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THE INTERNATIONAL COMMITTEE FOR THE HISTORY OF TECHNOLOGY (ICOHTEC)

ICOHTEC was formed in 1968. In 1993 the Constitution was amended to allow for individual membership. At the same time it was decided to publish an annual journal which would help to promote the study of the history of technology on the broadest possible basis. Volume 1 of *ICON* was published in 1995.

Membership in ICOHTEC is open to individuals, organisations and institutions. Subscribing members receive *ICON* as well as a regular electronic newsletter. Individual subscribers have electronic access to back issues on the ICOHTEC website (www.icohtec.org). Applications for membership can be obtained at the ICOHTEC website (www.icohtec.org) or by writing to Dr. Patrice Bret, IRSEM, Case 46, 1 place Joffre, F-75700 Paris SP 07, France. Back numbers can be obtained by writing to Dr. Bret.

Submissions for consideration for publication and other queries should be sent to Dr. James Williams, 101 Lake Winnemissett Drive, DeLand, FL, 32724, USA or, preferably, to his email address, techjunc@gmail.com. Articles in *ICON* are peer reviewed; book reviews are commissioned. Detailed notes for contributors are available at http://icohtec.org/publications-icon.html

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Officers

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About This Issue

This issue derives in part from the joint conference of the International Committee for the History of Technology (ICOHTEC) and the International Committee for the Conservation of Industrial Heritage (TICCIH) and the Association of Labor Museums (WORKLAB) held in Tampere, Finland, August 2010. In the opening essay Angus Buchanan explores the crucial role of the history of technology in understanding how the modern world has evolved and the value of sound historical understanding to the successful conservation of industrial heritage.

Four articles follow which explore various cases in the history of technology. Sonja Petersen explores how the image of craftsmanship was cultivated through advertising in the German piano industry even as the production of pianos increasingly became industrialized. The 'lone inventor' and 'invention marketing companies' in the United States are the subject of Carroll Pursell's essay on Cincinnati's American Patent Agency. Artemus Yagou explores the relationship of technology and design and emotions through radio sets, and Yoel Bergmann looks at the development of stabilizers for smokeless gunpowder, focusing on the work of Alfred Nobel.

The last two articles in this issue focus on conservation and re-use of industrial heritage sites and their significance in the history of technology. Brenda Buchanan reflects on her many years of work to preserve the industrial past of gunpowder production in Great Britain, offering in her conclusion some excellent principles as 'operational criteria' for 'the successful conservation and interpretation of our historic monuments'. Okada Masaaki concludes our contributions with an overview of what Japan has done over the past century in seeking to conserve and interpret its defence heritage.

This issue marks continued changes in *ICON*. Our book review section is expanded. We are seeking to review books which will be of particular interest to ICOHTEC members, and urge members to recommend works for review to the editor. Finally, you will note that we are now listing contributors' information at the bottom of the first page of each author's article.

Exploring the History of Technology

Power and Conservation:

The Importance of the History of Technology

Angus Buchanan

The essence of technology is the quality of physical power that enables people to make and do things, and the exploitation of non-human sources of power through machines and engines has been the outstanding characteristic of the process of industrialisation. Thus, the history of technology is concerned with understanding the nature of this process of power utilisation and with establishing its role in the development of the modern world. A sympathetic attitude towards the conservation of industrial artefacts is both the product of such increased understanding and an insurance that it will be carried forward in future policy-making. This article – first presented at the joint conference of the International Committee for the History of Technology and the International Committee for the Conservation of Industrial Heritage, held in Tampere, Finland, in August 2010 – argues the case for the crucial role of the history of technology in understanding how the modern world has evolved and for the importance of enlightened conservation in order to achieve this objective.

As one of the handful of surviving people who were Founding Members of both ICOHTEC, the International Committee for the History of Technology, and TICCIH, The International Committee for the Conservation of Industrial Heritage, I welcome the opportunity to speak on this first occasion in four decades that the two organisations have arranged a joint-meeting. I was present at the foundation of ICOHTEC in Paris in August 1968, when the organization was created as a Scientific Section of the International Congress for the History of Science, Technology and Medicine. It was an exciting moment to be in Paris, when the student riots had subsided, leaving piles of loose paving stones at the sides of some of the boulevards, and when the Soviet extinction of the liberalisation of Czechoslovakia in the Spring had marked a serious crisis in the prolonged 'Cold War' between East and West. I had been sent to the Congress as the representative of the Newcomen Society to attend the consultations about

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the history of technology, which led to the creation of ICOHTEC, and to my appointment as the first British representative and a member of the Executive Committee. In time, I became the Secretary General and then the President. Meanwhile, in June 1973, I attended the First International Conference for the Conservation of Industrial Monuments (FICCIM), at Ironbridge, and enjoyed the *camaraderie* of young museum curators and other conservationists anxious to give due emphasis to the industrial heritage. I went on to attend the Second Conference (SICCIM) at Bochum in 1975, and the Third Conference (TICCIM) at Grangärde in Sweden in 1978. Then my wife and I attended the Fourth Conference at Lyon and Grenoble in 1981, when the repetition of the first letter in the abbreviation made necessary the adoption of the permanent name as TICCIH.

Although I had greatly enjoyed participating in the activities of both these organisations, I decided at this point that it was necessary to concentrate my attention on one or the other, and as my primary interest at that time was academic rather than conservationist, I chose to devote my attention to the development of ICOHTEC. I reckoned, in particular, that the history of technology required stronger support than it was receiving, at least in the United Kingdom, while enthusiasm for industrial archaeology was giving an enormous boost to conservation studies and to securing the preservation of a magnificent range of features from the industrial heritage of the nation. This dichotomy between the history of technology and the practical conservation of industrial artefacts remains strongly entrenched, despite the success of SHOT – the American based Society for the History of Technology – and various other initiatives in the USA and Europe which seek to encompass both emphases, so I consider that it is appropriate on this occasion to reflect on the nature of the relationship and the continuing importance of the history of technology.

When James Boswell visited the famous Boulton & Watt factory at Soho, Birmingham, in 1776, he reported Matthew Boulton saying to him: 'I sell here, Sir, what all the world desires to have – Power.' This quality of physical power, enabling people to make and do things, is the essence of technology, and the exploitation of non-human sources of power through tools, machines and engines has been the outstanding characteristic of the process of human evolution and of industrialisation. The history of technology is thus largely concerned with understanding the process of power utilisation, and with establishing its role in the development of the modern world. A sympathetic attitude towards the conservation of industrial artefacts is both a product of such increased understanding, and an insurance that it will be carried forward in future policy-making. So I am concerned here to demonstrate the crucial role of the history of technology in understanding how the modern world has evolved, and of the importance of enlightened conservation in the process of achieving this objective.

Perhaps the most effective way of showing the vital part played by the history of technology is through the experience of some of its outstanding exponents, and I would like to consider three such examples. I take first the career of Joseph Needham (1900–1995), because this points up in a most emphatic way the value of history – and the history of technology in particular – to understanding one of the most important conundrums of the modern world: the rapid rise in the power and influence of China since the middle of the twentieth century. Needham came to maturity in the unsettled years between the two World Wars. Despite some colourful eccentricities and wide-ranging interests in religion and philosophy – he was a devoted Anglo-Catholic in religion and had strong Left-wing views in politics – he had trained as a biologist and had established himself by the 1930s as a brilliant researcher, a Fellow of Caius College Cambridge, and a Fellow of the Royal Society. When the Second World War broke out in Europe, he was commissioned to go to China as an official representative of the British government to give scientific advice to the government of China, then locked in a desperate resistance to Japanese invasion.

Needham stayed in China for four years, travelling widely, mastering the written and spoken language, and assembling a vast collection of Chinese scientific literature. In this period he acquired a better grasp of the history of Chinese science and technology than any previous Western scholar – and possibly even any Chinese scholar – and he formulated the massive work of scholarship that dominated most of the rest of his long life. This was the preparation of a comprehensive study of *Science and Civilisation in China* which began to appear from Cambridge University Press in 1954 and has continued ever since, now reaching 21 volumes, with no end in sight. Needham wrote much of the text himself, but he also assembled an excellent team of Chinese scholars to assist him and he set up an Institute in Cambridge to carry the project forward, even after his death in 1995.

The problem that inspired Needham to undertake this enormous task was the puzzling fact that Chinese civilisation had been ahead of the rest of the world in virtually every branch of science and technology until around AD 1500. In iron and steel technology, in the manufacture of fine porcelain, in paper and printing, in the use of the magnetic compass, and in the development of gunpowder – to mention only a few of the outstanding fields of technological skills – China led the world for well over a millennium. Yet in comparison with developments in Western Civilisation after 1500, when the Scientific Revolution and the intellectual Enlightenment transformed the technological competence of the West, Chinese science and technology were relatively stagnant. Needham's explanation of this remarkable shift in the balance of technological achievements was long and complex, but in summary it involved a number of cultural factors amongst which the most important was the crucial position played in the hierarchy of Chinese government by the mandarins – the professional, non-hereditary, clerical class – who determined most matters of economic policy and technological administration in successive Chinese empires. Needham argued that, despite the astonishing success of this clerical class in maintaining the stability of Chinese society over two millennia, it had acted as a brake on Chinese enterprise by preventing the adoption of innovations unless they were of immediate economic importance such as those involved in river works to control flooding. There is, of course, no completely satisfactory answer to the problem of what we have come to call 'the Needham Question', but by deriving his answer from a coherent mass of thoroughly researched evidence Needham has presented both scholars and administrators with a well-structured foundation for planning and action. There can be little doubt that the awareness of Chinese decision-makers to their own technological history has been greatly enriched by this work of scholarship, and that it has helped to promote the rapid advance of China in recent decades. In this instance, the work of one devoted historian of technology has had a truly momentous effect on the modern world.[1]

My second example is that of another academic, the distinguished American Professor of the History of Technology, Melvin Kranzberg (1917–1995). In the 1930s, Kranzberg was a promising student of European History who seemed destined to an academic career as a teacher of Modern French History. But service in the American army on the Western Front in the closing stages of the Second World War set him on a different trajectory. He returned to academic scholarship and established a reputation as a brilliant teacher and organiser, but his interests had widened from European History into more general cultural fields so that he took the lead in promoting the emergence of a new historical specialisation, the history of technology. Kranzberg used to like telling how he had been rebuffed by prominent historians of science when seeking to get more academic attention for technological history, so that he had decided to seek recognition for the history of technology as a discipline in its own right. His first great success in achieving this objective came with the founding of the Society for the History of Technology (SHOT) in 1958, with its own distinctive journal, *Technology and Culture*, of which Kranzberg became the first Editor. Within ten years, the SHOT and its journal had flourished mightily, with many American universities and colleges introducing courses and teaching posts in the history of technology.

Kranzberg always had the vision of SHOT as an international society, and from the early days it had supporters in Europe and elsewhere, and several excursions have been made abroad for its Annual Conference, but the bulk of its membership has remained American. However, Kranzberg seized the opportunity of meeting international representatives at the International Congress for the History of Science, Technology and Medicine to establish a 'Scientific Section' for the history of technology, and this was fulfilled in Paris in 1968 with the creation of ICOHTEC, as I have already described. By persuading historians from the Soviet Union and its dependent states to take part in its formation, Kranzberg managed to give ICOHTEC a modest but not insignificant role in overcoming the tensions of the Cold War by creating a genuine fellowship of scholars who sought constructively to explore the differences in their historical interpretations of technology. The organisation made a strong start with a Symposium organised by Maurice Daumas at Pont-à-Mousson in France in 1970. A Russian delegation was led by S. Schuchardine, and the first Chairman was Eugene Olszewski from Poland, and with Mel Kranzberg leading an impressive American delegation the meeting was a cordial and instructive occasion. It was the first of a long series of symposia, with meetings at first alternating in Europe between East and West. Whether or not ICOHTEC made any material difference to the course of political events, it flourished throughout the 1970s and 1980s. It then calmly rode out the collapse of the Soviet empire and the political reorganisation of Europe, and it has continued to provide a forum for international discussion of the history of technology into the twenty-first century.

Mel Kranzberg died in 1995, having attended his last ICOHTEC meeting in Bath, UK, the previous year, but he had lived to see the outstanding success of both SHOT and ICOHTEC. This was no mean achievement, greatly contributing to the establishment of the history of technology as an international discipline and demonstrating the value of the subject as a means of interpreting the character of modern industrial society. He remained to the end of his life a creative and effective scholar, coining such gnomic aphorisms as: *Technology is neither good nor bad, nor is it neutral*, the first of a series of 'Kranzberg's Laws of Technological History'. He was undoubtedly one of the giants of the history of technology, but he will be best remembered by those who knew him for his irrepressible good humour, his inspirational enthusiasm for his subject, and his unflagging support for his fellow scholars in the history of technology.[2]

The third of my great men of the history of technology is L.T.C. Rolt (1910–1974), the centenary of whose birth has been the subject of several commemorative ceremonies this year. Tom Rolt was trained as a mechanical engineer, but he discovered a talent for writing about engineers and their work in a way that was lucid and instructive, and used it to write a series of engineering biographies and industrial studies. His first great success came with *Narrow Boat*, an elegant travelogue of a voyage that he made with his first wife over the British canal network, at that time in serious decline as a result of rail and road competition, in the first months of the Second World War. Immediately after the war, this book became the rallying call of one of the most successful British conservation movements, the Inland Waterways Association, which was largely responsible for bringing the condition of the neglected waterways to the attention of the public and winning support for their retention and revival. Once launched upon the conservation of obsolete industrial artefacts, Rolt went on to inspire the preservation of narrow gauge mineral railways such as the Talyllyn Railway which had served a quarry in North Wales. Not only did he succeed in rescuing the decaying track and rolling stock, but he also organised the system of running such restored railways as a commercial venture staffed mainly by volunteers. It was a system which was then applied to many other redundant railways, including several of standard gauge tracks, and it has been tremendously successful in keeping such railways open as tourist attractions.

Rolt showed similar dedication and ingenuity in promoting several societies for the maintenance of Vintage and Veteran motor vehicles, the promotion of a National Railway Museum in York by the Science Museum, and the salvage of the rusting hull of I.K. Brunel's steamship *Great Britain* from the Falkland Islands. With the surge of interest in British industrial archaeology in the 1960s, Rolt generously devoted time and energy to the encouragement of a wealth of local society activities concerned with the conservation of the industrial heritage. The last and most ambitious of these was the Association for Industrial Archaeology (AIA), which grew out of conferences held at the University of Bath in the 1960s, and which had been unstintingly supported by Tom Rolt. It therefore was very appropriate that he should have become the first President of the AIA when it was established at a conference on the Isle of Man in 1973, and his death the following year was a sad loss to the conservation movement. But by then the main points had been secured in the recognition of the value of the industrial heritage and the creation of an administrative infrastructure to ensure its preservation, and Tom Rolt's legacy has been sustained by interest in his superb books, many of which remain in print and continue to enthuse new generations of readers in the lives and works of British engineers.[3]

These sketches of the careers of three men who have made substantial contributions to the history of technology represent a much larger number of men and women, scholars and practical people, who have been enthused by their example. While this sort of *ad hominen* discourse does not necessarily provide scientific proof of the importance of the history of technology, it nevertheless justifies the formulation of a series of propositions which imply such a conclusion. In the first place, these experiences demonstrate the value of a sound historical understanding to the successful conservation of the industrial heritage, and that the history of technology is an indispensable component of such intellectual equipment. This is because the history of technology illuminates most clearly the role played by the control of physical power in human history, determining the transitions between the four great human epochs: the reliance on human power alone during the long eons of hunter-gatherer societies; the introduction of animal power in the rise of societies depending upon agriculture and animal husbandry; the development of devices for the utilisation of wind and water power during the rise of urban civilisations; and the transition to mechanical power in the period of industrialisation, when human beings had begun to harness the deep powers of the universe. An understanding of this process implies an insight into the nature of invention and its transformation into successful innovation in manufacturing industry, in transport systems, and in modes of communication. Such an understanding had been firmly grasped by Needham, Kranzberg and Rolt, and it enabled them to interpret the social significance of the great transformations which they studied. Without such an historical understanding, both large scale and modest scale developments lack credible foundations and cannot produce lasting success.

The second proposition which I suggest arises from my 'case studies' is derived from the same historical understanding, and it is the perception that, for all its weaknesses, forms of democratic participation provide more enduring foundations for sound growth than any imposed by dictation from politically powerful elites. The major weakness of democratic governance is the difficulty of taking painful decisions, so that the choices which would be clinically the most efficient have frequently been moderated by compromises and rewards in order to make them socially acceptable. Nevertheless, the frustrations represented by Needham's analysis of the role of the mandarins in slowing down the rate of Chinese development, and the perception of Kranzberg that technology is capable of being used and abused by human direction, both illuminate the value of personal participation in government. When it comes to promoting the ingenuity of innovation and enterprise in society, technology is more likely to flourish where such qualities are encouraged by social rewards in a relatively 'open' society than in one under strong dictatorial domination. Democratic participation is thus a vital component in ensuring that effective controls are maintained over technological development. They can not prevent its abuse if it falls into the wrong hands, but they can protect the interests of the individual from being submerged by collective pressures.

As a third proposition, I suggest that historical understanding and democratic participation are both implied in well-contrived exercises in industrial conservation. This was clearly demonstrated in the many conservation campaigns undertaken by Tom Rolt, in which a well-informed historical intelligence harnessed the enthusiasm of teams of volunteers willing to devote their time, energy and money to achieving the preservation of key industrial monuments in ways which presented their power and working capacity. No serious conservationist would want to preserve everything from past industrial and transport systems, and the process of selecting the best specimens for conservation can be difficult, but it is important that those features selected for protection should be preserved as far as possible within their social and historical context. This means that, as Rolt clearly understood, they should be preserved as working exhibits, preferably doing the work they were intended to perform, although, as this would not normally be possible, they should at least be able to simulate the circumstances for which they were designed. Tom Rolt had a vision of the revival of the British canal network as a transport system serving the needs of modern industry, but as this was no longer a realistic objective he had to settle for saving the canals as attractive social amenities and sources of tourist revenue. It was for him a second-best, but better than the complete annihilation of the canals which seemed imminent in the 1940s, and it represented the conservation of a valuable educational and leisure amenity.

