select Committee of the House of Lords (1862)*, p. xvii, and House of Lords, *Noxious Vapours Commission. (1878)*, pp. 32-6, summarised evidence.

together... Further, the power to remove county court actions into a superior court, which is almost invariably exercised by manufacturers, is said to amount almost to a denial of justice to persons of the class of farmers'.³²

This was a general point on noxious vapours but it was pertinent to Swansea where copper smelting was highly concentrated in the lower Tawe valley just north of the town. Prevailing winds from the south-west spread the smoke to the north and north-east along the Tawe valley, through the villages of Llansamlet, Morriston and to Clydach four miles to the north and towards Neath to the north-east.³³ East and north-easterly winds put the smoke over Swansea town itself where damage was evident in the erosion of the stone buildings.

Hussey Vivian's evidence to the 1878 Commission indicated a refusal to acknowledge the difficulties of resorting to law. He opined that there was sufficient remedy at common law for all the relevant grievances complained of.³⁴ When questioned on the case of 1833 referred to previously, he dismissed it as an attorney stirring up some small farmers, 'aiming to put something into his pocket'.³⁵ He was curt and evasive on a number of questions of damage and the range of pollution but spent some time telling a 'tradition' or joke that a deformed cow taken to the Carmarthen trial in 1833 as evidence had died in the fresh air of Carmarthenshire having lived happily in stimulating Swansea copper smoke, where it might have lived many years longer. He then denied any knowledge of the livestock deformities known locally as *Effryd dod* or smoke-crippling disease³⁶ although it had formed part of many damages claims. Another major coppermaster, Pascoe Grenfell, gave evidence that his firm had never been subject to action for damages.³⁷ He seems to have overlooked the *David v. Grenfell* actions of 1834-6 referred to above. Charles Lambert, whose works were just to the east of Swansea town also said that there had been no complaints or actions

³²House of Lords, *Noxious Vapours Commission*. (1878), p. 34, includes cross-references to evidence pages.

³³House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 537-8, questions 13,470-82.

³⁴House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 454, question 11,507.

³⁵House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 452-3, questions 11,489 and 11,513.

³⁶House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 454, questions 11,518-9.

³⁷House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 472, question 11,941.

against his firm to his knowledge.³⁸ The commissioners noted in their summary that several witnesses had been 'exposed to much injury from these new works, which might be enlarged'.³⁹ Individual testimony suggests the witnesses held out no prospect of complaints being successful.⁴⁰

While potential claimants clearly existed, it seems that the experience of prior cases and manufacturers' intransigence meant that there was no more prospect of compensation being achieved by litigation in the 1870s than had been described in the 1862 Select Committee report. The 1878 Commission held back from recommending new specific damages and nuisance legislation. Recently enacted general law reform had opened the way for multiple plaintiff and defendant actions, and the commissioners stated 'We think that exceptional legislation should not be resorted to until the failure of the existing general law is established by experience.'⁴¹

³⁸House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 462-3, questions 11,755-6.

³⁹House of Lords, *Noxious Vapours Commission*. (1878), p. 19.

⁴⁰House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 545-6, questions 13,736-8 and 13,764-5.

⁴¹House of Lords, *Noxious Vapours Commission*. (1878), p. 35.

Chapter Three

The Promise of Technology

From the end of the eighteenth century, the Glamorgan non-ferrous smelting industry had developed a world-leading position, not only in production volume but also in advanced technology. As has been noted, 'The Welsh Method' could produce high-grade copper from unpromising ores, albeit with large quantities of waste slag and smoke. This technological advantage was one of the contributors to Swansea's monopoly position during the first half of the nineteenth century. The method comprised seven separate furnace roastings and meltings using different coals, temperatures and airflows. Only the roasting stages where much of the volatile matter was driven off were at a sufficiently low temperature to allow flue condensation of gases. The first roasting known as calcining drove off most of the arsenic and fluorine along with about half the sulphur. A first smelting of the calcined ore produced an intermediate product called regulus, which held the remainder of the sulphur but from which much of the slag had been removed. Regulus became a traded commodity. At various times, smelters experimented with capturing some of the waste from the calcining phase. The motive for this in some cases was to capture a potentially valuable product and in other cases to avoid having to pay compensation or defend litigation. Some projects were applauded for their altruism and for solving the copper smoke problem but it is clear from testimony to the enquiries, discussed in more detail below, that no manufacturer was willing to introduce pollution prevention processes that were not profitable or at least break-even.