The conclusion that I wish to draw from these sketchy observations is that the enterprise of discriminating conservation in which ICOHTEC and TICCIH are both engaged, with their different but convergent emphases and perspectives, is one in which the illumination of a constructive understanding of the history of technology is of fundamental importance. Without it, we are likely to preserve the wrong things and to display them in ways that are out of context and as such are either inaccurate or meaningless. With historical understanding, however, they acquire a 'landscape' and become powerful instruments of illumination and enjoyment. To secure such a combination it is necessary to build up our expertise in the history of technology, academically and professionally, and to make sure that we give it scope to determine the future development of conservation policy. The way in which this is done will obviously vary from one national tradition to another, but the need to promote the relationship between the history of technology and the strategies of conservation is one to which we all need to apply our resources. As the joint conference of ICOHTEC and TICCIH in Tampere recently demonstrated, the discourse arising from this conjunction has begun: let us hope that it will continue to flourish.

NOTES

1 For Joseph Needham, the best resource is the multi-volume *Science and Civilisation in China*, but the argument of the 'Needham Question' is more succinctly presented in various essays which Needham wrote, such as those published as *The Grand Titration: Science and Society in East and West* (London, 1969). An excellent recent account of Needham's career has been written by Simon

Winchester: *Bomb, Book and Compass: Joseph Needham and the Great Secrets of China* (London, 2009; first published in the USA as *The Man Who Loved China* by Harper Collins in 2008). I have also found useful the obituary notice and commemorative articles in *The Caian*, the magazine of Gonville and Caius College, Cambridge, for 1994–1995 and for 2003–2004. I am grateful to my friend Christopher Couchman, for bringing these articles to my attention.

2 For Melvin Kranzberg, see Robert C. Post, 'Chance and Contingency: Putting Mel Kranzberg in Context', in *Technology and Culture*, 50 (October 2009): 839–872.

3 For Tom Rolt, the best account is his autobiography, published in three volumes: *Landscape with Machines* (London, 1971); *Landscape with Canals* (London, 1977); and *Landscape with Figures* (Stroud, 1992). For some of his best writing, see also *Narrow Boat* (many editions since 1944), and *Isambard Kingdom Brunel* (London, 1957).

Piano Manufacturing between Craft and Industry:

Advertising and Image Cultivation of Early 20th Century German Piano Production

Sonja Petersen

Piano-making is often seen as an artisan craft, but through the late 19th and early 20th centuries this craft developed into a fully mechanized industrial manufacturing sector. Small artisanal one-man workshops shifted to large factories based on division of labour and mechanization throughout the entire manufacturing process. Piano-making companies established scientific laboratories and collaborated with external domain experts, such as physicists, to develop special components of their instruments and exchange innovative thoughts and ideas. These companies, as examples of German craft-oriented industry, use(d) their industrial development to demonstrate technological improvements, distance themselves from the received opinion of piano-making as a backward sector and cultivate an image of progressiveness. Based on a case study of the Grotrian-Steinweg Piano Company in Brunswick, I explore how piano-making was transformed from an artisanal handcraft into a fully mechanized industry.

INTRODUCTION

In popular culture, piano-making is seen as an artisan craft. The artisan spends thousands of working hours without the efficiency of complex machinery to produce a magnificent, melodious concert grand based only on individual expertize and skill. This artisanal stereotype persists, in large measure and piano-making companies themselves encourage it. But the craft of piano-making began to change in the second half of the 19th century because of industrialization and changing musical tastes. Even before the industrialization of piano-making, one person alone did not build pianos. In the small pre-industrial workshops, there were always several craftsmen and journeymen who contributed to the production of each instrument.[1] I argue

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here, however, that the field converted from artisanal handcraft to a modern factory-based industry through the introduction of the division of labour and the use of machines.

As a successful example of German craft-oriented industry, piano-making (in addition to silk-weaving, toy-making, and the colour-print industry) increased German exports to England significantly between 1870 and 1913. In 1870, British, American and French piano-makers annually produced between 21,000 and 25,000 pianos apiece, while German piano-makers produced only 15,000 pianos per year. Forty years later, German piano-makers ramped up production to 160,000 upright pianos and 12,000 concert grands per year, of which 50 percent were for export. In the same early 20th century period, British manufacturers produced about 86,000 instruments, exporting 10,000 units, but importing 24,500, at least 22,500 of which had been produced in Germany. By 1913, Germany was perceived as the leading global exporter of pianos; German piano-makers held 20 percent of the world market and, after the United States, was the second-largest producer.[2] The success of German piano-makers was based on a rapid organization of rationalized and mechanized factories beginning in 1870. Instead of crafting each piano in-house, components were obtained from specialized third-party suppliers. By engaging modernized production techniques and supply chains, German piano-makers quickly took over the most important technical developments of the instrument during the second half of the 19th century (for example, the cast iron frame and cross stringing). The development of the piano as an instrument and status symbol of the bourgeoisie influenced the transformation from handcraft to industrial production. The growing middle class created demand for lower-priced pianos, and production methods evolved in parallel to provide a steady supply. This innovation process prompted new developments in technical standardization to accommodate increasingly mechanized factory-based production models of pianos.[3]

Most 21st century piano-making companies emphasize traditional production methods in their advertisements. Atmospheric and mystic photographs demonstrate the stereotype of an artisanal one-man workshop as described above. But that was not the reality during the portrayed transformation process of the industry between 1870 and 1930. During this time period, piano producers began adopting advertising methods that, in the case of the Grotrian-Steinweg Piano Company, for example, demonstrated modern production methods – the industrial reality. In the first section of this article, I discuss the development of production methods in piano-making companies from Austria, the United States and Germany. Based on a case study, I will show in section two how the German company Grotrian-Steinweg changed their advertising strategy because of significant changes in production methods and their establishment of an internal acoustic laboratory. Quite simply, between 1870 and 1930, piano-making companies used their industrial development to demonstrate technological improvements and, by changing advertisement strategies, distanced themselves from the dominant view of piano-making as a technologically impoverished industrial sector.

FROM HANDCRAFT TO INDUSTRIAL PRODUCTION – AUSTRIAN, AMERICAN AND GERMAN PIANO-MAKERS BETWEEN 1870 AND 1930

The development of the American and German piano industries ran parallel to the process of industrialization. At the end of the 18th and well into the 19th century, small craft workshops dominated piano-making. The workshop was part of the home of the master, and his journeymen learned through observation and imitation, often living in the master's house. Pianos were expensive luxury goods, and as individual pieces, they carried the signature of the master.[4] During the 19th century, small artisan workshops became less important, giving way to the rise of modern mechanized factories. This change in production mode began around 1830 and by 1850 was widely exploited, thus beginning the industrialization of piano-making. As manufacturing plants grew in number, more workers were employed, division of labour implemented, and individual components obtained from a specialized supply industry. In Germany, this coincided with the establishment of a unified economic area and abolition of guild regulations, which was decisive for the country's economic upturn in general. By 1900, the change from artisanal workshops to large factories was fundamentally complete. In comparison to German as well as British and North American production, handcraft remained the dominant feature of the Austrian piano industry.[5]

The peak of worldwide production was reached shortly after 1900; between 1850 and 1910 worldwide production of pianos increased from 43,000 to 600,000 instruments per year. The proportion of European producers was reduced in the same period from two-thirds to one-third, while the proportion of American producers increased from one-quarter to over two-thirds. England and North America dominated the export sector, their position supported by the quick development of the North American wood-processing and steel industries. Meanwhile, Germany became an ever-stronger exporter at the end of the 19th century.[6]

The famous company Steinway & Sons, founded in 1850 by German producer Heinrich Engelhard Steinweg and who later named himself Henry Steinway, is an example of the American industrial production of pianos.[7] Steinweg emigrated from Germany in 1850 with two sons, Charles and Henry, Jr., and founded their business in New York.[8] By 1914, Steinway's

American-based manufacturing was configured for large production figures. The U.S. had moved quickly to industrialize production and its 478 factories employed 41,723 workers, whereas Germany lagged behind, its 1,680 smaller piano-making companies employing only 26,000 workers.

On arriving in New York in 1850, the Steinways opened a small workshop in the city, but soon they rented a larger space. At the time, they did not have a circular saw or planing machine for woodworking. There were no elevators to transport the heavy, large instruments between the shop's floors. Soon the family relocated their production area to a district on the edge of New York City along the railway to New Haven. The new six-level L-shaped factory with 16,258 square metres was built at a cost of $150,000. Three steam engines heated the building, and four drying cabinets for 76,000 cubic metres of wood were installed. The steam engines also produced energy for saws, lathes and planing machines. No other piano-making factory had more belt transmission-driven machines at the time, but despite the purchase of significant mechanical resources, production time did not shorten; rather, it increased, because most workers were untrained on the new machinery.[9]

In 1870, Steinway & Sons expanded again with a new factory. A separate wood storage facility with a capacity of 4,600,000 square metres was built in Queens on 162 hectares of land, which stretched along 800 metres of the East River. The location had the advantage that millions of cubic metres of wood, several tons of pig iron, sand for casting moulds and other large lots of materials could be delivered easily with load cranes. Steinway & Sons built iron and brass melting and processing enterprises in Queens and produced nearly every component of their instruments at the factory. The company's new factory was an example of the characteristic vertical integration of American industry after 1840. It integrated all the production sectors necessary to build a piano – an iron and brass melting facility, sawmill, metal processing enterprises – and the location promised cheap and quick transportation access for raw materials. All this allowed Steinway & Sons to launch mass production of pianos in 1870.[10]

In contrast to the developments in North America, Austrian piano-making was characterized by craftsmanship for a long time. During the first third of the 19th century, piano-making became the most important Viennese economic sector, although production output stayed low in comparison to Germany, and even lower in contrast to the production levels achieved in North America. Around 1847, at the Company Seuffert, 20 to 30 workers produced 90 to 120 instruments per year. Twenty years later (1870), 100 workers produced 600 instruments per year. In 1845, all the Viennese piano-making companies together produced about 2,600 pianos. In comparison, the single London firm Broadwood & Sons produced 2,300 instruments.

During the second half of the 19th century, Austrian production shifted to the slightly larger factories of Bösendorfer and Ehrbar (Bösendorfer never employed more than 120 workers at a time); however, as the century closed, the Austrian piano-making industry still lagged behind because its companies only very slowly embraced new technical developments. For example, in 1900, Bösendorfer still produced pianos with an outdated Viennese hammer action which had been replaced by the English hammer action.[11] Even in 1900, machine use was only accepted where, as Ludwig Bösendorfer stated in 1885, '… a mechanical dull world was created, where humans with their valuable capabilities should be relieved.'[12] Bösendorfer adhered to the craft ideals of his profession even at the beginning of the 20th century.[13] In 1910, he produced instruments with craft-based production methods and demonstrated them in photographs. It is striking that the workers did not work when the photographs were taken. Rather, they, their tools and their work pieces were arranged in the rooms. Not a single machine was shown or represented in any of the photographs. The 1910 photographs suggest that pianos were produced only by handwork, but machines may have been used at least for preparatory works.[14] They also reveal a division of labour, because different workers carried out the steps of production in different rooms.

In 1870, almost 100 workers touched each piano during the course of production at Bösendorfers, and an additional 100 men worked for other companies supplying the firm. In 1910, Bösendorfer produced 404 instruments, which meant that only one or two instruments left the facility each day.[15] Although Bösendorfer used machines at least for preliminary work, their photographs and advertising did not show this so as to preserve the myth of a piano-making company characterized only by handcraft methods.[16] In their 'Arbeitsnummernbücher' between 1870 and 1970, each production step is documented for each instrument. Up to 15 different steps of production can be detected: making the cabinet, the soundboard, the frame, stringing, installing the damper, assembling, varnishing, voicing and tuning, to name only a few.[17] This documentation shows that already, in 1870, there was an extended division of labour in a less mechanized company.

In contrast to Viennese piano-making, the German method, which also was characterized by handcraft production until the middle of the 19th century, began employing industrial production methods after 1850. At the beginning of the 19th century, German pianos were made by hand, and most of the early piano-making companies were family businesses that employed few workers. Piano-makers and masters produced all components in-house. During the first quarter of the century, when industrialization started in Germany and transportation and communications systems developed, the first piano-making centres appeared in Leipzig, Dresden, and Stuttgart, and the first specialized workshops producing single components also appeared.

In 1879, Berlin replaced the earlier piano-making centres, and a differentiated supply chain evolved in which supply companies with specialized machines produced low-cost single components, such as cast iron frames, strings, and actions. The larger companies organized production in factories with division of labour. Thus, rationalization and standardization took place during the second half of the 19th century. This change to mass production was possible due to the adoption of the so-called American system of piano-construction, which employed e.g. cast iron frames and cross stringing. The division of labour also led to many different working operations that demanded different qualifications. Skilled workers were prized and well paid, whereas semi-skilled and unskilled workers did less difficult operations and were poorly paid. Machine work and handwork existed side by side, while specialists and managers monitored the work process and compliance with defined targets.[18]

The Grotrian-Steinweg Piano Company of Brunswick provides an appropriate example. This small workshop developed over a period of less than 100 years into a large, fully-mechanized 30,000 square metre factory. Over 900 workers were employed, and the managers standardized and systematized company knowledge in correlation with standardization and mechanization of production. This process led to the establishment of an acoustic laboratory around 1930, in which a physicist carried out acoustical tests.[19] Whereas Bösendorfer emphasized the perception of its production methods as handcraft, Grotrian-Steinweg changed their advertising strategies in line with their industrial development. Around 1900, Grotrian-Steinweg began emphasising their industrial production methods and scientific research to demonstrate their progressiveness, long after the industrialization of piano-making had become established.

IMAGE CULTIVATION THROUGH PHOTOGRAPHS – GROTRIAN-STEINWEG PIANO COMPANY

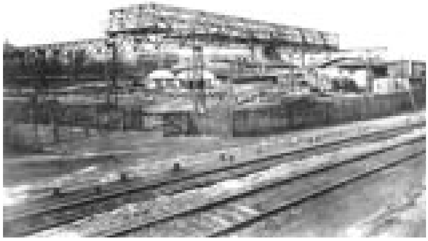
The transformation of the Grotrian-Steinweg Piano Company of Brunswick, Germany from a small handicraft workshop into a large industrial factory is illustrated by a 1924 photo album, which allows one to look inside the company and at the technical equipment that generally stayed hidden from outsiders. It demonstrates how the company wanted to be seen from outside.[20] The company evolved from the workshop of Heinrich Engelhard Steinweg, established in 1835 in Wolfenbüttel. His son Theodor Steinweg (later named Steinway) merged with Georg Friedrich Grotrian and they relocated the workshop to Brunswick. In 1865, after tragic deaths in the family, Theodore Steinway immigrated to the United States to help his brother Henry stay in business, selling his stock in the Brunswick firm to his German partners, H. G. W. Schulz, Aldolph Helfferich and the son of Georg Friedrich Grotrian, Wilhelm Grotrian. From 1886 onward, Wilhelm Grotrian was sole owner of Grotrian-Steinweg, and in 1895, his sons Kurt and Willi joined the company, becoming partners in 1917.[21] Through Wilhelm's tutelage, the technical management rested mainly in the hands of Willi Grotrian. After Theodore Steinweg's 1865 departure to join Steinway and Sons in the USA, the Grotrian's retained the name Grotrian-Steinweg, even though the Steinwegs were no longer associated with the firm.

The 1924 photo album documented all production steps with hundreds of photographs. They take the viewer on a tour of the factory, from the delivery of wood and through each individual production step to the finished instrument. In contrast to the well-known romantic pictures of piano-making, Grotrian-Steinweg wanted to demonstrate their progressivness and efficiency. While pictures exist that clearly depict the handcraft aspects of piano production, one is struck by the fact that there are also many pictures that showcase the company's industrial and scientific methods, such as a photo of the 'scientific examination of resonance wood' in a testing or drawing room.

The album's first pages show company buildings and outdoor areas from all directions. Photo 1, for example, shows a typical 30,000 square metre multi-level industrial factory with clinker or brownstone façade, which at the time employed 900 workers. Only the wood sheds point out that a wood product was produced in the building.[22] Except for the sign 'Flügel & Pianos' (Grands & Pianos) appearing on the building, no one would have known what product was fabricated in the facility.

Photo 1. The factory building of Grotrian-Steinweg Piano Company, 1924, Brunswick, Germany. By courtesy of the Grotrian-Steinweg Piano Company.

Photos 2 and 3 show the storage facility with assorted logs, two machine shops, a shed, rails and a crane system located directly at a railway, which allows easy delivery of wood.[23] The chosen imagery is dominated by technology, in this case by the modern crane system called 'Riesenkran' (giant crane), a kind of loading crane that runs on two guide rails and has a cantilever arm and a lifting device (photo 3, right). Behind the crane, a freight train can be seen. A man positioned under the cantilever arm and conducting a lifted log with a chain demonstrates the proportions of this machine.




Photos 2 and 3. The timber stockyard of Grotrian-Steinweg Piano Company, 1924, Brunswick, Germany. By courtesy of the Grotrian-Steinweg Piano Company.

A track runs from the railway into the storage place, and freight wagons could be placed directly under the cantilever arm to be unloaded with the giant crane. The logs were then sorted at the timber stockyard (photo 2, left), and after the logs had been unloaded and sorted, they could be forwarded directly to the adjacent lumber mill. Again, the giant crane was used to lift the logs on to a rail-guided lorry. The rails ran directly into the lumber mill where the logs were pre-cut before shipment to the timber stockyard where they would dry for several years. The crane system, as presented in the photographs, is a symbol of Grotrian-Steinweg's industrial presence, cultivating the image of the company as a modern and progressive piano-making factory of the early 20th century.[24]

The photo album contains two different groups of production photographs, one group showing production rooms in which workers work on machines and the other showing rooms in which handwork dominates. Over twenty different production steps are documented in these photos, such as, for example, wood cutting, drilling and lacquering cast iron frames, rim making, rim bending, board making, work on the soundboard, adjusting works on the frame, soundboard fitting, veneer cutting, gluing of veneers and installation of the action and keyboard. Hand and machine work clearly coexisted in 1924.

Photo 4 shows an industrial production method for machine processing of the cast iron frames. Three electric drill machines with corresponding workbenches are located in front of the windows. At each machine stands a man, who drills the cast iron frames that lay on the workbenches. The drill machine is positioned on a swivel arm with two hinges, which allows the drill machine relatively free movement over the workbench and cast iron frames. This was necessary because the frames could be up to 2.9 metres long. At the right side of the photo, two men are seen preparing the cast iron frames for drilling by hand. The man in the front uses a hammer and chisel to mark the holes that will be drilled by the drilling machines. It is evident that in this production step machines have become important and that

Photo 4. Machine processing of the cast iron frames, Grotrian-Steinweg Piano Company, 1924, Brunswick, Germany. By courtesy of the Grotrian-Steinweg Piano Company.

aspects of production at Grotrian-Steinweg used modern equipment.[25] The photo is staged, particularly as the man with hammer and chisel seems to stop in his movements, betraying the fact that actual work was not being performed at the moment the picture was taken.

At the beginning of the 20th century, Grotrian-Steinweg was already using machines such as a band saw, dressing machine and planing machine.[26] The use of machines for rough work increased during the next twenty-five years, but fine job steps still were executed by handwork. In 1906, Willi Grotrian thought that machines in piano-making only could be used for rough work and that machines would never be used as extensively as in the iron industry.[27] He also believed that specialized machines would reduce profits and thus were not cost effective. Finally, he valued hand workers over less capable machine workers: 'These kinds of workers have to be chosen carefully … Proficient and diligent people in good piecework are much better and work more than unintelligent workers … who also cause more accidents.'[28]

By the 1920s, Grotrian-Steinweg's machine use had grown steadily, and included machines of varying size and complexity to do general planing, milling, drilling, tennon cutting, rim milling, joining, moulding, round-bar planing, sandpaper grinding, sawing (with both circular and scroll saws), veneer brushing, soundboard planing and bridge milling. The company used several specialized machines as well, designed specifically for the special needs of piano manufacturing and accounting for the characteristics of different materials.[29] Due to the division of labour, workers became specialized in their skills. While workers needed specific skills to operate machines, machines did not replace the ideal of handwork.

Skilled workers remained irreplaceable in the piano-making industry, both for handwork and for the operation of machines. As early as 1906, Willi Grotrian wrote a document showing that mechanized and handwork coexisted in the factory, and that workers' personal experience, scientific knowledge and methods contributed significantly to the production process.

Scientific methods were adopted, and other companies besides Grotrian-Steinweg, then as now, aimed to demonstrate scientific methods with an emphasis on applied scientific knowledge evidenced in photographs and advertisements.

The adjustment of the piano's action and keyboard (photo 5) is an example of enduring handwork. We see a room brightened by daylight with work-benches. An instrument would be positioned opposite each workbench, and the action and keyboard could be put on the benches for adjusting before being put inside the instrument.

Photo 5. Adjustment of action and keyboard 1924, Grotrian-Steinweg Piano Company, Brunswick, Germany. By courtesy of the Grotrian-Steinweg Piano Company.

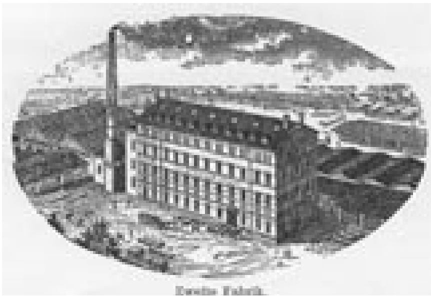
No large machines can be seen, but this and other pictures demonstrate that pianos were made in larger factories with many workers. Further, they show that nearly each production step was done in a different room. Industrial photographs were often staged, as in photo 4, with workers merely pretending to be working.[30] But many of the Grotrian-Steinweg pictures are different, and most of them, as in photo 5, actually depicted real work. The blurred man in the middle provides strong evidence of this, as he is moving too rapidly for the exposure time of the contemporary photographic technology.[31] Of course, Grotrian-Steinweg had an interest in pictures showing attractive perspectives and in which technology was put into the limelight, but most of these also documented aspects of the authentic work processes.

ADVERTISING – HOW TO USE YOUR INDUSTRIAL PAST AND PRESENT

As we have seen, piano-making developed after 1850 from handcraft to industrial production, even as it stayed a handcraft-oriented industry. But how was the contrast between this industrial past and the present leveraged by the piano-making companies themselves? Some used advertisements to demonstrate progressiveness only during a specific period; others continuously and conspicuously emphasized their glorious artisan past right into the modern era. Steinway & Sons, for example, highlighted collaboration with scientists like Hermann von Helmholtz, who published the groundbreaking book on acoustics, *On the Sensation of Tones*.[32] Theodore Steinway studied Helmholtz's work and actively corresponded with him, as well as provided him with several pianos for his experiments. Steinway & Sons was consequently able to endorse their instruments with proven scientific statements. They did so, for example, with a letter from Helmholtz in June 1871: 'With such a perfect instrument as yours … I must modify many of my former expressed views regarding pianos.'[33] Steinway & Sons also used a letter from 1873 in which Helmholtz praised a new development, the so-called *duple scale*. Helmholtz wrote that he had examined the new development and said it significantly improved the sound of the strings.[34] Theodore Steinway exploited the advertising potential of this letter in an article for the journal *Signale für die Musikalische Welt*. By citing Helmholtz, he drew on the opinion of one of the best-known contemporary physicists for support of his pianos. Steinway & Sons also intentionally displayed their factory and explicitly referred to their industrial production methods in advertising. They used their industrial past and present in concert with scientific contacts to demonstrate their progressiveness at the end of the 19th century. Their advertising and production methods were aligned for strategic advantage in managing the public perception of their instruments.

Grotrian-Steinweg started using industrial production methods slightly later than Steinway & Sons and with more care. Until 1900, only some hints about their industrial production could be found in advertisements. For example, in two advertising leaflets, one from 1898 and one from 1899, the reverse side displays drawings of the factory buildings (photo 6, left, and photo 7, right)

The drawing of 1898 shows a typical multilevel, brownstone factory building with wooden sheds on the sides and two horse carts in the front of the main building. They appear to be loaded with products. A typical smoking chimney is, of course, visible. This drawing demonstrated, on the one hand, the progressiveness of the company, but on the other hand, it invokes romanticized imagery. One year later, the factory drawing had changed (photo 7). Now the customer looks at a huge U-shaped factory plant with many woodsheds. The romantic horse carts still symbolize the past and the smoking chimney the present. Whereas the drawing from 1898 has more romantic elements the 1899 drawing conveys an impression of a



Photos 6 and 7. Drawings of the factory buildings of the Grotrian-Steinweg Piano Company, 1898 (photo 6) & 1899 (photo 7), Brunswick, Germany. By courtesy of the Grotrian-Steinweg Piano Company.

full industrial production unit. Both are industrial drawings typical of the time, but did the drawings correspond to the written texts?

The 1898 advertising text starts with a list of royal courts to which Grotrian-Steinweg provided instruments and a list of famous pianists, such as Franz Liszt and Clara Schumann, who played Grotrian-Steinweg instruments. They also named famous musical conservatories that used their instruments, implying that future generations of piano genius would be developed through the use of Grotrian-Steinweg instruments. The advertisement goes on to mention medals awarded the firm in several exhibitions, such as the Chicago World's Fair of 1893. The company is mentioned as a factory only once, but with no further detail. The only hint that the instruments were built by industrial production methods was the drawing on the back of the leaflet.[35] The 1899 advertisement showed a more industrial-looking drawing of the factory, emphasing that their craft tradition had already shifted during preceding decades into a large factory with industrial production methods. Not surprisingly, the company also still highlighted the quality of their instruments with references to royal courts, music conservatories and pianists. They emphasized the craft-tradition, but gave small, yet identifiable hints of their progressive production methods with industrial-style drawings on the leaflet's back cover.

In a 1904 leaflet, we find the same drawing on the back cover as that of 1899. The statements that the company had manufactured pianos for several royal courts as well as praise of pianists and conservatories were still conspicuously included. But now the company additionally described their industrial production methods and cultivated their image of progressiveness:

> The factory employs 250 experienced workmen, controlled by a highly efficient officer staff. It consists mainly of five storied buildings, admirably arranged, constructed upon the most approved principles and equipped with excellent timber drying and seasoning sheds. It is capable

of an annual production of about 1,000 pianos and over an area of 169,000 square yards.[36]

Note that the phrase '… controlled by a highly efficient officer staff …' highlights the separation of management and production as an important characteristic of industrial production. While these are the only sentences concerning industrial production methods in the leaflet, the combination of craft past and industrial present shows a significant change in Grotrian-Steinweg's strategy: they were selling their instruments not only by promoting their glorious past but also by beginning to combine this romanticized historical position with their industrial and, later, scientific present.

Grotrian-Steinweg emphasized both the importance of progressive industrial production methods and the irreplaceable experience of craftsmen. Consumers could be sure, even if Grotrian-Steinweg had a modern factory equipped with the latest technologies and machines, that the quality of their instruments still depended in part on the handwork and experience of craftsmen. With the combination of handwork and industrial production, customers could benefit from the firm's progressivness as well as from its celebration of what was now a piano-making myth of artisanal handcraft.[37] This combination also is seen in a 1912 advertisement, in which the company emphasized their modern factory and equipment but also their discipline and cleanliness. They notably called to attention the semantic differences between fabrication and building and between mass production and artisanal craft, the latter terms connoting the familiar and expected handcraft-based expectations of traditional piano construction. Interestingly, they chose the comparison of Cremona and Markneukirchen to characterize production, with Italian Cremona as the piano analogue of Antonio Stradivari, the world's premier violinmaker, as culturally definitive of artisan craft in instrument production. The German Markneukirchen, on the other hand, communicated the imagery of industrial mass production and low cost violins and other string instruments. Naturally, Grotrian-Steinweg aligned their factory and products with those of Cremona.[38]

But Grotrian-Steinweg did not stop at merely demonstrating scientific methods; they employed physicist Dr. Heinrich Hörig and established an internal acoustic laboratory during the 1920s.[39] They did not hesitate to highlight that the composition of their soundboards, consisting of wood pieces, was fabricated in their scientific laboratory. There, special attention was given to tightness and elasticity of each piece, and the final product was marketed as the 'homogenous soundboard of Grotrian-Steinweg'. They claimed that the scientific procedure guaranteed that each instrument was of consistent high quality, the result of the scientific method where specialists improved new methods to build the perfect piano.[40] The modern equipment and methodology were presented in an advertisement printed around 1927, which contained not only written material but also photographs of the production line as well as of the laboratory.[41] The company pointed out that their pianos' construction was based on scientific research methods and emphasized this statement with photographs of different test-benches and measurement devices and the documentation of sound figures. Nothing was left to chance or imagination. Only the latest scientific methods applied with mathematical precision ensured that every instrument was of the same quality.[42] Contrary to the days when only craftsmen guaranteed a good instrument, now it was the modern-equipped factory with a laboratory and scientific methods that made such a guarantee. Especially in an English-language advertisement, Grotrian-Steinweg emphasized their progressiveness (photo 8): 'Not only as humanly perfect as it is possible to be but also as meticulously perfect as the most advanced resources of Physical Science can make it – THAT is the secret of the glorious Grotrian-Steinweg Tone – so superbly beautiful that it is unforgettable.'[43] The company advertised a combination of science and craft: 'It is fascinating to take a glimpse at some of the exclusive Grotrian-Steinweg technical patent processes which, allied with the loving care of each and every craftsman, and the most up-to-date scientific equipment in the world, make it impossible for any other instrument to equal the superlative standard of Grotrian-Steinweg Pianos.'[44]

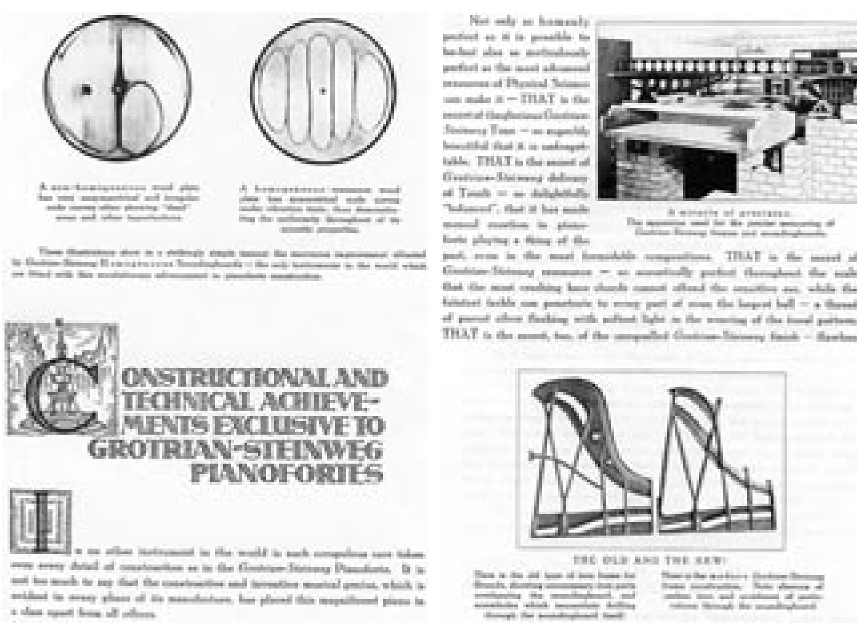


Photo 8. English-language advertisement, Grotrian-Steinweg Piano Company 1927, Brunswick, Germany. By courtesy of the Grotrian-Steinweg Piano Company.

Photo 8 juxtaposes the different forms of knowledge that have been characteristic of piano-making as a craft-oriented industry, even if the knowledge emphases in the image cultivated by piano-makers themselves differed over the years. It also shows that Grotrian-Steinweg wanted their customers to believe that the combination of scientific methods and craft experience guaranteed as good an instrument as had the craft methods alone in the earlier 19th century.[45] Grotrian-Steinweg followed a similar approach to Steinway & Sons by using statements of scientists for advertisements, such as the work of Dr. Adolph Aber of the University of Leipzig, who wrote about the homogenous sounding board.[46] The most important statement, however, seems to be that through the development of scientific methods the construction of pianos of equal quality was guaranteed. In contrast to traditional methods, these quoted scientific methods could be found in numerous professional journals and newspaper articles all over Germany.[47] Grotrian-Steinweg effectively used the industrial and scientific past as well as their present to demonstrate progressiveness and, of course, to sell their instruments.

CONCLUSION

The history of piano-making as an example of German craft-based industry shows that the artisanal craft of piano-making changed during the 19th century to a fully mechanized industry that also used the latest scientific research results to produce greater production efficiency and quality, even though the modern production methods used did not always match the external presentation of the companies. Shifts in the social and political economy around 1900 prompted a need to show a progressive orientation; thus, German piano manufacturers leveraged their industrial past and present by representing and describing factory buildings, equipment and industrial and scientific methods in photographic documentation and advertisements, even though the industrialization of piano-making actually started some fifty years earlier. But now it was important for piano manufacturers to distance themselves from dominant cultural views that piano-making was a technologically lagging sector, even as they capitalized on the past by the continued framing of piano production as a craft.

Grotrian-Steinweg's strategy changed again after 1945. At the conclusion of World War II, hints about production methods disappeared in their advertising, but the expertize of Clara Schumann remained. The quality of instruments was not evidenced by showing the industrial past, but by demonstrating the cost effectiveness and space-saving potential of instruments. For example, Grotrian-Steinweg developed a fabric-covered upright piano, which was affordable and small enough to be fitted into the interior of any flat or house.[48] Today, nearly all piano-making companies have resumed showing their handcraft methods, even when they use advanced technologies, such as CAD machines.

NOTES

1 S. Petersen, *Vom 'Schwachstarktastenkasten' und seinen Fabrikanten: Wissensräume im Klavierbau 1830–1930* (Münster, 2011), 11.

2 C. Buchheim, 'Grundlagen des deutschen Klavierexports vom letzten Viertel des 19. Jahrhunderts bis zum Ersten Weltkrieg', *Technikgeschichte*, 1987, 53: 231–240 (see 109–113, 231–236); C. Buchheim, *Deutsche Gewerbeexporte nach England in der zweiten Hälfte des 19. Jahrhunderts. Zur Wettbewerbsfähigkeit Deutschlands in seiner Industrialisierungsphase: Gleichzeitig eine Studie über die deutsche Seidenweberei und Spielzeugindustrie, sowie über Buntdruck und Klavierbau* (Ostfilden, 1983).

3 Ibid.; D. Schmidt, 'Das Klavier kann alles' – Klavierbau und Klavierspiel im 19. Jahrhundert', in *Homo faber ludens: Geschichten zu Wechselbeziehungen von Technik und Spiel*, eds., S. Poser, K. Zachmann (Frankfurt, 2003), 135–154; G. Zuna-Kratky, ed., *Technisches Museum Wien* (München, Berlin, London, New York, 2002), 136–144.

4 C. Meglitsch, *Wiens vergessene Konzertsäle: Der Mythos der Säle Bösendorfer, Ehrbar und Streicher* (Frankfurt, 2005), 17; E. M. Good, *Giraffes, Black Dragons, and other Pianos: A Technological History from Cristofori to the Modern Concert Grand* (Stanford, 1982), 58; C. Ehrlich, *The Piano: A History* (Oxford, 1990), 9.

5 G. Pfeiffer, Die Entwicklung der deutschen Pianoforteindustrie (PhD, diss., Wirtschafts-universität Wien, 1989), 30.

6 I. Bontinck, 'Das Klavier im 19. Jahrhundert. Technologie, künstlerische Nutzung und gesellschaftliche Resonanzv', in *Das Klavier in Geschichte(n) und Gegenwart*, M. Huber, M. Desmond, E. Ostleitner, A. Smudits, eds. (Strasshof, 2001), 11–31 (see 13–23); L. Botstein, 'Ludwig Bösendorfer: Viennese Traditionalism and Cosmopolitan Modernitiy in Conflict', in *Festschrift Otto Biba zum 60. Geburtstag*, I. Fuchs, ed. (Tutzing, 2006), 545–565 (see 551–552); N. Ely, 'Pianofortebau in Deutschland', in *Faszination Klavier 300 Jahre Pianofortebau in Deutschland*, K. Restle, ed. (München, London, New York, 2000), 163–226 (see 166); H. Henkel, *Besaitete Tasteninstrumente. Deutsches Museum - Kataloge und Sammlungen: Musikinstrumenten-Sammlung* (Frankfurt, 1994), 9; Meglitsch, *Wiens vergessene Konzertsäle*, 17–24; Schmidt, 'Das Klavier kann alles', 135; Pfeiffer, *Entwicklung der deutschen Pianoforteindustrie*, 10–25.

7 R. K. Lieberman, *Steinway & Sons. Eine Familiengeschichte um Macht und Musik* (München, 1996).

8 Bontinck, 'Das Klavier im 19. Jahrhundert' , 14.

9 Lieberman, *Steinway & Sons*, 42–43.

10 Ibid., 125–128; A. D. Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass, 1980), 7; Ehrlich (n. 4 above), *The Piano*, 50–54.