The attempts in 1822 by Hussey Vivian's father John Vivian to find a solution to the smoke problem are well documented. The competition he promoted was won by him, having recruited such luminaries as Michael Faraday and Sir Humphrey Davy. The proposed solution incorporating long condensation flues and tall chimneys was installed by Vivian but was only partly successful on a number of criteria.⁴² Technically, it removed the arsenic compounds well but not much the sulphurous gases. Economically it was expensive with

⁴²Rees, 'The South Wales Copper-smoke Dispute, 1833-95', pp. 483-4.

little value in the by-product. In the short term, it headed off an action for injunction which from 1821 threatened the Vivians. The threat was believed by the plaintiff to have 'goaded the Vivians' into promoting the competition.⁴³ Perhaps the strongest positive effect was that the reputation of John Vivian and his firm was enhanced and there were a number of positive press reports. The results were announced in *The Cambrian*, with excess optimism, as having 'so very materially contributed to the doing away the inconvenience complained of'.⁴⁴ John Vivian submitted a statement to the editor which took three of the weekly editions to publish in full.⁴⁵ In it he explained at length and in much technical detail which methods had been experimented on and which were successful. He seemed to show indignation at the lawsuit against him and other implied sources of criticism, stressing his good intentions to mitigate the nuisance. In the longer term, the installation of tall chimneys seems to have been a double-edged sword. This had spread the smoke further and contributed to the later 1833 dispute of *David v. Vivian* previously discussed. Farmers a greater distance from the works were claiming damages.

John Vivian's winning method was referred to in the 1862 Select Committee. William Michael, who had held senior posts in Swansea local government including as mayor and chairman of the Board of Health, gave evidence critical of the damage to vegetation and livestock. His opinion on the industry's actions to mitigate smoke pollution was also negative.⁴⁶ He claimed no other coppermasters had copied Vivian's method and the Vivian Company itself had given it up. He stated 'they know that the damage has been done; and they know that they are free from legal liability as the law at present stands, and therefore they care nothing and do nothing.' He further linked earlier activity with impending lawsuits in 1823 and 1832, and that without such pressure the manufacturers had returned to maximising profits. He stated actions were taken under risk of compensation where works were established in new areas and where damage had not yet been done; demonstrating

⁴³Rees, 'The South Wales Copper-smoke Dispute, 1833-95', p. 483, footnote 13 but also see John Vivian's admission to this in 'Statement', *The Cambrian* (22 March 1823), p. 4.

⁴⁴'At a Meeting of the Subscribers', *The Cambrian* (1 Feb 1823), p. 3.

⁴⁵'Statement', *The Cambrian* (22 March 1823), p. 4, and (29 March 1823), p. 4, and (5 April 1823), p. 4. (One document posted over three weeks)

⁴⁶House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, p. 51, questions 605-7.

that action for mitigation was possible. He gave a further reason for abandoning the use of tall chimneys. They required highly skilled workmen to control the draft and to minimise the loss of copper particles into the smoke and, as skilled workmen cost more money, the operation could be less profitable. It was also true that the areas closer to the works were already almost completely destroyed, abandoned for farming and often taken over as sites for slag heaps. It was more profitable to keep polluting this ground rather than dispersing the maybe more dilute, but still damaging, smoke to new areas still under cultivation.

In 1864, Hussey Vivian installed Gerstenhöfer furnaces which made more efficient use of fuel but also made condensation of gases during calcining easier. Newspaper reports were very positive. *The Times* report noted the extreme damage previously caused, the enormous sums paid in compensation and the public statement of Hussey Vivian that 'the invention will prove completely successful, and that it will enable the firm to make 1,000 tons of sulphuric acid a week from the copper smoke'⁴⁷. In *The Cardiff Times*, Vivian was quoted as expecting to capture at least two-thirds of the copper smoke.⁴⁸ The acid was to be used in the production of chemical manure, or superphosphate, and Vivian mentioned the irony of a substance which had destroyed so much farmland being used to enrich it. In his evidence to the 1878 Commission, Vivian confirmed that his firm captured just under 38 percent of sulphur and that they had produced 3,304 tons of sulphuric acid in 1785-6, about 275 tons a week.⁴⁹ That reconciles with the 1,000 tons reported in *The Times*, as capture was only half what had been expected and a considerable amount of Vivian's throughput by 1875 was using regulus rather than ore so that recoverable sulphur was much reduced.