11 Botstein, Ludwig Bösendorfer (n. 6 above), 549–550; Meglitsch, *Wiens vergessene Konzertsäle* (n. 4 above), 17–22. M. Meyer, Historische Betriebsanalyse der Firma L. Bösendorfer Klavierfabrik AG unter besonderer Berücksichtigung der Entwicklung der österreichischen Klavierindustrie und der Exportaktivitäten des Unternehmens (PhD. diss., Wirtschaftsuniversität Wien, 1989), 82–90; Pfeiffer, Entwicklung der deutschen Pianoforteindustrie (n. 5 above), 35. Zuna-Kratky, *Technisches Museum Wien* (n. 3 above), 143. V. Cizek, Die Geschichte der Firma Seuffert und Ehrbar, nebst der Geschichte des Klaviers als ausführliche Einleitung (Diploma Thesis, Wirtschaftsuniversität Wien, 1989), 57.

12 Translation by author: '… wo eine meachnische geistlose Arbeit geschaffen und wo der Mensch all seiner besseren Leistung fähig und würdig solcher Arbeit enthoben werden soll.' See Ludwig Bösendorfer 1885, quoted in Meglitsch, *Wiens vergessene Konzertsäle* (n. 4 above), 24.

13 L. Bösendorfer, *Das Wiener Clavier. Die Grossindustrie Österreichs* (Wien, 1898).

14 Historical photographs from Bösedorfer, Vienna, 1910. Archive of Gesellschaft der Musikfreunde Wiens. Vienna, Austria. Legacy of Ludwig Bösendorfer, fascicle G, folder I, no. a-d.

15 Megltisch, *Wiens vergessene Konzertsäle* (n. 4 above), 64–65.

16 Opusnummernbuch September 22, 1898 to December 26, 1900, No. 14736-15640; Opusnummernbuch January 1901 to May 30, No. 25641-1531; Opusnummernbuch 1903 to 1905, No. 16529-17435; Opusnummernbuch 1905 to 1907, No. 17436-18402; Opusnummernbuch 1907 to 1909, No. 18403-19002; Opusnummernbuch 1909 to 1911; Opusnummernbuch 1911 to 1915, No. 19899-21250, all in Company Archive L. Bösendorfer Klavierfabrik GmbH, Wiener Neustadt, Austria. Graphische Darstellung (Bösendorfer Produktion) 1971 and Produktionskurve der Fa. Bösendorfer seit 1900, Archive of Gesellschaft der Musikfreunde Wiens, Legacy of Ludwig Bösendorfer, fascicle C, folder VI, no. 16. Jahresproduktion-Verkäufe; Archive of Gesellschaft der Musikfreunde Wiens. Legacy of Ludwig Bösendorfer, fascicle C, folder VI, no. 16.

17 Arbeitsnummernbuch 1870–1890, Arbeitsnummernbuch 1890–1902, Arbeitsnummernbuch 1901–1908, Arbeitsnummernbuch 1908–1914, Arbeitsnummernbuch 1915–1931, Arbeitsnummernbuch 1928–1945, Arbeitsnummernbuch 1949–1965, Arbeitsnummernbuch 1966–1974, all in Company Archive L. Bösendorfer Klavierfabrik GmbH, Wiener Neustadt, Austria. Consiknation fürs Arbeitsbuch, Archive of Gesellschaft der Musikfreunde Wiens, Legacy of Ludwig Bösendorfer, fascicle D, folder III, no. 3. Preis-Tarif angelegt am 15/II 1872, Archive of Gesellschaft der Musikfreunde Wiens, Legacy of Ludwig Bösendorfer, fascicle D, folder II, no. 1. Preis-Tarif, Archive of Gesellschaft der Musikfreunde Wiens, Legacy of Ludwig Bösendorfer, fascicle D, folder II, no. 2. Ausbezahlter Arbeitslohn 31/3 1877, Archive of Gesellschaft der Musikfreunde Wiens, Legacy of Ludwig Bösendorfer, fascicle D, folder III, no. 3.

18 Henkel, *Besaitete Tasteninstrumente* (n. 6 above), 137–140; C. Dürer, D. Anderson, 'Grotrian-Steinweg', in *The Piano. An Encyclopedia*, R. Palmierie, ed. (New York, London, 2003), 159. Buchheim, *Grundlagen des deutschen Klavierexports* (n. 2 above), 235–236; Zuna-Kratky, *Technisches Museum Wien* (n. 3 above), 29, 71; Ehrlich, *The Piano: A History* (n. 4 above), 19. Schmidt, 'Das Klavier kann alles' (n. 3 above), 150.

19 Petersen, *Schwachstarktastenkaste* (n. 1 above), 80–96, 133–194.

20 Grotrian-Steinweg, Betriebs-Aufnahmen 1924, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.

21 After the death of Kurt and Willi, Kurt´s sons Erwin and Helmut took their positions and, in 1961, Knut Grotrian-Steinweg followed. In 1999, Burkhard Stein was the first non-member of the family to lead the company, but Grotrian-Steinweg still remains a family owned business. C. Kammertöns, S. Mauser, eds., *Lexikon des Klaviers: Baugeschichte, Spielpraxis, Komponisten und ihre Werke, Interpreten* (Laaber, 2006), 302–303; Lieberman, *Steinway & Sons* (n. 7 above), 3, 76; D. Crombie, *Piano. Entwicklung, Design, Musiker* (London, 1995), 99; M. Novak Clinkscale, *Makers of the Piano: Volume 2, 1820–1860* (Oxford, 1999), 353–354.

22 Grotrian-Steinweg, Betriebs-Aufnahmen 1924.

23 Ibid.

24 Ibid.

25 Ibid.

26 Willi Grotrian, Aufgabe von Teilen und Arbeitsfolgen, 1906, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany, 26c–26f.

27 Ibid., 26a.

28 Translation by author: 'Auch die Arbeiter selbst sind sorgsam auszuwählen … Tüchtige und fleissige Leute in gutem Accorde liefern bedeutend bessere und noch einmal so viel Arbeit, als unintelligente in Lohnstehende Arbeitsleute, die dafür aber eine höhere Unfallziffer aufweisen.' Ibid.

29 H.K.A. Eilert, *Rundgang durch die Fabrik* (Braunschweig, 1929), 16–19 at the Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
30 A. Lüdtke, 'Industriebilder – Bilder der Industriearbeit? Industrie- und Arbeitsphotographie von der Jahrhundertwende bis in die 1930er Jahre', *Historische Anthropologie*, 1 (1994): 394–430. U. Wengenroth, 'Die Fotografie als Quelle der Arbeits – und Technikgeschichte', in *Bilder von Krupp. Fotografie und Geschichte im Industriezeitalter*, K. Tenfelde, ed. (München, 2000[2]), 89–104 (see 89).
31 Grotrian-Steinweg. Betriebs-Aufnahmen 1924 (n. 20 above).
32 H. von Helmholtz, *Die Lehre von den Tonempfindungen als physiologische Grundlage der Theorie der Musik* (Braunschweig, 1870[3]).
33 Helmholtz quoted in Ehrlich (n. 4 above), *The Piano*, 51.
34 Helmholtz quoted in T. C. F. 'Steinway, Duplex Scale (Doppelte Mensur) Patent No. 126, 848 vom 14. Mai 1872 und Herr Bösendorfer in Wien', *Signale für die Musikalische Welt*, 33 (1875): 71–79.
35 Hof-Pianoforte-Fabrik Grotrian, Helfferich, Schulz, Th. Steinweg Nachf. Braunschweig, 1898, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
36 Grotrian-Steinweg Nachf. Manufacturers to the Court Braunschweig, Germany, 1904, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
37 Grotrian, Steinweg Nachf. Hof Pianofortefabrik Braunschweig, 1910 and Hof-Pianoforte-Fabrik. Grotrian-Steinweg Nachf. Braunschweig, 1910, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
38 Translation by author: 'Wer einen Blick in die Grotriansche Fabrik wirft, begreift bei der dort herrschenden Ordnung, Ruhe, Sauberkeit, Disziplin, und beim Anblick der meist in reifereren Jahren stehenden Arbeiter mit ihrem klugen, überlegenden, vorsichtigen Wesen, daß hier nicht fabriziert, sondern gebaut wird, daß hier Cremona ist, nicht Markneukirchen.' See Grotrian-Steinweg Nachf. Braunschweig, 1912, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany; S. Neudörfer, *Tradiertes Erfahrungswissen und arbeitsteilige Produktions-netzwerke. Der Schönbacher Geigenbau im 19. und 20. Jahrhundert* (Aachen, 2007), 21–39.
39 Eilert, *Rundgang durch die Fabrik* (n. 29 above), 4, 16; Petersen, *Schwachstarktastenkasten* (n. 1 above), 162–194.
40 Grotrian-Steinweg Braunschweig, Pianos, Flügel, Einbau Klaviere, 1927, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
41 Grotrian-Steinweg Braunschweig, The immortal Grotrian-Steinweg Piano with the homogenous soundingboard, 1930, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
42 Translation by author: 'Nichts ist mehr dem glücklichen Zufall überlassen. Moderne wissen-schaftliche Methoden errechnen vielmehr auf Grund der Holzeigenschaften von vornherein mit mathematischer Sicherheit den Ausfall jedes Instrumentes.' See Grotrian-Steinweg Braunschweig, Pianos, Flügel, 5.
43 Grotrian-Steinweg, The immortal Grotrian-Steinweg Piano, 18.
44 Ibid., 19; The Birthplace of the world´s master piano, Romantic Brunswick, 1930, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.
45 Grotrian-Steinweg, The immortal Grotrian-Steinweg Piano, 21.
46 Ibid., 20.
47 Translation by author: '… daß es nunmehr möglich sein wird, einen Flügel jederzeit in völlig gleicher Beschaffenheit noch einmal nachzubauen.' See 'Neue Wege des Klavierbaues', Cottbuser Anzeiger, 24/4/1921, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany. P. Schwers, 'Grotrian-Steinweg "homogener Resonanzboden"', Allgemeine Musikzeitung. Wochenschrift für die Reform des Musiklebens der Gegenwart, 1921, 48: 254–255, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany;

M. Chop, 'Homogener Resonanzboden', Musik-Industrie. Zeitschrift für Musik-Instrumenten-Industrie und Handel, 1921, 3, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.

48 Grotrian-Steinweg Braunschweig. Ein neues Grotrian-Steinweg Klavier, Post 1945, Company Archive Grotrian-Steinweg Piano Company, Brunswick, Germany.

The American Patent Agency:

The Embedded 'Lone Inventor' in American History

Carroll Pursell

From the early 19th century through the 20th, the 'lone' American inventor had in fact been able to draw upon a wide variety of supporting services, from model makers to the staff of the Patent Office itself. Prominent among these services were what were termed 'invention marketing companies'. They claimed to be able to assist inventors at every step, from obtaining a patent to finding places for them in the marketplace. One of these, which flourished in the late 19th century, was the American Patent Agency of Cincinnati, Ohio.

In 1836, the United States Patent Office had one examiner to check applications for utility and novelty. Another was added the next year, there were twelve in 1861, twenty-two in 1870 and in the year 1991, the 1600 examiners at the Patent Office issued 160,000 patents out of the many more for which application had been made. One of these 160,000 was the 5 millionth issued since 1792.[1] Already by the middle of the 19th century, the scale and complexity of the patent system in the United States, not to mention the marketing of patents awarded, had made it exceedingly difficult for the individual inventor to find success. We know something about the work of a handful of highly visible and successful individuals, such as Samuel F.B. Morse (telegraph), Cyrus Hall McCormick (reaper), and Thomas A. Edison (light bulb and other electrical devices), but little of the host of inventors out of which they sprang.[2]

In fact, the 'Lone Inventor' was seldom alone in his or her work. Close investigation shows that inventors had available, and often drew upon, a wide range of specialized services, from model building and drafting, to professional patent agents and attorneys. They could also call upon the aid available from the federal Patent Office itself and a host of often ephemeral self-help organizations. In addition, they were courted by a swarm of not always helpful, or even honest, 'invention marketing companies'. One of

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these, the American Patent Agency which operated during the mid- to late-nineteenth century in Cincinnati, Ohio, has left a fascinating record of its services.

Great Britain passed its Statute of Monopolies in 1623 and soon several American colonies also began to issue patents of monopoly for useful devices and processes invented or introduced. After the American Revolution, Article I, Section 8 of the new federal constitution in 1787 authorized the granting of patents in order to 'promote the Progress of Science and useful Arts'. Making his first annual message to the Congress, President George Washington urged that body to implement this section of the Constitution: 'I cannot forbear intimating to you,' he told them, 'the expediency of giving effectual encouragement, as well to the introduction of new and useful inventions from abroad as to the exertion of skill and genius at home.' In 1790, a patent law was passed by Congress setting up an examining board which was so restrictive that over the next three years only 57 patents were allowed. At that point a new system of registration was set up and by the time the present Patent System was inaugurated in 1836, some 9,957 patents had been granted. After 1836, the pace accelerated and over the years, many thousands of otherwise quite ordinary Americans were consumed by what President Abraham Lincoln, himself the holder of a patent, called 'the fire of genius' to which the Patent System, in his phrase, had added 'the fuel of interest'.[3]

These inventors constituted a growing category of worker called into existence by the Industrial Revolution and integral to its spread. At mid-century, however, Horace Greeley sadly noted that 'a complete history of Inventions would solve many curious problems – among them, that of the comparative pecuniary rewards of inventors who have done the world good service, and those who have served only themselves. … Neither [Robert] Fulton, [Eli] Whitney,' he asserted, 'nor any other eminent American inventors now deceased, is known to us as having amassed and retained wealth; while the majority of the class have dodged duns and sheriffs from the luckless day wherein they first became absorbed by the idea of inventing, down to that in which they were shielded from further persecution in the harsh but secure embrace of the coffin.'[4]

All of this activity testifies not only to the continued existence of uncounted and unsung inventors, but as well to the complexity of that social activity called invention. At least since the organization of the modern Patent Office in 1836, American inventors have organized themselves for mutual protection and advantage and, more often, found themselves solicited by agencies and organizations which have offered to steer the inventor through the procedures and requirements of the Patent Office and often lead them through the jungle of commercial competition as well. Today many, perhaps most, American research universities have offices designed to help faculty members get patents, license them, and form partnerships with commercial firms willing to market them. The fact is that now, as then, inventors needed help with that web of requirements and opportunities that the historian Carolyn Cooper called 'patent management'.[5]

Besides the mechanics' institutes and industrial fairs which seemed to spring up in most American cities in the years before the Civil War, inventors sometimes formed their own self-help organizations. In 1847, Clinton Roosevelt of New York City organized what he called the Reformed Association of Inventors to further the interests of its members. In 1869, the San Francisco Inventors' Association was established in that city, though it had failed by 1872, in which year another such group was organized in New York.[6] Besides offering mutual support, some of these organizations also were designed to provide workrooms and machine shops, model makers and draftspeople for the use of the members. In 1892, on the occasion of the centenary of the Patent System, a group of women inventors gathered to seek recognition and an end to discriminatory practices based on gender.[7] The many efforts of inventors to organize for mutual aid remain uncounted and unstudied, but persist into our own times.

More common were patent agencies, the most famous of which was arguably Munn & Co., which in 1846, bought the year-old publication *Scientific American* and turned it into one of the nation's major journals of technology and science – as well as a vehicle for promoting the agency's clients. Alfred A. Beach, a partner, was an inventor and lawyer whose father published a successful newspaper. Orson Munn, the other partner, was also a lawyer. They soon established a Patent Department within their firm and over many successful years were retained as agents by such prominent inventors as Morse, Edison, Elias Howe, Dr. John Gatling and others. One important part of their services was that they featured the inventions they represented in the pages of *Scientific American*. When reading a feature story in that journal, it was not always easy to sort out the latest client from the most important new device.[8]

Less well known, but probably typical of its kind, was the William A. Bell & Co., which worked out of Sigourney, Iowa. A striking feature of Bell's operation was a specially-designed wagon, with glass sides and somewhat resembling a hearse, which displayed 150 patents to curious passersby. In 1891, the wagon toured Midwestern cities during the summer and fall and southern cities during the winter.[9] Another regional broker was the American Patent Agency which operated out of Cincinnati, Ohio.

By 1841, Charles Cist could call Cincinnati 'the largest city of the west'.[10] Based in large part on the manufacture and traffic of steamboats on the Ohio River, the city had early developed into a centre of mechanical activity. Indeed, Cist counted 10,866 persons working in manufacturing and the mechanic arts. In terms of separate establishments, there were two pattern makers, five steamboat yards, fifty two blacksmiths shops, thirteen foundries, two rolling mills, eight bell and brass founders, six draftsmen and designers, three makers of mathematical, optical and philosophical instruments and many more. There was a Society for the Promotion of Useful Knowledge, founded in 1840, which among other duties undertook to disseminate information on 'new books, discoveries, and inventions'. And, typically, there was an Ohio Mechanics' Institute, chartered in 1828. Cist noted that while the city contained many industrial works powered by steam, most were still, as he put it, 'works of the hand. These last embrace the principal share of the productive industry of our mechanics, and are carried on in the upper stories, or in the rear shops of the warerooms, in which they are exposed for sale. …'[11] It is safe to say that Cincinnati, well before the mid-century, was a city where the useful arts were widely understood and practiced. It was a milieu no doubt conducive to invention and one, as it turned out, that encouraged and facilitated the turning of those inventions into commercial products.

When the American Patent Agency began to publish its monthly newspaper, *American Inventor*, in January 1878, it had been in business for perhaps five years and was described as being an already far-flung operation.[12] Besides its headquarters in a fine four-story building in Cincinnati, it had branch offices in 35 other cities, from New York City to Virginia City, Nevada, and Boston to Galveston, Texas. It seems likely that these 'branch offices' were in reality little more than some sort of relationship with local attorneys in those cities, although what was styled the Western Office in St. Louis, Missouri, was also housed in an impressive building. F.E. Zerbe served as 'General Agent', and in addition eight 'travelling agents', all 'responsible men of experience', were at work, covering the hinterlands. Clients of the agency were encouraged to buy advertising circulars to be distributed, and each patent represented by the company was described, and often illustrated, in their journal.[13]

The agency offered a complete range of services to inventors. J.S. Zerbe, 'Attorney and Counselor In Patent Cases', presumably a relative of the General Agent, worked in cooperation with their 'Associate Office' in Washington, D.C., and for a fee would obtain patents for clients as well as undertaking to fight both rejections and infringement cases. For obtaining patents outside of the United States, the agency maintained a relationship with Messrs. Brewer & Jenson, in London, England. Then, if the client wished, the agency would make use of its commercial arm, superintended by J.S. Hughes, to try to match up patents with manufacturers who might want to build or use the new inventions.[14] Eventually they began also to distribute, without charge, a 68-page pamphlet entitled *The Inventor's Manual. How to Procure and Sell Patents.*[15]

Cautionary tales printed in the *American Inventor* were presumably designed to give some insight into the problems of disposing of new inventions, as well as the reputation of salespeople employed by less scrupulous agencies. In one story, 'Sharper No. 1' toured an agricultural region, offering agencies for the exclusive disposal of a certain machine, in a given county, for $600. He would leave one of the machines, valued at $10, with a farmer with the advice that the agency could be purchased later, after 'he sells his hogs'. When that time comes, the 'Capper', an associate of 'Sharper No. 1,' appeared and offered the farmer $700 for the agency, giving him $100 to clinch the deal, the rest to be paid the next week when the deed was delivered. The farmer, seeing an easy $100 to be made, would find $500 to put with the $100 deposit, and send it off to the 'Sharper'. In return he received a worthless 'deed', but needless to say, never saw the 'Capper' again. Not surprisingly, the editor Zerbe concluded that 'these confidence men' caused patent agents generally to be 'looked upon with suspicion'.[16]

On March 25, 1884, a convention was held of inventors gathered in Cincinnati to form a National Association of American Inventors. Not surprisingly, J.S. Zerbe was chosen President, and his journal, the *American Inventor*, was designated the 'official organ' of the new group.[17] Certain proposed changes in the organization and workings of the patent system appear to have motivated those who convened the meeting, as well as the 'hundreds of America's most loyal geniuses' who were in attendance. The consensuses seemed to have been that Congress, propelled by 'outside influence', had recently made changes in the patent process and that inventors themselves needed to put forward a united front so as to make their influence felt in Washington as well. They wanted the Patent Office to be better funded and to work more efficiently, but supported no major change in its structure.[18]

Embedded in this apparently straightforward issue was one of even more interest to the social historian of technology.[19] Running through the convention there was an obvious tension between inventors and manufacturers, made more complicated, of course, by the fact that some delegates played both roles. The *American Inventor* forthrightly declared that 'this is the first definite action which inventors have taken in behalf of maintaining their rights against the encroachments of large corporations.'[20] Although the problem of inventors being defrauded by manufacturers, sometimes through the instrument of protracted and expensive lawsuits, clearly surfaced at several points, specific examples pointed the finger not at great railroads or large manufacturing firms but rather what seemed to be local 'sharpers'.[21] One delegate from Indiana, who according to Zerbe made 'a disgraceful exhibition of himself at the Inventors' Convention', was said to have an 'unsavory reputation for integrity' at home due to his having 'amassed a fortune by infringing on other inventors' patents, and has robbed them of their inventions by continuous litigation.' When confronted later in the lobby of the Burnet House with the charge that he had robbed one Jesse P. Fulgham of his invention, the Hoosier grain drill, the miscreant was reported to 'have the word GUILT written across his contenance.'[22]

State conventions were subsequently called in a number of places, and by 1886, most states had designated vice presidents. That for Ohio was Josiah Kirby, of Cincinnati. A prolific inventor of machinery to cut bungs and drill bung holes in kegs and barrels, he held at least six patents dating from 1848 to 1867. The Association's librarian, John J. Geghan, was also from Cincinnati. J.S. Zerbe served as President and all the other officers were from the upper Midwest states of Illinois, Indiana and Michigan. As became an organization of inventors, dues were a mere two dollars a year. A third annual convention was already being planned for Chicago.[23]

After a decade of publication, the *American Inventor* last appeared in December, 1887, though it was succeeded, after a time, by another journal titled *World's Progress* which lasted from 1890 to 1899. By the earlier date the American Patent Agency was proudly proclaiming itself 'THE OLDEST, LARGEST & ONLY Successful Agency for the Sale of Patents in the World.'[24] It continued to provide a broad and critical service to inventors, though other firms were needed to provide different services as well. Also operating in Cincinnati, for example, C.E. Jones & Bro., a dealer in and manufacturer of telegraph and electrical supplies, offered to make models and do experimental work for independent inventors.[25] Together the two firms suggest a continuing need by inventors for specialized assistance, mechanical as well as commercial and legal.

Kara W. Swanson has coined the useful term 'professional patent practitioners' to encompass the growing group of patent agents, 'who were virtually indispensable to American invention by the late nineteenth century', as well as the lawyers who came to specialize in patents.[26] In 1839–40, some 20 percent of patents granted were facilitated by one of two patent agencies, but among the scores of other practitioners by mid-century there were believed to be numerous unscrupulous agents who preyed on inventors by drawing up specifications which, while almost ensuring approval, afforded little actual protection.[27] The Patent Office itself, in keeping with the needs of the time, increased its staff of examiners, warned against fraudulent agents and urged inventors to deal directly with the Office, but the propensity of some examiners to turn down a large proportion of applications led many petitioners to seek help from agents. And increasingly from lawyers; by the end of the 19th century the legal aspects of successful patenting were proving to be as challenging as the technical.[28]

The dream of finding fame and fortune through one's mechanical creativity has persisted, of course, and during the post-World War II years was actively encouraged by the Federal and state governments. In 1966, Vice President Hubert Humphrey chose the pages of *Popular Science* to declare that 'America's independent inventors now have a significant new resource.'[29] He was referring to an initiative of the federal Department of Commerce's Office of Invention and Innovation to encourage State Invention Expositions where independent inventors could showcase their devices. The American Bar Association announced in 1967 that already seventeen states had held such fairs since the inception of the programme.[30]

South Dakota was early off the mark. It held its first Inventors Congress in 1956 and in 1962 it was decided to make it an annual event. Each year some 75 to 80 inventors exhibited their new products to about 5,000 visitors. According to the event's coordinator in 1965, 'the purpose of the congress is to assist inventors in obtaining patents and to give them an opportunity to show their ideas to people who may want to finance, manufacture, market or purchase their invention.'[31] In 1967, at least ten states held such events and in 1971 five were reported.

Alongside the government's efforts to stimulate invention, 1971 saw a continuation of private initiatives, with a plethora of companies offering to help evaluate and patent inventions. Classified advertisements in the back pages of tabloid newspapers in the United States in the late twentieth century often encouraged inventors to step forward. One beckoned 'INVENTORS! HAVE an idea? …'; 'INVENTIONS. IDEAS, technology wanted! …'; 'A NEW idea? Call …'; 'INVENTORS: IF you have an invention for sale or license …', and so on.[32] In 1972 the Imperial Inventors of S.F., Inc., ran a half-inch by inch and a half ad in the *San Francisco Chronicle* declaring 'INVENTIONS IDEAS WANTED Our network of national offices will assist in marketing your ideas. Free info'. A larger advertisement in the *Los Angeles Times*, which featured a drawing of a pair of dice, read 'INVENTORS ATTENTION Don't gamble with your good ideas or inventions. The most reputable name to remember is Royalty Engineering and Development Company, Inc., who can develop your idea into a marketable reality on a Royalty sharing basis.'[33]

In Los Angeles in 1974 The National Inventors Foundation provided 'seminars, open to the public, on various subjects related to inventions, practical needs, and procedures that affect inventors. The Foundation also arranges financing for inventors of special ability and for inventions of special merit.' Additionally, the Foundation provided a home for the Invention Marketing Institute and the Inventors Assistance League. The latter, like the Foundation a non-profit, tax-exempt organization, was said to serve 'the needs of independent inventors through education, development, guidance and protection. By using programmed instruction courses on subjects related to inventions, patents, licensing and marketing, members/students learn all about inventing. Among the services and facilities available to the inventor/member are a technical and marketing library, a model-making shop, a photo studio, and a graphic arts department.'[34]

In 1999 the passage of the American Inventors Protection Act required, for the first time that patent marketing companies disclose to potential clients a range of information from how many patents the firm had evaluated in the past five years to the number of clients who had received a net financial profit as a direct result of the efforts of the company. The United States Patent and Trademark Office also began to accept complaints against companies in 2000, and by January 2012, some twenty-five invention marketing companies had been reported by customers. Presumably not all such firms took unfair advantage of inventors, but the dependence of the 'lone' inventor on outside help in the patenting and marketing process created a fertile field for unscrupulous operators. One intellectual property firm used the web to circulate a list of twenty-five invention marketing companies against which complaints had been filed in just the first two months of 2012.[35]

The story of the American Patent Agency suggests more important questions than answers concerning the work and culture of American inventors during the 19th century. We have long known that most successful inventors did not, in fact, work alone, but again the well-known stories of such successful examples as Robert Fulton and Thomas Edison do little to inform us about the circumstances of those tens of thousands of inventors who are mere names to us, listed in the reports of the Patent Office. 'Invention' is a broad term, which aggregates a number of discrete tasks and stages, ranging from inspiration to marketing, and including such large areas between as legal entanglements and manufacturing. It is a social activity, encompassing agencies and relationships about which we know too little. The widespread presence and variety, as well as apparent impermanence of inventors' organizations suggest that it was, and still is, a matter of both importance and experimentation. The typical result of invention may very well be the privileging of economic elites, but as an activity it has over the years been a ubiquitous and democratic practice, employing the time and energies of what must have been a small army of often very ordinary men and women.

NOTES

1 *Science*, July 5, 1991, 253: 20.

2 We have recently been able to learn more about three famous Black inventors who were, of course, doubly handicapped. See Rayvon Fouche, *Black Inventors in the Age of Segregation: Granville T. Woods, Lewis H. Latimer, and Shelby J. Davidson* (Baltimore, 2003).

3 Quoted in Archer H. Shaw, ed., *The Lincoln Encyclopedia* (New York., 1950), 236.

4 Horace Greeley, *Art and Industry as Represented in the Exhibition at the Crystal Palace New York – 1853–4 …* (New York, 1853), 296.

5 Carolyn C. Cooper, *Shaping Invention: Thomas Blanchard's Machinery and Patent Management in Nineteenth-Century America* (New York, 1991), 29.
6 *Scientific American*, December 18, 1847, 3: 99 and *Scientific Press*, January 6, 1872, 24: 12.
7 See Carroll Pursell, 'Women Inventors in America', *Technology and Culture*, July, 1981, 22: 545–549.
8 *Scientific American*, October 2, 1920, 123: 342.
9 An illustration of this wagon is in Cooper, 33.
10 Charles Cist, *Cincinnati in 1841:Its Early Annals and Future Prospects* (Cincinnati, 1841), 13.
11 *Ibid.*, 43, 54-57,133-4, 128, 238.
12 *American Inventor*, March, 1884, 7: 95.
13 *American Inventor*, January, 1878, 1: 14.
14 *American Inventor*, January, 1878, 1: 13 and (February, 1878), 1: 31.
15 *American Inventor*, December, 1887, 10: 521.
16 *American Inventor*, January, 1878, 1: 11.
17 *American Inventor*, March, 1884, 7: 70.
18 *American Inventor*, March, 1884, 7: 70 and (April, 1884), 7: 98.
19 *American Inventor*, April, 1884, 7: 100.
20 *American Inventor*, March, 1884, 7: 70.
21 *American Inventor*, April, 1884, 7: 98, 99.
22 *American Inventor*, April, 1884, 7: 98.
23 *American Inventor*, January, 1886, 9: 2.
24 *American Inventor*, December, 1887, 10: 521.
25 *American Inventor*, December, 1887, 10: 521.
26 Kara W. Swanson, 'The Emergence of the Professional Patent Practitioner', *Technology and Culture*, July, 2009, 50: 520.
27 Swanson, 526, 530.
28 Swanson, 529–530, 542.
29 Hubert H. Humphrey, 'We Need Your Inventive Skill', *Popular Science*, June, 1966, 102.
30 *American Bar Association Journal*, January, 1967, 53: 90.
31 Letter from Marvin H. Anderson to author, October 5, 1965.
32 *Star*, July 11, 1989, 42.
33 *San Francisco Chronicle*, August 7, 1972; *Los Angeles Times*, May 7, 1972.
34 Undated (c. 1974) flyer in possession of the author.
35 Brown and Michaels, *Invention Marketing Companies: Are they for real?*, http://www.bpmlegal.com/pinvmktg.html (accessed February 27, 2012).

Is Everyday Technology Serious or Fun?

Reflections on Emotional Styles in Product Design

Artemis Yagou

Product design renders technology accessible and usable in everyday life contexts. The radio set is a characteristic example: a range of design strategies have contributed to the assimilation of radio into people's lifestyles. Such strategies correspond to distinct emotional styles in the interaction between users and technical products. In this essay, I explore the role of different emotional styles in the popularization of the radio. I discuss in particular the playful design approach that emphasizes fun, as opposed to the design approach suggesting scientific progress. Although neglected by design historiography, play-oriented radio design foregrounds the significance of play as a key factor in appropriating technological innovations.

INTRODUCTION

Twentieth-century designers have employed a variety of strategies to deal with technological consumer products that turn technical elements or components into usable objects for daily life. It may be argued that such design strategies correspond to different emotional styles of interaction between users and technical products. These emotional styles define a framework in which product use takes place, thus they evidently influence users' relationship to technology.

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This essay discusses specifically the design of the radio set, a highly popular consumer product, which provides fascinating material for the study of the interaction between technology and design in everyday life. Different design approaches and their role in radio usage as well as the popularization of technology are discussed, with special emphasis on play-oriented design. The essay is meant to have an exploratory character and may serve as a springboard for further study of the correlation and interdependence between product design, technology and of play-oriented design in particular.

The first section of the essay sets the background of the study, by presenting a formal typology of radio designs. The second section focuses on one of the types described, a type demonstrating a fun attitude towards the radio, and discusses its characteristics. The third section comments on the silence of design historiography on playful design and relates this silence to dominant modernist beliefs on technology, science and progress. The fourth section explores the significance of fun and play as a factor in designing technical products for everyday use. The conclusion highlights the implications of play-oriented design for the reception of new technology by the wider public and suggests directions for further research.

TYPOLOGY OF RADIO SETS: CONTINUITY AND RUPTURE IN DESIGN

The human mind craves order and the idea of classification is fundamental to the study of the living world. Taxonomy, the process of categorization based on types, is central to modern science. In biology, taxonomy generates – or at least attempts to generate – comprehensible order to the dizzying multiplicity of living creatures.[1] It reveals existing patterns and makes understanding a possibility. A similar desire to reveal underlying patterns and generate informed understanding has underpinned my earlier research into the design of radio sets, which resulted in the development of a morphological typology of radio forms, consisting of five formal categories in which all radio sets may be classified.[2] More specifically, the five types are:

- *Early Domestic.* This type corresponds to the early period of radio development, in the first decades of the twentieth century, when amateur enthusiasts dominated the new medium. Sets classified in this type consist of an assembly of technical components such as coils and valves.[3] (Figure 1)
- *Classic Domestic.* The radio as a piece of furniture prevailed in the late twenties and throughout the thirties, reflecting the attempt to domesticate the product by following familiar household object typologies. (Figure 2)
- *Modern Domestic.* Plastic was introduced as a radio cabinet material in the mid-thirties and dominated the market after the Second World War until the emergence of transistors. It did so without causing a major break with the formal choices of the previous type. (Figure 3)

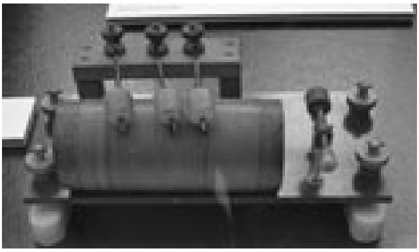

Figure 1. Radio receiver of the Early Domestic type, a crude assembly of components. Manufactured in Greece, 1948. From the collection of G. Panagiotides, presented in the Exhibition on Greek Broadcasting History, Athens, December 2008–January 2009. Photo by author.

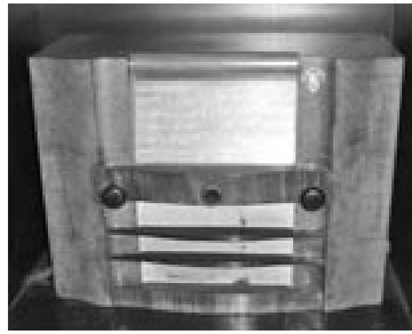

Figure 2. Wooden radio of the Classic Domestic type, following furniture standards. Manufactured by Radiomarelli, Italy, 1930s (private collection, Athens). Photo by author.

Figure 3. Radio of the Modern Domestic type, manufactured by Philips, 1960s (private collection, Athens). Photo by author.

- *Modern Portable.* Since the mid-fifties, the emergence of transistors changed the nature of the radio from a static, domestic object to a portable, personal one. Established interface conventions were retained. (Figure 4)
- *Outsider.*[4] Formal inspiration for the Outsider was drawn from a vast range of sources, especially related to nature and popular culture. This typology appears throughout the history of radio. (Figure 5)

As the Early Domestic radio type shows, the very first attempts to give form to this new product exhibited insecurity and treated the object as a

Figure 4. Radio of the Modern Portable type, manufactured by Silver, 1980s (private collection, Athens). Photo by author.

Figure 5. Radio of the Outsider type imitating a cat's head, made in China, early 21st century (private collection, Athens). Photo by author.

scientific instrument that did not require concealment of technical parts or add-on beautification. The three subsequent types (Classic Domestic, Modern Domestic and Modern Portable) dominated radio production and, in a sense, exemplified the increasing diffusion of the radio and the growing familiarity of the wider public with this product. The morphological continuity of these types emphasized their interconnectedness: the study of detailed formal characteristics of radios belonging to these three types has identified a standardized interface pattern, consisting of a dial and two knobs, the right knob used for tuning while the left one for volume control (Figure 6). This abstract visual representation of a dial and two knobs became an icon of the radio as product and function; simplified versions of it may be seen in stylized radio images (Figure 7). Diversification applied to the radio cabinet through different styles did not change the basic perception of the interface conventions just described, and even heavily decorated objects easily could be identified as radios.[5] The radio interface pattern was diffused into other categories of technical consumer products, thus establishing morphological models for a wide range of consumer and professional goods.[6] Through such formal models, the radio set influenced everyday-life

Figure 6. The standardized interface clearly exemplified by two wooden radio sets. Exhibition on Greek Broadcasting History, Athens, December 2008–January 2009. Photo by author.