The 1878 Royal Commission took evidence from a number of Swansea smelter owners as well as from technical experts. Hussey Vivian appeared as both. At his first attendance, he gave what amounted to a technical lecture. He described in detail, using samples, the six-stage Welsh method of copper production, describing at each step the quantity of sulphur

⁴⁷'The Copper Smoke Question', *The Times* (21 Aug 1865), p. 10.

⁴⁸'Copper Works and Agriculture', *The Cardiff Times* (11 Aug 1865) p. 5.

⁴⁹House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 425, question 10,906

driven off. He went on to describe his father's experiments in 1821, his own introduction of Gerstenhöfer furnaces in 1864 and his recovery of sulphurous gases to use in the production of fertiliser.⁵⁰ This seems to have been a successful attempt to set the standard for best practice, as other coppermasters were subsequently questioned on their processes in this context. Charles Lambert described his muffle furnaces, a system where he could condense the sulphur from calcining.⁵¹ He applied sulphuric acid to the production of copper sulphate but only to the limited extent he could sell it and it was not profitable. He therefore left 80 percent of recoverable sulphur to vent to the atmosphere. He said he could not sell sulphuric acid if he produced it and professed ignorance on the viability of making superphosphate with it. Pascoe Grenfell reported⁵² that his firm had employed experts in the 1840s to carry out experiments but to no avail. They had looked at the Gerstenhöfer furnaces but could not accommodate them on their site. They did not have tall chimneys as he considered it would just spread the pollution further creating new claimants. He saw no use for sulphuric acid. He acknowledged his pollution was unchecked but claimed he was only affecting already blighted land and that pollution was diminishing. He said it would continue to do so as regulus at 50 percent copper and block copper, a partly refined product at 96 percent, was more and more imported to replace crude ore.⁵³ This all reduced the sulphur content of the inputs while maintaining a static level of fully refined copper produced in Swansea.

Whatever the promise of new methods of smoke capture throughout the period, they were only partially successful. Universal take-up of Vivian's process could have cut pollution considerably. The Vivian works captured about 38 percent of the 3,111 tons of sulphur they processed in 1875, meaning roughly 1,200 tons were captured.⁵⁴ They accounted for about 15 percent of the region's output and therefore with all works capturing available sulphur, 8,000 tons could have been captured. That equates to over 22,000 tons of recoverable concentrated sulphuric acid being discharged to the environment each year. The sulphuric

⁵⁰House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 420-6, questions 10,894-910.

⁵¹House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 462-4, questions 11,751-811.

⁵²House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 472-3, questions 11,934-66.

⁵³House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 473, questions 11,964-5.

⁵⁴House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 425, question 10,906.

acid by-product was not pure enough for resale to the chemical industry therefore it needed a local use. Coppermasters were not prepared to make the investment unless the process was profitable. Without the constraint of litigation or the threat of legislation, there was no impetus to find a solution.

Chapter Four

The Threat of Legislation

The profitability of the industry varied considerably over time. While on the input side the large producers had control over Cornish ore prices and to some extent over local coal prices, on the output side the price of copper was subject to demand fluctuations which the producers tried to control by acting as a price fixing cartel.⁵⁵ What producers could not control other than by political lobbying were the mercantilist and later free trade policies of government, which had affected the industry in both positive and negative ways. Ability to process ore in bond, duty-free for re-export, had been a major benefit. This was withdrawn in 1842, partly compensated by reductions in import duties, although they existed at various levels until 1853.⁵⁶ As described previously, Hussey Vivian blamed the withdrawal of advantageous excise legislation for the long-term decline in the industry. Beyond fiscal statute, the uncontrolled pollution arising from the rapid expansion of industry during the late eighteenth and early nineteenth centuries brought pressure for new legislation to control nuisance, rather than having to wait until damage was done and resort to common law remedies.