Figure 7. A representation of the standardized radio interface, Greek cartoon, 1950s.

Figure 8. Small, portable radio receiver in the form of an airplane. Sold on KLM flights, early 21st century. Photo by author.

perceptions of usability, patterns of technology usage and standards of human-machine interaction. Assessing the contribution of the radio set for the popularization of technology, Anthony Dunne has observed that 'perhaps the radio is the electronic equivalent of the chair.'[7]

The fifth type (Outsider) breaks away from the morphological limitations of the aforementioned types by including radio sets in the form of cartoon figures, Coca-Cola bottles, airplanes, bugs, or other unexpected shapes (Figure 8). This type represents a significant formal rupture from the standardized radio.

THE OUTSIDER TYPE: PLAYFUL RADIOS

Evidence suggests that radios of the Outsider type entered the market at the beginning of the twentieth century and extended into the twenty-first, having proved highly popular. The Outsider type is the only formal type that spans all radio technologies, from crystal sets through valves to transistors. Early examples of this type in crystal-set technology include the postcard set of 1922 (both British and German production), which contained a slider-tuned coil sandwiched between cards and appeared with a variety of picture fronts, as well as the British Felix crystal set of 1923, which represented a popular animated cartoon movie that was tuned by moving the leg.[8] Valve radios were less conducive to a similar design treatment, because of the substantial volume of valves; however, several examples do exist, such as the 1934 five-valve radio from the United States in the form of a globe.[9] The emergence of the transistor and the miniaturization potential that it brought along gave a special boost to Outsider type designs; there is a whole range of radios in the form of bugs, sunglasses, soda bottles, etc.[10] Characteristically, British author Ian McEwan writes in his 2006 novel *Saturday* about 'the plastic radio in the form of a leaping blue dolphin, attached by suckers to the mosaic wall in the shower'.[11]

Because of their unusual forms, these radios may not be easily identified as such or may be tricky to operate, but they are certainly meant to be fun to look at, own, use and carry around. The continuing popularity of such toy-like radios, even though the control buttons are minimal, camouflaged or both, suggests a different conception of user-friendliness. The extra difficulty in using them is compensated by an element of surprise and playfulness.

Radio sets belonging to the Outsider typology manifest a highly emotional treatment of a technological consumer product, where user fun becomes a crucial element.[12] User enjoyment is the key idea behind the creation of these objects as well as the main attraction for consumers. I would argue that these radios express an emotional style that is clearly differentiated from that of radios belonging to the other four types, which emphasize practicality and efficiency. Significantly, the Outsider type approach is not limited to radios but extends to other technical goods, such as telephones (Figure 9).

Figure 9. Shop window with telephones following the Outsider type logic, London, 2008. Photo by author.

While the names of the designers of various less 'playful' radios are preserved in the design literature, a fact which emphasizes the authority of the designer and assigns certain radio sets the status of design icons, Outsider type radios reside primarily in the grey area of anonymous design; they are often treated as toys or gadgets rather than 'proper' technical consumer products.[13] In European countries, Outsider type radios are marketed primarily in shops selling gadgets and assorted gifts, whereas more 'technical-looking' radios are sold

Figures 10–11. Comic strips showing small, yellow plastic radios in the form of ducks. The radios are represented as being fun and cheap products sold through informal as well as illegal networks. MIKY (Mickey Mouse, Greek edition), issue 2141 (2007), pages 6 and 8, © DISNEY, by courtesy of Christos Terzopoulos and Nea Aktina S.A. Publications (Greece).

alongside other electrical and electronic goods. The toy-like features of the former position them in the realm of popular culture rather than the high-brow world of 'good design' (Figures 10–11).

Admittedly, elements of fun and humour occasionally infiltrate the design mentality and experimentations of big electronics companies, as the example of a Philips radio concept in the form of a stylized Beethoven head indicates.[14] However, this is not a typical product by a major electronics corporation catering for the consumer market. The dichotomy between 'serious' and 'fun' radios may also be illustrated by museum displays presenting the history of radio exclusively through non toy-like radio sets (Figure 12).[15]

Figure 12. Display related to the history of radio technology, National Museum of Science and Technology, Denmark, 2007. Photo by author.

This distinction between 'high' and 'low' design is challenged by Victor Margolin and his idiosyncratic Museum of Corn-temporary Art, which, as Hannah Higgins points out, embraces the 'joyful, fantastical, unpredictable and living world of play'.[16] Nevertheless, as the next section will show, standard works of design historiography underpin and perpetuate the discrimination between 'high' and 'low' design.

DESIGN HISTORIOGRAPHY: MARGINALISING PLAYFUL RADIOS

Outsider type radios are covered extensively and often glorified in publications aimed primarily at collectors, antique enthusiasts or the wider public.[17] Such bibliographic sources place great emphasis on Outsider type designs, which are often described as 'novelty'.[18] It is however intriguing that Outsider type radios are ignored by many historical accounts of radio design development.

One characteristic example is provided in *Objects of Desire*, Adrian Forty's classic study of design and society from 1750 to 1980, in which he dedicates to 'Wireless Sets' a good part of his chapter on 'Electricity – the Fuel of the Future'[19] and claims that the appearance of wireless sets went through three distinct stages. In the first stage, the sets tended to be rude assemblies of diodes, capacitors and resistors, a fact that reflected the almost total preoccupation of both manufacturers and public with the technical properties of the apparatus. This stage corresponds to the aforementioned Early Domestic radio type. The second stage, which according to Forty resulted from the slowing down of technological advance, led manufacturers to compete with each other in terms other than technical innovation. Consequently, they employed the furniture approach to radio cabinet design, which facilitated the assimilation of the unfamiliar medium into people's homes. This stage corresponds to the aforementioned Classic Domestic type. The third stage, according to Forty, employed imagery of technological futurism, such as streamlined forms suggesting speed, and fulfilled the popular idea of radio as a symbol of future progress. This stage corresponds to the Modern Domestic and Modern Portable types. Forty claims:

> The wireless set … provided most people's first experience of owning a piece of modern technology and thus carried great weight as a symbol of scientific progress, putting them in touch with changes that they were told that technology would bring in all areas of life. Because of its great potency as a symbol of what life in the twentieth century would offer, radio became one of the most popular metaphors for the changes that technology would bring about in everyday life. It is hardly possible for us today to appreciate the impact of radio, because we have become so used to technical innovation and the claims made for it.[20]

In this sense, the radios of the Modern Domestic and Modern Portable types, by representing contemporary ideas of modernity, enabled users to express an emotional style quite different from the playfulness of the Outsider type, namely an emotional style founded on conceptions of advanced technology, progress and social status.

Forty also notes that, although '[the radio's] technical development slowed down around 1930, radio continued for the following decade to be the most universal and available symbol of social change based upon technical progress. People still expected radios to move with the times and characterize the future.'[21] Similarly Jeffrey Meikle acknowledges the emergence of 'a new machine style … recognized by a sensitized public as "modern". … The public indeed desired novelty, but a coherent machine style provided, as well as a sense of security amidst rapid change, a feeling that everything was under control … the public yielded to this vision of harmony and control.'[22]

The widespread indulgence of fantasy, play and technology is described by George Basalla as primarily Western and can be attributed to certain values that gained ascendancy during the Renaissance, namely secularism, the idea of progress and the domination of nature.[23] Radios designed as modern machines symbolizing efficiency and progress may be examined in the light of 'a designer's belief that the public desired visual confirmation of technological progress.'[24] Meikle noted that

> increasingly, in the late twenties American designers found harmony in the image of the machine with its attributes of speed, efficiency, precision and reliability. And as for a moral dimension to design, publicists and apologists repeatedly stressed the social benefits of progress, the social harmonies possible through intelligent direction of the machine, and the fitness of an environment made over in its image. The resulting machine aesthetic provided a satisfying rationale for industrial designers … [and] an abstract vision of a machine-age world transformed into a place of efficient, harmonious living.[25]

In a similar vein, Meikle claims that Le Corbusier's work expresses such this desire for stasis, for attaining perfect social equilibrium through design, where society is conceived as a machine for which the designer could provide 'a feeling of calm, order and neatness'. Le Corbusier desired a progression from the organic to the inorganic, from the natural to the artificial, from the random uncertainties of life to the reliability of the perfect machine.[26] The emotions implied were abstracted, controlled, even calculated; they were expected to elicit user satisfaction through ease of use and good function. Modernist ambitions of social transformation promoted the idea of liberation through efficiency, an idea still present in the rhetoric of usability.[27]

When the transistor radio appeared, miniaturization of technical components became much easier, so designers were offered more freedom, as they realized that tiny electronic components allowed them to deviate from the box-like appearance of radios and experiment with a much wider selection of housings. Yet, although transistor radios stood for the de-domestication and mobilization of the set as a symbol of youth culture, mainstream radio production by big firms did not break radically away from the iconography of form table-top radios; instead, radio sets simply became smaller. Adrian Forty suggests that manufacturers 'persisted in making radio sets look as if they were breaking the frontiers of science. … This self-conscious futurist symbolism has continued despite the fact that radios are no longer the only pieces of electronic technology in popular possession.'[28]

In her own discussion of the radio, the historian Penny Sparke emphasizes the transition from the radio-as-furniture, which expresses a connection to the past, to the radio as 'a modern machine', which symbolizes the future.[29] David Attwood follows a similar analysis, with only a passing reference to 'witty – anything goes objects', but his visual material does not support any discussion of Outsider type, toy-like radios.[30] In a chapter of his book *Industrial Design* entitled 'Play, learning, work and leisure', John Heskett discusses play in connection with children and the history of toys, without, however, making any connection to adult products with toy-like qualities. His reference to the radio as a leisure product in the same chapter focuses on the radio-as-furniture concept, as well as to the reduction in scale and portability brought by transistors; toy-like radios are not mentioned at all. [31]

Finally, although Forty does not mention toy-like radios as a separate category, he acknowledges the production of radios in the form of light, hand luggage following the popularization of transistors.[32] Rather ordinary-looking radio sets were turned into bag-like fashion accessories, covered by imitation crocodile leather or fur, thus epitomising fashion-consciousness and pleasure rather than technical efficiency. This is an indication that perhaps the importance of scientific and futuristic symbolism has been overplayed. For example, the first radio of many children belonged to the Outsider type ('novelty' sets). It appears unlikely that children or users of trendy, handbag models were particularly preoccupied with scientific imagery and with futuristic or utopian visions.[33] The popularity of radio designs expressing technological visions and ideals is of course indisputable; but at the same time the persistence of the Outsider typology throughout the twentieth century and into the twenty-first should be taken seriously into account. The next section further explores the role of the play element in design.

DESIGN AND TECHNOLOGY: PLAY AS A KEY FACTOR

Toy-like products in general express playfulness, relaxation, and irony; they evoke a spontaneous and straightforward sense of fun. Although they are primarily intended for adults, they encourage playful attitudes otherwise restricted to the realm of childhood. These objects challenge the over-determinacy of more conventional radios in an amusing and often provocative manner; they encourage unintended or unexpected uses, for example as toys or personal accessories rather than as radio receivers. This doesn't mean that radios with less playful designs could not be used (or have not been used) in unpredictable ways or for purposes unintended by the designers; it means that they were less *conducive* to such uses, because of the highly formalized, restrictive interfaces built into their design in the name of usability and efficiency. However, Outsider type radios allow for more individuality and for a wider range of personal experiences; they thus lead to increased complexity.

It may be argued that Outsider type designs are akin to the idea of a gadget, which has a toy-like quality. They are unconventional and challenge standard ideas of function and use. What appears at first sight as user-unfriendliness might not be necessarily negative but might be 'a form of gentle provocation', subverting the idea of user-friendliness itself and providing an alternative model of interactivity.[34] Thus Outsider type designs allow users to explore different conceptions of aesthetics, function and meaning in technical products for everyday use. Thus, such radios exemplify approaching technology through pleasure and joy, and encourage a playful interaction with technology. Outsider type radios are objects for which the notions of a special past or a better future are irrelevant; such radios are primarily, if not exclusively, about the present. They provide instant gratification by being funny, even bizarre, as well as unpredictable. Technical quality is not so important, whereas higher value is placed upon portability, casual use and fun.

More generally, the area of fun and play holds a central position in culture. The classic work by Johan Huizinga showed the fundamental role of play and playing in human culture. According to him, civilization stems from our inherent tendency towards play; all human activities, including philosophy, poetry and art, may be viewed as manifestations or transformations of our immanent play drive. Through play, each society expresses its interpretation of life and of the world. Huizinga made explicit the connection of play with technologies, including military ones.[35] He also argued that 'the meaning of play is a higher concept than seriousness. Because seriousness seeks to exclude play, while play could very well include seriousness.'[36] In a similar vein, in his seminal essay on intrinsic motivation and human-centred design, Klaus Krippendorff discusses the paradigm shift from object-centred to human-centred research and design, making room for models of human-machine interactions that are derived from the human use of language, conversation and play. He is critical of the fact that leisure, fun and community have come to be seen as either wasteful or dangerously interfering with the rational attainment of technological objectives.[37] As a conference call has suggested,

> the infantilization of play, that is, the historical association of playing with children and non-serious activities, has led to the systematic exclusion of play and fun from 'serious' creative, scientific and technological investigations. While the ludic (i.e., play-related) dimensions of artistic creativity have been variously explored recently in both art works and in scholarly research, the interactions between technological developments and the pleasures described as 'fun', are few and far between.[38]

It is therefore a positive development that the relationship between play and the technologies employed in modern consumer culture is a dynamically emerging and highly promising research area.[39]

Following Brian McVeigh, I would further highlight Outsider type radios as possible manifestations of 'resistance consumption', defined as 'acts of consumption that counter the dominant, official world view'. He clarifies the concept by stating:

> By 'resistance consumption' I do not mean a conscious, organized and systematic insurrection against the statist and capitalist order. Resistance consumption does not forcibly question, it raises some doubts; it does not directly challenge, it playfully provokes; it does not deride, it humorously mocks; it does not threaten, it ignores; it does not attempt an overthrow, it briefly displaces; it is not insurgent, it is carnivalesque; it does not subvert, it diverts attention (if only temporarily) from the dominant structures; it does not attempt to stage a political revolution, it encourages participation in hedonistic agitation.[40]

Outsider radio designs may also be discussed in relation to McVeigh's juxtaposition of the aesthetics and ethics of official ideology (based on capitalist production), against those of anti-official ideology (representing popular consumption). The first emphasizes production, labour, work and reality, whereas the second stresses consumption, leisure, play and fantasy.[41] This is an area worth further investigation.

Dunne examines more generally the role of various contemporary experimental products, which prompt users to question 'the crude interpretations and explanations offered through the well-mannered and facile metaphors of mainstream design' and challenge the way we experience reality.[42] He notes that: 'Although transparency might improve efficiency and performance, it limits the potential richness of our engagement with the emerging electronic environment and encourages unthinking assimilation of the ideologies embedded in electronic objects.' Instead, the distance between ourselves and the environment of electronic objects might be 'poeticized' to encourage sceptical sensitivity to the values and ideas this environment embodies.[43] In this vein, Dunne proposes the concept of 'parafunctionality', a form of functional estrangement that does, however, encourage an emotional as well as more critical treatment of objects. He explores various experimental objects that express parafunctionality and discusses their subversion of the functionalist style and the enriched interactivity that they provide. This is the realm of the gadget, the opposite of the well-designed object, a curious, original and witty accessory of seemingly dubious purpose but possessing increased emotional potential.[44] Various conceptual objects that Dunne presents and analyses 'promote interaction with "designed" objects that subvert their anticipated uses. In doing so, they challenge the mechanisms that legitimize the conceptual models embodied in the design of the product or system'.[45] Designer Giulio Ceppi also remarks that 'probably the gadget has never been considered, by official design culture, as a result of a design effort, an industrial product capable of revealing interesting technical features or of influencing peoples' behaviour' and that 'the most important phenomenon caused by gadget is, however, a psycho-behavioural factor: wonder … The fact that wonder and surprise are two variables that rarely enter into the design of industrial objects has induced the development of a clandestine niche in which such forbidden emotions can be found.[46]

Although the views expressed by Dunne and Ceppi appear attractive and thought-provoking, one might be cautious to apply them to the case of toy-like radios, as the latter do not constitute conceptual or experimental products but highly popular products in commercial contexts. It would be an exaggeration to claim (as Ceppi does) that 'wonder and surprise are two variables that rarely enter into the design of industrial objects', given the examples of exuberant design celebrating modern technology at World Fairs, the witty objects of Charles and Ray Eames, the Memphis movement or Alessi products. [47] Instead, toy-like radios may be considered as examples of product differentiation, a well-established strategy within modern commercial practice. Thus, toy-like radios may be examined in the context of an inclusive design-historical scholarship, in which designing technology as fun may be treated as an alternative mode of domestication or appropriation of novel technology based on wonder and surprise and also humour and sensory pleasure. This has been emphasized by Meikle

Figures 13–15. The Panasonic Toot-a-Loop radio (1972) is also known as 'bangle radio', because it was meant to be worn round the wrist, in addition to being table-top. This model, promoting an unconventional use of the radio as a portable accessory, is now considered collectable. See http://www.panasonic.eu/design-museum/ (accessed 24 August 2012).

in his discussion of appropriating modernity; in this process, the role of toys and novelties has been decisive in domesticating frightening aspects of modernity, neutralizing their potential for arousing anxiety and thus rendering them less threatening to the consumer.[48] Outsider radios therefore represent a highly successful design strategy of appropriating technological innovation. (Figures 13–15)

CONCLUSION

Designing a product is very much about the emotions involved in its usage. Different design approaches to technical consumer products represent distinct emotional styles in interacting with technology. The design of such products reflects a society's concerns, priorities, desires, and fears, and generates insights about the role and meaning of technology within everyday life and culture. The case of the radio set presented in this essay is an illuminating example of the relationship between design and technology throughout the twentieth century and into the twenty-first.

By discussing radio design, I have attempted to unravel the ways in which emotions are embedded in the use of technology in everyday life. This essay has particularly focused on radio designs based on fun; such examples suggest that designs inspired by and based on play have contributed to the assimilation of technology in everyday-life contexts. Historically, toy-like radios have presented users with the possibility of using everyday technology in a playful manner, thus creating a novel emotional style of interaction with technical products and expanding their role beyond usability and efficiency.

Despite the marginalization of the playful design approach by design historiography, this approach has exhibited remarkable endurance and has remained valid regardless of technical developments over the decades. The present study suggests that a playful approach to technical objects for everyday use may be essential in facilitating the popularization of technological concepts, in supporting the appropriation of technological innovations, and generally in making technology more accessible and user-friendly.

Play-oriented design of technical products is not limited to radios but extends to other product categories such as telephones, clocks, computers, and various home appliances. The discussion of emotions related to the design of technical products could also expand into professional and specialist technical products, used beyond the household. Additional case studies would further elucidate the topic of playful design for technical products as well as more generally the role of emotions in the appropriation of technology; these issues deserve more attention by researchers and designers alike.

NOTES

1 David Quammen, *The Kiwi's Egg – Charles Darwin and Natural Selection* (London: 2007), 97.

2 Artemis Yagou, 'Shaping Technology for Everyday Use: The Case of Radio Set Design', *The Design Journal*, 5: 1 (March 2002): 2–13. The formal types identified are not strictly defined or mutually exclusive; their limits are often vague and in many cases there is overlap between them.

3 In the U.S. context, valves are usually referred to as "tubes".

4 In my previous work, I used the term 'Independent' here; however, I believe 'Outsider' is a more appropriate term, which I gratefully borrow from Victor Margolin, 'Culture is Everywhere: An Introduction to the Museum of Corn-temporary Art', in Victor Margolin and Patty Carroll, eds., *Culture is Everywhere: The Museum of Corn-temporary Art* (Munich: 2002), 9.

5 It has been observed that, by virtue of design, the passage of radio from a tinkerer or hobbyist medium – requiring technical skills and a special tacit knowledge – to a mass medium for the unskilled was a process where the visual overpowered the aural. This is illustrated in particular by the introduction and elaboration of the station scale, which embodied the visualization of the sound experience, downgraded the hearing experience and consolidated the supremacy of the visual sense. Andreas Fickers, 'Visibly Audible: On the Symbolic Representation and Imagined Construction of the European Broadcast Space in the 1930s', paper presented at Design and Evolution: Design History Society Annual Conference, Delft, 31 August–2 September 2006.

6 Yagou, 'Shaping Technology'. Further research would be necessary to establish how this interface standard first came into being and was gradually diffused beyond radio, as well as whether/in what ways it was driven by technology.

7 Anthony Dunne, *Hertzian Tales – Electronic Products, Aesthetic Experience and Critical Design* (Cambridge, MA, 2008), 40.

8 Robert Hawes, *Radio Art* (London, 1991), 67 and 58 respectively.

9 Ibid., 88.

10 Roger Handy, Maureen Erbe, Aileen Antonier and Henry Blackham, *Made in Japan – Transistor Radios of the 1950s and 1960s* (San Francisco, 1993).

11 Ian McEwan, *Saturday* (London, 2006), 55.

12 In this sense, the Outsider type is more akin to the first type, the Early Domestic type of exposed valves and components, a scientific instrument that also serves as a 'plaything' and a source of great enjoyment for radio amateurs and hobbyists.

13 See: Adrian Forty, *Objects of Desire – Design and Society 1750–1980* (London, 1986); Penny Sparke, *An Introduction to Design & Culture in the Twentieth Century* (London, 1986); as well as Charlotte and Peter Fiell, *Design of the 20th Century* (Cologne, 2001), 49, 169 and 185.

14 David Raizman, *History of Modern Design* (London, 2003), 365–366.

15 A similar approach to the Copenhagen Museum display shown here is encountered at the Deutsches Museum, Munich.

16 Hannah Higgins, 'Curiouser and Curiouser: Looking through the Museum of Corn-temporary Art', in Margolin and Carroll (n. 4 above), 111.

17 Relevant sources: Hawes, *Radio Art* (n. 8 above); Handy, et. al., *Made in Japan* (n. 10 above); Philip Collins, *Radios – The Golden Age* (San Francisco, 1987); Philip Collins, *Radios Redux – Listening in Style* (San Francisco, 1991).

18 Handy, et.al., *Made in Japan* (n. 10 above), 68.

19 Forty, *Objects of Desire* (n. 13 above).

20 Ibid., 200.

21 Ibid., 204.

22 Jeffrey L. Meikle, *Twentieth Century Limited – Industrial Design in America, 1925–1939* (Philadelphia, 2001), 39.

23 George Basalla, *The Evolution of Technology* (Cambridge, UK, 1988), 77.

24 Meikle, *Twentieth Century*, 38.
25 Ibid., 27 and 95.
26 Ibid., 29.
27 Johan Redström, 'Towards User Design? On the Shift from Object to User as the Subject of Design', *Design Studies*, 27 (2006): 125. The idea that designs can be optimized on the basis of knowledge about users has been further developed and extended today to include the notion of fit not only in terms of utility or usability, but also with regards to interpretation, understanding and experience, thus leading to unambiguous communication or user experiences. Here lies the risk of a situation where the use of designs is over-determined and excessively pre-defined, thus leaving no room for unrestrained action and improvization. (Ibid., 129.) The contemporary emphasis on 'designing the user experience' may limit the range of acceptable emotions and lead to restrictive, predetermined modes of use. As Redström points out, 'this is not to say that we cannot use notions of use and users in design, but that we perhaps should take more care how to do so' (Ibid., 136). For related views, see also Ben Matthews, Marcelle Stienstra and Tom Djajadiningrat, 'Emergent Interaction: Creating Spaces for Play', *Design Issues*, 24: 3 (Summer 2008): 58–71.
28 Forty, *Objects of Desire* (n. 13 above), 205.
29 Sparke, *Design & Culture* (n. 13 above), 27–28.
30 David Attwood, *The Radio – An Appreciation* (London, 1997).
31 John Heskett, *Industrial Design* (London, 1987), 164–165.
32 Forty, *Objects of Desire* (n. 13 above), 205.
33 Handy, et.al., *Made in Japan* (n. 10 above), 71.
34 Dunne, *Hertzian Tales* (n. 7 above), 14, 32 and 38.
35 Johan Huizinga, *Man and Play (Homo Ludens)* (Athens, 1989), 73. Translated from the original English edition: *Homo Ludens – A Study of the Play Element in Culture* (London, 1949). Huizinga's ideas are further developed and expanded in Roger Caillois, *Les Jeux et les Hommes* (Paris, 1958), as well as in Maaike Lauwaert, Joseph Wachelder and Johan van de Walle, 'Frustrating Desire – On Repens and Repositio, or the Attractions and Distractions of Digital Games', *Theory, Culture and Society*, 24: 1 (2007): 89–108.
36 Huizinga, *Man and Play*, 73.
37 Klaus Krippendorff, 'Intrinsic Motivation and Human Centered-Design', *Theoretical Issues in Ergonomics Science*, 5: 1 (2004): 43–72.
38 In the same conference call it is observed that the history of technological development has more instances of people enjoying technologies than of those willing to acknowledge or systematically deliberate on such pleasures. The phenomenal development of the game and entertainment industries, primarily driven by various technologies that engender the expanded exploration of embodied pleasures, has highlighted the potential of technologically-driven experiences of fun. Conference call for ISEA 2008, International Symposium on Electronic Arts, 25 July–3 August 2008, Singapore, http://www.isea2008singapore.org/themes/ludic_interfaces.html (accessed 24 August 2012).
39 See, for example, Stefan Poser, 'Nothing More than Play? Playing with Technology as Subject of the Cultural History of Technology' and Joseph Wachelder, 'Toys as Mediators': papers presented in the 34th Annual ICOHTEC Meeting, Copenhagen, 14–18 August 2007, as well as numerous papers presented in the 39th Annual ICOHTEC Meeting, Barcelona, 10–14 July 2012. Poser also presents a useful outline of research and scholarship related to play in his article 'Playing with Technology', ICOHTEC Newsletter 49 [Newsletter of the International Committee for the History of Technology], April 2009, 2–10.
40 Brian McVeigh, *Wearing Ideology: State, Schooling and Self-Presentation in Japan* (Oxford, 2000), 157–8.
41 Ibid., 162.; see Table 6.1.
42 Dunne, *Hertzian Tales* (n. 7 above), 42.

43 Ibid., 43. This might be related to the following quote by distinguished Japanese designer Kenji Ekuan, who assesses the possible advantages of multifunctional, complex objects, as opposed to monofunctional objects which may be used easily and without ambiguity: 'The Western tool is made for a specific purpose, and anyone who uses the proper tool will presumably achieve the same results. The traditional Japanese multi-purpose tool demands, by its sheer versatility, greater creativity and aptitude on the part of the user. One might say that the Western tool is like hardware and the Japanese like software. The one is a mechanical implement that serves a particular purpose but no more than that one purpose, while the other makes greater demands for its user but is capable of an infinite extension of its possible functions according to the powers of the human imagination.' Quoted in Matthias Dietz and Michael Mönninger, *Japanese Design* (Cologne, 1994), 13.

44 Dunne, *Hertzian Tales* (n. 7 above), 46–48.

45 Ibid., 61.

46 Giulio Ceppi, 'Playing with Technology', *Modo*, no. 136 (1991), quoted in Dunne, *Hertzian Tales*, 47–48.

47 The Memphis design group, founded in Milan, Italy, in 1981, became an influential force in design through its unconventional approach and its close ties with popular culture. See Peter Dormer, *Design since 1945* (London, 1993), 27–28; Guy Julier, *The Thames and Hudson Encyclopedia of 20th Century Design and Designers* (London, 1993), 127–128. Also, the series of playful kettles, corkscrews, cruet sets and other domestic equipment produced by the Italian manufacturer Alessi have proven very popular internationally. It should be noted, however, that these are products that do not carry a significant technological component; they are simple hand-tools and therefore only indirectly related to the connection between design and technology. It is also worth pointing out that such products have been condemned as being 'useless, expensive and exclusive', their play value being considered only a marketing trick. See John Heskett, *Design – A Very Short Introduction* (Oxford, 2005), 40.

48 Jeffrey L. Meikle, 'Domesticating Modernity: Ambivalence and Appropriation, 1920–40', in Wendy Kaplan, ed., *Designing Modernity: The Arts of Reform and Persuasion, 1885–1945 – Selections from the Wolfsonian* (New York, 1995), 143–167. Attitudes towards playful product design exhibit, however, national or regional variations, as suggested by Jan Michl, in 'Am I just seeing things – or is the modernist apartheid regime still in place?', where he discusses the continuing dominance of austere modernism in Northern Europe (http://janmichl.com/eng.seeingthings.html, (accessed 24 August 2012). I would formulate the hypothesis that 'novelty' or toy-like designs are not as widely or uniformly acceptable in Europe as in the United States or in the Far East. The plausibility of such a bias requires however further research.

Alfred Nobel, Aniline and Diphenylamine

Yoel Bergman

This article examines Nobel's famed requirement for a chemical stabilizer in his ballistite smokeless powder formulation in July 1889. It suggests that the stabilizer, diphenylamine was part of Nobel's intensive and intricate efforts to improve his product during mid 1889, a point not emphasized in his biographies. It also points to the likely possibility, based on newly found documents, that Nobel's stabilizer was not the first to be conceived, or used in smokeless powders, as may be understood from several sources. Another similar stabilizer, aniline, seems to have been considered by Italian officials shortly before diphenylamine, prompting Nobel to propose diphenylamine for commercial or scientific reasons. The inquiry can help to better understand Nobel and how different formulations emerged prior to WWI, a war where the choice of ingredients greatly affected strategy.

Alfred Nobel began smokeless gunpowder (propellant) development in 1878, but he filed his first patent for a new formulation and process only in 1887. His powder was named ballistite. The French smokeless development project was much shorter. It began in late 1884 with Paul Vieille's laboratory study and ended its first phase in 1886 with the new poudre B formulation and production technology. In that year poudre B was introduced in the form of thin flakes to the Lebel 8mm rifle and, later, to higher calibres in the shape of ribbons. The less efficient black powder was largely replaced in France as the standard propellant by the year 1900.

The major European armies, in the 1880s, were in a rush to be the first to use smokeless powders in rifles. It was recognized, in the 19th century, that a decrease in the rifle calibre would afford a number of ballistic and tactical advantages, as long as an increase in initial velocity could be achieved for balancing the loss in weight of the projectile as a consequence of its decreased diameter. As far as black powder was concerned, its limit of efficiency in this direction had been reached by the middle of the eighteenth century.

Poudre B was based on one energetic material, found in 1845, and named

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nitrocellulose, which comprised a large part of the powder. Ballistite was much more energetic, since it contained, in addition to nitrocellulose, approximately 50 percent nitroglycerine. The French army did not need ballistite when it came out in 1887. Poudre B was already in service and was considered to be less erosive and safer to produce. Ballistite's practical limitations were overlooked in some of Nobel's biographies. Much more emphasis was given to the chemical wonder of ballistite; e.g., the mixing of two explosives, nitrocellulose and nitroglycerine, to obtain a gun propellant, a less sensitive compound.

Nobel's correspondences with French, Russian and Swiss officials were found lately by Petter Wulff in the Swedish national archive. They reveal that, at the end of the 1880s, the armies were concerned about the presence of nitroglycerine in the powder. Yet Nobel did not give up and exercised intensive development and marketing efforts against the growing rejection. Ballistite samples were sent to the French, Russian and Swiss armies in an effort to obtain a hold on the market. Private gun makers, such as Forges et Chantiers de la Méditerranée in southern France and Krupp in Germany, tested ballistite with satisfactory results in 1889. Nevertheless, according to Paul Vieille's report,[1] Russia, Germany, Austria and Switzerland had by 1893 chosen similar powders to poudre B as their standard army type. Britain developed its own powder, similar to ballistite and named cordite.

The Italian government was the first to introduce ballistite. A large section for making this powder was added to the Nobel plant at Avigliana near Turin and the first important contract for delivery of 300,000 kg of ballistite was concluded between the Italian government and Nobel's representative Ristoro as early as 1 August 1889.[2] According to an August 1890 letter from Nobel to the Russian Minister of War, the large-scale production in Avigliana began only in late 1889. An accidental fire in the facility disrupted production for several months and, by August 1890, some 210,000 kg of ballistite were manufactured. (The self ignition of the nitroglycerine and nitrocellulose mixture, when put on the warm rollers, continued to be a problem with the ballistite process for many years after Nobel. The heat tends to ignite the air bubbles or perhaps other materials of the mixture.) The first Avigliana powders were produced for rifles.

Why did Italy turn to Nobel? This requires a separate inquiry, but it may be possible that Italy looked for rapid improvements to its arms due to tensions with France. Not having production capabilities such as France and Russia, it sought help from Nobel who possessed the needed production plants. On the scientific level, however, Italy had capable individuals who could assess the formulation and stability from a chemical viewpoint, such as Ascanio Sobrero, a professor of chemistry at the University of Turin, who invented nitroglycerine in 1847. Nobel was respectful of Sobrero, offering him a position as a consultant to the Swiss–Italian Nobel Company – a job held from 1873 until Sobrero's death in 1888.[3]

Following Paul Vieille, who reported testing ballistite samples but without listing their year of receipt and tests, I recently questioned several of ballistite's historic milestones.[4] I estimated that Nobel sent samples to the French military for field tests and Vieille took some powder for his closed bomb laboratory experiments in 1889, although, in the literature, Nobel seems to have had loose ties with French officials as early as 1887.[5]

Letters from French officials to Nobel confirm that Nobel did send samples to the French military during 1889 and, seemingly, not before. The earliest samples were received in March 1889 for the Lebel rifle. They were in the shape of tiny, thin, square flakes and cubes. Tests were conducted most probably in April 1889 and seemed to have been unsuccessful. In what followed, Charles de Freycinet, the Minister of War, sent a letter to Nobel's French partner Paul François Barbe (the influential member of the Chamber of Deputies) on 3 July 1889, suggesting more optimal thicknesses and lengths. The two samples tested by Vieille are estimated to have been received later, beginning in July 1889. The first was sent from Nobel's plant in Bilbao and was made of square-based filaments. The second sample was tablet-shaped and seemed to Vieille as coming from Avigliana. The shapes and dimensions of both indicate that they were made for higher calibres than the Lebel rifle. Vieille was perplexed by the Avigliana sample since it was a single grain versus numerous grains from Bilbao, had a tablet-shape as against filaments and exhibited a much less compact texture than before. Looking into Vieille's bomb results, it can be seen that the composition was that of the Bilbao sample,[6] since the maximal bomb pressure for both was almost equal. However, the average burning speed of the Avigliana sample was twice as high, which can be explained by the presence of inner pores with very small diameters which are hardly visible. The pore diameter increased during burning, providing additional burning surfaces and decreasing the total burning time inside the bomb. The tablet configuration and the less compact texture of the samples (due to the rough surface and possible inner pores), could be connected with Nobel's unusual patent, which was filed in August 1889 in Britain and Italy. There he proposed the cutting of the ballistite sheets into thin-plate grains, each with an exact dimension and weight needed for a given rifle or artillery cartridge. Each was to be rolled into one cartridge case, eliminating the need for the meticulous weighing and pouring of the grains. In order to prevent adhesion between the surfaces of the rolled plates, the surfaces were to be roughened. Perforations in the plates could improve burning efficiency. Vieille and the French army thus may have received this type of powder for ballistic tests.[7]

The Bilbao sample of filaments (presumably for large calibres) may have also been sent in mid 1889. In his 3 July 1889 letter, the Minister of War wrote that he was ready to test powders for cannons that Nobel would like to send. In this letter and in another one on 5 July, he furnished for Nobel all the needed data for the tested cannon, a 90 mm calibre field gun. So the Bilbao sample may have been an outcome of the letter. This is further corroborated in Nobel's August patent in Italy for the tablet-shaped grains (submitted in Milan in French on 19 August 1889). Here he describes the ballistite grain shapes that hitherto had been created: cubes, lamella and parallelepipeds. Cubes and square lamellar flakes already had been sent to France in March 1889. Square-based filaments from Bilbao belong to the geometrical group of parallelepipeds and these grains may already have been created in late July or early August 1889.

Was the sample from Bilbao produced in that city? In Nobel's August 1890 letter to the Russian Minister of War, he writes that large-scale production began in Italy in late 1889 and, afterwards, in Spain and Germany. It is thus possible that Nobel produced the sample in mid 1889 in Avigliana but needed to conceal the fact due to tensions with France. The second sample was referred to by Vieille as 'Avigliana (?)'. Its origin may have been blurred for the same reason. Was it plausible that Nobel used Avigliana as a platform for sending samples to France? This seems likely since Nobel, according to his August 1890 letter, had sent from Avigliana to St. Petersburg, some 2500 kg of ballistite for tests.