The threat to the copper smelters from legislation came first with the Local Government Act, 1858. This legislation put an onus on operators of furnaces to consume the smoke arising from the combustibles on penalty of a fine. Exemptions could be granted locally where manufacturers could show that the best-known means had been adopted to control the smoke. William Michael, the past chairman of the Local Board of Health in Swansea, invoked this legislation in 1859. His evidence to the 1862 Select Committee not only demonstrated that the legislation was ineffective against copper smoke but also showed the political influence of the coppermasters.⁵⁷ Swansea Town Council had obtained

⁵⁵Newell, 'Copperopolis', p. 85.

⁵⁶Newell, 'Copperopolis', p. 84.

⁵⁷House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, pp. 52-5, questions 611-21.

a detailed response to their questions on how to operate the Act from the Secretary to the Local Government Office, Tom Taylor. He confirmed the applicability of the Act and when and how exemption could be granted. Hussey Vivian and Pascoe Grenfell intervened and contacted Taylor directly, persuading him that parliament intended that the smoke described in the Act was, in the case of copper smelting, only that from the coal not that from the copper ore. Taylor subsequently 'clarified' his guidance to the Council and declared copper smoke outside the legislation, an opinion he confirmed to the Select Committee⁵⁸. Vivian's letter to Taylor⁵⁹ claimed rather disingenuously that because parliament knew there was no practical method to remove copper smoke, it had not legislated against it. In fact it had legislated that manufacturers would need to demonstrate best practice to obtain an exemption, which would mean they would be able easily to get an exemption if they were doing what they could, however little. Michael still went ahead in 1860 with his intention to give a month's notice to the smelters but was voted down by the majority of the Council who claimed it would be the end of the industry and the ruination of the town. However, this effort on the part of the coppermasters was not to avoid the risk of stopping smelting but to avoid having to demonstrate to a magistrate that they were applying the best-known means in mitigation and therefore entitled to exemption. Michael commented his opponents' opinion was 'We do not want the exemption; because if we have the exemption, then we shall be liable to these informations'.⁶⁰

The 1862 Select Committee was an investigation of the nuisance of noxious vapours in general. The Committee took evidence from a number of experts who concluded that there was no practical method of reducing pollution from copper smelting, a conclusion that the Committee accepted in its report.⁶¹ By practical they meant not profitable. One comment was 'the experiments...have been abandoned: they were found not to pay', and that no remedy was discovered that would not interfere with an important manufacture.⁶² One

⁵⁸House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, p. 237, questions 2,461-7.

⁵⁹House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, p. 54, question 617.

⁶⁰House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, p. 55, question 621.

⁶¹House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, p. v.

⁶²House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, pp. 96-7, questions 1,101 and 1,107-8.

consideration not apparently taken into account was the profitability of the industry at that time and its capacity to absorb extra cost. Roberts provides some snapshots of the partnership values of several of the major enterprises, particularly the Grenfells and the Vivians.⁶³ Simple inflation over the period from 1862 to 2019 indicates that £1 then would be worth about £120 now.⁶⁴ Roberts quotes the capital asset value of the Vivian enterprises as over £880,000 in 1868, a figure that continued to climb to over £1.2 million by 1887.⁶⁵ Using the 120 times multiplier, it approximates to asset values of £105 million and £145 million. He estimates the profitability in the 1830s as averaging ten percent, allowing both significant reinvestment and a life of considerable affluence for the partners. Charles Lambert considered the trade to have been 'very prosperous indeed' up to about 1870.⁶⁵ The alkali industry had economic solutions to its pollution and was subsequently regulated by the Alkali Act of 1863 and a system of inspection was instituted. A number of other industries were captured by the legislation but copper smelting, which was seen to be as pernicious as the alkali industry by the Committee, was excluded.⁶¹

The 1878 Royal Commission was set up to consider the effectiveness of the 1863 Act, as subsequently amended, and its inspection regime. The manufacturers gave evidence on the precariousness of the copper trade to the Committee. They all suggested that any legislation was likely to kill off an industry that had significant economic value to the area and was a strategic industry for the country. Both Vivian and Grenfell gave figures for the reduction in ore processed indicating an industry in steep decline. Vivian recorded a reduction of two-thirds in ore bought by ticket auction over the twenty years to 1876. He acknowledged this excluded private sales and regulus.⁶⁶ He also gave figures for the increase in refined copper being imported as about a sevenfold increase over the same time. Grenfell gave similar evidence and mentioned the last three years as having been bad for copper prices.⁶⁷ The sense given was of a declining trade although in fact copper

⁶³Roberts, 'Enterprise and Capital for Non-Ferrous metal smelting in Glamorgan, 1694-1924', pp. 55-7.

⁶⁴'£100 in 1862 → 2019 | UK Inflation Calculator.' U.S. Official Inflation Data, Alioth Finance, Available at <https://www.officialdata.org/uk/inflation/1862?amount=100>, Accessed 13 May 2019.

⁶⁵House of Lords, *Report from the Select Committee of the House of Lords. (1862)*, p. 763, questions 11,772-3.

⁶⁶House of Lords, *Noxious Vapours Commission. (1878)*, Minutes of Evidence, p. 426, questions 10,911-2.

⁶⁷House of Lords, *Noxious Vapours Commission. (1878)*, Minutes of Evidence, p. 474 question 11,967.

production was increasing and only peaked in the 1890s.⁶⁸ The apparent contradiction was that much more part-refined material was being imported making up for the drop in crude ore. The process in decline was the calcining of ore, which was the process where pollution control was possible. It was also the least skilled and least value-adding part of the smelting sequence.⁶⁹ A number of witnesses had reported that smoke pollution had reduced and attributed it to the capture of smoke by the Vivian works but it would seem that a major contributor was the large reduction in use of uncalcined ore by the industry.

Landowners and farmers gave evidence as to the serious damage done to vegetation and livestock as well as to depressed land values. Vivian in particular was as dismissive of this⁷⁰ as he had been to the problems of resorting to law as a remedy. He also gave evidence that copper smoke was not damaging to human health and was potentially beneficial, and produced mortality figures to illustrate this. Medical opinion was divided. Some linked the smoke with increased lung disease, others with immunity from cholera. The workers were well paid for the harsh conditions they suffered allowing them and their families to be well fed. In an era of poor living conditions, poor nutrition, limited medical support and exposure to all kinds of toxic substances, comparing mortality statistics by region or by trade was confusing and could be used to make whatever conclusion was wanted.

Vivian's most assertive comments were to oppose any form of legislation for the copper trade. This extended to resisting the lightest form of inspection, even for the purpose of sharing best practice. He talked of the legislature imposing disabilities on the great trades, which had caused 'serious damage to our manufactures and our commerce'⁷¹. He added that there must be a

'great dislike on the part of any manufacturer to have inspectors running over his works with power to go where they please and spy into anything they like. I for one, as a free Englishman, object to that on principle to the greatest degree'⁷¹ and 'No one

⁶⁸Newell, 'Copperopolis', p. 92.

⁶⁹Newell, 'Copperopolis' p. 86.

⁷⁰House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 448-9 questions 11,439-40.

⁷¹House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 450, question 11,441.

has a right to come into our works. I want no one to come into our works unless I choose to allow him.⁷²

He further claimed that if government chose to legislate, it should do so only for districts which wanted it and Swansea did not want it.⁷³ In this final view his brother Graham Vivian contradicted him, a partner in the family works who was extremely alarmed by the proposal and feared special status would encourage works in non-exempt areas to transfer to Swansea, worsening pollution.⁷⁴

The Commission made recommendations for a number of industries. Their summary on the copper industry was that copper smelting remained a major polluter, that mitigating processes such as the Gerstenhöfer furnaces used by the Vivian works were available but that the precarious state of the trade was such that 'best practicable means' should not be imposed.⁷⁵ They did however propose a system where inspectors should have access to works but only in order to give the 'benefits of that suggestive criticism' as had been applied to the alkali trade.⁷⁶ The 1878 Alkali Bill included copper works as one of the trades subject to inspection and application of best practicable means, at reasonable expense, to limit noxious fumes.⁷⁷ This was further than the Commission's recommendation but the Bill was not enacted. In the 1880 Alkali and Works Regulation Bill, copper works had been removed from the list entirely⁷⁸ and escaped the Alkali Act 1881. When copper was included in the 1906 Act, the industry was in terminal decline.

⁷²House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 450, question 11,967.

⁷³House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 452, questions 11,441-2.

⁷⁴House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, pp. 535-7, questions 13,414 and 13,455.

⁷⁵House of Lords, *Noxious Vapours Commission*. (1878), pp. 16-19.

⁷⁶House of Lords, *Noxious Vapours Commission*. (1878), p. 19.

⁷⁷Great Britain, Parliament, House of Commons, *Noxious gases. A bill to provide for the more effectual condensation of noxious and offensive gases in alkali and other works*. (1878-9), pp.15-16, paras. 12-13.

⁷⁸Great Britain, Parliament, House of Commons, *Alkali Acts Amendment. A bill to amend the Alkali Acts 1863 and 1874, and to provide for the more effectual condensation of noxious and offensive gases in alkali and other works*. (1880), p. 14.

Chapter Five

Conclusion

There was no dispute that copper smoke was noxious and destructive to local vegetation. Plant damage was instant, making cause and effect obvious. The crippling effect on animals arose from grazing on polluted vegetation. It was gradual and the cause could be, and was, challenged. Similarly, in an age of high mortality and limited epidemiological data, people subject to copper smoke did not necessarily appear more affected than groups in other industrial areas. The coppermasters put forward consistent justifications for accepting the situation. Firstly, that little that was economically sound could be done to limit the pollution. Secondly, that the business was vital to the economy of the Swansea region and a strategic industry for the nation both commercially and militarily. Thirdly, by acknowledging damage in the immediate areas of works and often buying out the local land for slag heaps, that all the damage had already been done and compensated for. Fourthly that the people of the Swansea region understood the great economic benefits to them and accepted that the price to pay was the 'inconvenience'⁷⁹ of the pollution. While each of these arguments had merit, they were somewhat simplistic. Partial solutions were available which were not universally taken up or fell into abeyance. Paying compensation was a cost of doing business and when the pollution zone increased, new costs were resisted, firstly through aggressive use of the law and secondly through political pressure to resist legislation. In particular, some form of inspection with a move to technical guidance and a requirement for reasonable best practice could have been brought in by the Acts of 1858, 1863 and 1881.

Swansea was steadily losing many of its competitive advantages. The cartel and monopoly had been broken. Technological leadership was being lost. First calcining then some smelting stages were carried out near the mines. New technology used elsewhere needed less coal, removing the 'ore to coal' imperative which had favoured Swansea. It remained however a leading centre for the most technical and costly processes of final

⁷⁹House of Lords, *Noxious Vapours Commission*. (1878), Minutes of Evidence, p. 454, question 11,532. Hussey Vivian refuted Lord Aberdare's description of vapours as producing 'mischief' and substituted 'inconvenience'.

refining to high-grade metal with output peaking in the 1890s. So, were the producers right to claim in 1877, as Vivian did vociferously, that even a modest level of oversight was a mortal threat to the industry? Hindsight demonstrates the inevitable decline but that is not to say it was clear in 1878 when the issue seemed to be the market price of copper. The shifts in processing patterns seem to have been coped with as the industry concentrated on higher skilled and valued processes. It seems likely that the effect of applying best practice pollution control would have been to hasten the reduction in calcining of ore but this was already the trend.

The leading coppermasters saw themselves as the experts. Hussey Vivian presented to the 1878 Commission as a technical expert and also as MP for Swansea protecting the trade and its workers. He claimed that he complied with best practice because he had set it but that others could not afford to follow. He objected on principle 'as a free Englishman'⁷¹ to any right of inspection of his works. They were clearly determined to limit any challenge to their position and any threat of interference in their business. When litigation or legislation threatened, strong blocking steps were taken. At the same time the industry, led by the Vivians, made sure it was seen to be doing something to find technical solutions, always paraded through the press as breakthroughs. On balance one could say that the copper industry did as little remediation as it had to. This may be no different from other industries. However, by effective lobbying, the coppermasters persuaded government not to bring in even the mildest oversight at a time when most other industries were subject to increasingly rigorous legislation.

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