The samples in Vieille's report contained aniline, used in early Italian ballistite as a chemical stabilizer. Powder production in Italy began in 1889 but the date of aniline's first inclusion is unknown. Two sources describe aniline as an early Italian initiative and this is also implied when checking Nobel's patents up to July 1889, which do not propose any stabilizer.

Diphenylamine is believed to be the first stabilizer in ballistite and in all smokeless powders, following Nobel's July 3, 1889 ballistite patent in Germany, where he required a stabilizer (diphenylamine). However, since Nobel probably sent the samples with aniline shortly before or after the July 1889 patents, it may indicate that no powder with diphenylamine was available at ballistite's early phase and aniline was thus the first stabilizer in use. Furthermore, in a recently found update to his Italian ballistite patent, filed by Nobel on 20 July 1889,[8] Nobel requires the addition of diphenylamine or similar materials for stabilization. Aniline complies with characteristics of the similar materials described by Nobel and can thus have been an eligible candidate. This differs from the patent in Germany approved only seventeen days earlier and which left no options for other materials except diphenylamine. The difference may suggest that Nobel was aware of the importance of aniline in Italy, as a stabilizer already in use in Nobel's samples or as a possible future candidate. In one recent publication on ballistite, it may be understood that aniline and diphenylamine originated in Nobel's 1888 British patent;[9] however, the original British application and the final version, both of 1888, do not mention aniline or diphenylamine. In addition, Paul Tavernier, in his 1950 seminal work on powder history,[10] also reviewed both the British and German patents and indicated that the requirement for a stabilizer (diphenylamine) began with the German July 3, 1889 patent.

If aniline was proposed or already used in mid 1889, then Nobel could have conceived of diphenylamine based on his previous experience with aniline. Thus, we must examine the possible reasons for Nobel's conception of diphenylamine, first by reviewing Nobel's patents, next by comparing diphenylamine and aniline and, finally, by examining the July 1889 application for a patent update in Italy for a more precise understanding of the two stabilizers.

PATENTS OF LATE 1887 TO EARLY 1889

Ballistite patents in this period were similar and were written by Nobel as an outcome of the initial formulation and process development efforts between 1878 and 1887 that he conducted in his Paris laboratory and by test firing at his explosives company in Ardeer, Scotland. The patents describe the process and formulations in general terms and, as a result, seem to reflect a lack of 'hands on' experience in large-scale production and ballistic tests. Patents in this group include, by country and date of application: France – July/August 1887; Britain – January 31, 1888; Italy – February 6, 1888; Spain – January 20, 1889.[11] All patents were filed personally by Nobel.

In these patents, a mixture was first created with oily nitroglycerine and camphor, a non-energetic solvent. Fibrous nitrocellulose was then introduced into the mixture and agitated together, resulting in a viscous mass to be processed further under warm rollers. Thin, hard and brittle sheets were obtained from the rollers and cut to the desired powder grain shape. The allowable ratios (by weight) of nitrocellulose and nitroglycerine in the formulation varied considerably, from 1:2 to 2:1. Camphor was approximately 10 percent of the formulation.

PATENTS OF JUNE AND JULY 1889

This new 'cluster' of ballistite patents filed by Nobel seems to be an outcome of his intensive improvement efforts in the first half of 1889, the goal of which was to prepare for his first large contract with Italy and to supply small arms samples in the required quality for several countries. He focused largely on improving the first step of the process; e.g., mixing of nitrocellulose and nitroglycerine prior to being put through warm rollers. A better mix perhaps was needed to increase the homogeneity of the sheets exiting the rollers or to reduce the chances of self-ignition. A stabilizer was first introduced in the German patent (Nobel's first patent in that country) and in the Italian patent update, both in July 1889 and which are reviewed below.

Update to the British 1888 patent, applied on June 5, 1889 and named: 'Improvement in the manufacture of explosives' [12]

This update is primarily devoted to mixing improvements. Camphor was eliminated as a solution aid and plasticizer and the nitroglycerine was directly mixed with the wet nitrocellulose. Two additional (alternative) methods for mixing were also listed to improve dissolution: Nitroglycerine may be added in much higher proportions than required and then the excess is squeezed out to form the final mixture. Alternatively, the mixing process may be carried out at a temperature low enough to guard against the possibility of the easily soluble nitrocellulose becoming prematurely dissolved in the nitroglycerine. The fact that Nobel offered three methods for mixing suggests that he was not yet experienced with or set on the preferable method.

A few weeks later, on June 25, 1889, two chemists, Carl Olof Lundholm and Joseph Sayers, applied in Britain for a patent where nitroglycerine and nitrocellulose are placed in water and mixed by vigorous agitation. This method soon came to replace the direct mixing methods suggested by Nobel in his 1889 patents. Previous scholars have made no link between Nobel and Lundholm and Sayers, who appeared to work independently; however, when examining their original application, there seems to be some link. The two chemists in the application are described as being 'both of Stevenston in the County of Ayr, North Britain'. The County of Ayr is the official name of the registration county of Ayrshire in Scotland and the town of Stevenston is located in North Ayrshire. Stevenston was a major base for Nobel Industries and later Imperial Chemical Industries (ICI), whose nearby Ardeer site employed many thousands of workers producing explosives and chemicals. Ardeer is now part of Stevenston. Thus, Lundholm and Sayers most probably worked with Nobel in Ardeer, assisting him in improving the mixing operation. They may have proceeded to patent an alternative method found during development, perhaps on their own initiative or on Nobel's behalf.

A few additional pieces of evidence also support the link assumption. The patent came out only a few weeks after Nobel's patent update and bore a similar name to Nobel's original patent save for one pluralizing the first word: 'Improvements in the Manufacture of Explosives' (Lundholm and Sayers) as compared to 'Improvement in the Manufacture of Explosives' (Nobel). Lundholm's clearly Swedish name also suggests that he followed

Nobel to Scotland. The story of this patent is quite meaningful for the possible process development in Ardeer and supports the notion of intensive and intricate ballistite efforts at this period. It also points to three misconceptions in the literature: that the two engineers and Nobel worked separately,[13] that aniline addition was part of their patent[14] – a claim that was not found in the initial July 1889 application or in the final version of March 1890 – and that the patent came from Sweden.[15]

First patent in Germany, approved on July 3, 1889 and named: 'Procedure for the description of explosive gelatine that is suitable for gunpowder' [16]

The process and formulation described here are similar to the British, June 1889 update, but there are several differences, which indicate that Nobel had become more determined to correct his mixing technique and formulation:

a) The mixing options were reduced to one: refrigerating the nitroglycerine and nitrocellulose to low temperatures (of +6 to +8 degrees Celsius) and then mixing them.
b) The possibility of mixing equal weights was removed, leaving the addition of nitroglycerine to nitrocellulose in a much higher proportion than required before the excess is squeezed out.
c) Nitrocellulose to be mixed could be either in a dry state or a wet condition.
d) To facilitate nitroglycerine dissipation into the pores of the fibrous nitrocellulose, a new phase was introduced, that of placing the mixed mass under vacuum to draw out air bubbles from the nitrocellulose.
e) The optimal recommended ratio of nitroglycerine to nitrocellulose in the final formulation is 1:1, since this leads to a satisfactory mutual dissolution (or gelatinization) while creating a brittle hard sheet that can be cut into grains.
f) Finally, in order to safeguard the chemical stability of the manufactured gun powder, 1 to 2 percent of the diphenylamine could be added to the nitroglycerine at the beginning. (Nobel does not indicate if the percentage is of the total powder weight or only of the nitroglycerine, but Paul Tavernier determined that these percentages were of all powder, which Nobel makes clearer in his Italian patent a few weeks later.)[17]

In Tavernier's work, Nobel's German patent is presented as the initially proposed solution to the emerging stability problem of the new smokeless powders.[18] The reader is thus left with the impression that Nobel was the first to conceive of the need for a stabilizer in smokeless powders and the first to incorporate such a material.

Update to the Italian 1888 patent, applied on July 20, 1889, named: 'Improvements in the production of explosive compositions without smoke'

The July 1889 update to the original 1888 Italian patent is similar in content to the German patent but is more detailed. It divides the process into six distinct steps and resembles an SOP (Standard Operation Procedure) used in production plants to guide the actual manufacturing process. These details were perhaps needed, since Nobel was about to sign, on 1 August 1889, a contract with the Italian government for the production of 300,000 kg of ballistite. Another difference with the German patent concerns the addition of a stabilizer.

DIPHENYLAMINE & ANILINE

T.L. Davis writes what seems to be an Italian initiative on aniline: 'The Italians early used aniline as their stabilizer for their military Ballistite.'[19] Marshall writes similarly that 'Ballistite was adopted by the Italian Government soon after its invention but instead of using it in flake-form, it was drawn out into cords and hence given the name "Filite". Italian Ballistite generally consists of equal parts of nitroglycerine and colloidon cotton, together with 0.5 to 1 per cent aniline.'[20] Both Davis and Marshall imply an Italian initiative, and since Marshall wrote his book during WWI, it may testify to the continued use of aniline in Italian ballistite, even after Nobel's 1889 update. (Aniline in general was used as a replacement for diphenylamine during the times of diphenylamine shortage in WWI.)[21]

Marshall also wrote that the German navy began to use ballisite versions in 1897. Some were stabilized with aniline and some with diphenylamine.[22] By 1906, however, Germany found both materials to be unfit for use in smokeless powders that contained nitrocellulose and nitroglycerine (as ballistite), since they decomposed the nitroglycerine over time. The material centralite emerged to become the standard ballistite stabilizer in Germany in 1906, and Henri Muraour wrote that, on the eve of WWI, all such German powders contained 1.0 percent centralite.[23] Diphenylamine became the primary choice in Germany for powders based only on nitrocellulose and, by the beginning of WWI, as the primary choice in other countries. Yet, the transformation to centralite in ballistites was not carried out in all countries, and some ballistites contained diphenylamine even in WWII.[24]

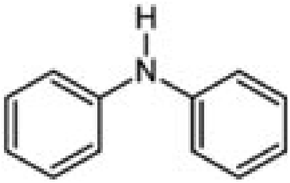

Figure 1. Molecular structure of diphenylamine.

Diphenylamine belongs to the family of organic bases (see Figure 1). It is composed of two six-sided rings (based on carbon and

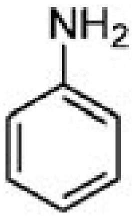

Figure 2. Molecular structure of aniline.

hydrogen – the 'aromatic rings') with a nitrogen (N) atom and hydrogen (H) atom in between.

Diphenylamine is produced from two units (or molecules) of aniline, which also belongs to the family of organic bases and has only one aromatic ring (Figure 2).

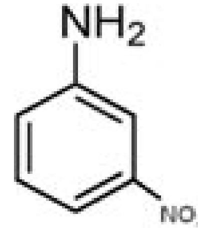

Figure 3. Annexation to the aromatic ring in aniline.

The active sites on the molecules are those on the six-sided rings where decomposition products are annexed. Figure 3 depicts an annexation of nitrogen dioxide (NO_2). It comes either from the breakage of nitrocellulose or nitroglycerine bonds or from acids remaining in these materials despite the thorough washings at the end of their production.

STABILIZERS IN THE ITALIAN UPDATE OF JULY 20, 1889

The Italian update differs from the German July 1889 patent in lower diphenylamine percentages, in the allowance for other materials as stabilizers in place of diphenylamine and in the introduction of a scientific explanation. These differences point to aniline as a material already in use in Nobel's Italian samples, or, under serious consideration by the Italian government.

Nobel writes in the update that, in order to increase the chemical stability of ballistite, he incorporates into the powder a small quantity of stabilizer, 0.5 to 1.0 percent of the total ballistite weight. The stabilizer has the inherent property of various organic bases and of primary amides, of reacting with decomposing gases and reducing their content to trace levels. Too many decomposing materials propagated the decomposition reaction – what is called an autocatalytic reaction.

This stabilizer content of 0.5 to 1.0 percent was in contrast to the 1.0 to 2.0 percent in the German patent and equal to the percentages of aniline used in Italian ballistite, as reported by Marshall. Here I assume Nobel equated diphenylamine percentages with aniline, so as to prove that diphenylamine was just as efficient in lower percentages. The scientific explanation on chemical stabilization was not found in the German patent, indicating perhaps that a high degree of scientific understanding was prevalent at the time in Italy.

Nobel also implies that any substance which belonged to the family of organic bases or primary amides had the capability to serve as a stabilizer. This becomes clearer in the summary part of the update, on the last page in his last claim, where he writes that diphenylamine or analogue materials should be added to improve ballistite's stability. Aniline, although not named here, thus becomes an eligible choice for stabilization, since it is an organic base like diphenylamine.

Nobel writes that diphenylamine is a very good candidate for stabilization, since it is to be dissolved in nitroglycerine before the dissolution phase of nitrocellulose in nitroglycerine. What were the advantages of diphenylamine over other materials? Nobel stops short of providing an answer.

The discrepancies in Nobel's claims between the German and Italian patents seem to stem either from commercial or scientific logic:

Commercial logic: Aniline was added to ballistite samples in Italy according to a requirement by the Italian government in the first part of 1889. Since Nobel could not patent aniline in his July 1889 update, he chose diphenylamine, a similar and superior material and a perfect choice for awarding him exclusive rights. This was easy in Germany since no production there had begun. In Italy he tried to encourage the use of diphenylamine to eliminate future contradictions in ballistite formulations in different countries.

Scientific logic: Nobel may have concluded that aniline (whether proposed by him before or by the Italian government) was not suitable. He may have been convinced that diphenylamine was better and was interested in promoting a more suitable material in Italy and elsewhere.

CONCLUSIONS

This article has exposed Nobel's intensive and intricate efforts to advance his ballistite during mid 1889. The efforts were part of his 1888–1890 campaign to market ballistite across Europe, described only in brief in Nobel biographies. His efforts with the armies at that period were mostly unsuccessful. The introduction of diphenylamine was part of his campaign, but, contrary to conclusions drawn elsewhere, the stabilizer was probably not the first to be conceived of or used in smokeless powders. Several documents corroborate this assumption and point both to Nobel's allowance for aniline in his Italian update on July 1889 and to the presence of aniline in samples sent to France during 1889. Nobel may have introduced diphenylamine with some knowledge about aniline, preferring the former for commercial or scientific reasons. The aniline precedence can also explain why Italian ballistite contained aniline years after Nobel's July 1889 update, as late as WWI. More definite answers on the above estimations may be found in the future in undiscovered personal documents of Nobel and his contemporaries.

NOTES

1 Paul Vieille, 'Étude sur le mode de combustion des matières explosives', *Mémorial des Poudres et Salpêtres (MP)*, 6 (1893), 358–359.

2 H. Schuck and R. Sohlman, *Alfred Nobel* (London, 1929), 118.
3 *Ibid.*, 62.
4 Yoel Bergman, 'Paul Vieille, Cordite and Ballistite', *ICON: Journal of the International Society for the History of Technology*, 15 (2012): 41, 45.
5 Erik Bergengren, *Alfred Nobel, the Man and his Work* (Walton-on-Thames, Surrey, 1962), 105–106.
6 Vieille, 'Étude sur le mode de combustion', 362–363.
7 The issues of France, Russia and Nobel's August patents will be examined in greater details in future articles.
8 The patent was handwritten and the author previously was unable to determine whether the date of the submission was July 20, 1889 or July 30, 1889. Ciro Paoletti an Italian military historian active in ICOHTEC social history of military technology symposia has advised me in a personal correspondence on 8 September 2011 that the date was 20, since during the 19th century in Italy, the 2 was graphically similar to 3.
9 Richard E. Rice, 'Smokeless Powder: Scientific and Institutional Contexts at the End of the Nineteenth Century', in *Gunpowder, Explosives and the State*, Brenda J Buchanan, ed. (Farnham, Surrey, 2006), 357.
10 Paul Tavernier, 'Évolution Historique des Poudres Sans Fumée', *Mémorial des Poudres et Salpêtres*, 32 (1950), 245.
11 Copies of patents in this group were reviewed, except for the French patent whose data is based on descriptions given by Schuck and Sohlman, *Alfred Nobel* (n. 2 above), and Erik Bergengren, *Alfred Nobel* (n. 5 above).
12 The existence of this update was found lately in Schuck and Sohlman, but a copy could not be found in the British Patent Office. Schuck and Sohlman listed and described all of Nobel's British patents. They are a much quoted source on the ballistite issue in recent biographies. Their description of Avigliana best conforms to Nobel's own description. Other parts of their ballistite reviews also seem credible. Copies of all other patents of June–July were found and reviewed.
13 Basil Fedoroff, ed., *Encyclopedia of Explosives and Related Items* (Mineola, New York, 1960–1983), B8–B9; Paul Tavernier, 'Évolution Historique des Poudres Sans Fumée', 245–246; Arthur Marshall, *Explosives: Their Manufacture, Properties, Tests and History*, vol. 1 (London, 1915), 233.
14 *Encyclopedia of Explosives,* B8.
15 *Ibid.*, B8.
16 I would like to thank Stefan Poser for his initial review of the patent. The copy of the patent that I reviewed was a second edition. It was compared by Ms. Evelyn Benke of the German Patent office and found compatible with the first edition of July 1889.
17 Paul Tavernier, 'Évolution Historique des Poudres' (n. 10 above), 245.
18 *Ibid.*, 250.
19 Tenney L. Davis, *The Chemistry of Powder and Explosives* (Hollywood, CA, 1998 [1943]), 308. Bergman, 'Paul Vielle,' (n. 4 above), contains a similar discussion.
20 Marshall, *Explosives* (n. 13 above), 234.
21 Tadeusz Urbanski, *Chemistry and Technology of Explosives*, Vol. III (Oxford, 1967), 530, 652
22 Arthur Marshall, *Explosives* (n. 13 above), 234
23 Henri Muraour, 'Note sur les différent types de poudres utilisés en Allemagne avant et pendant la guerre', *Mémorial de l'Artillerie Française*, vol. 2 (1923), 505.
24 *Encyclopedia of Explosives* (n. 13 above), B8.

Re-using the Industrial Past

The Gunpowder Heritage:

'Re-using the Industrial Past'

Brenda J. Buchanan

As a subject of historical and practical research, gunpowder provides a prime opportunity for 're-using the industrial past' in order to learn more and to understand more about our heritage. The power of gunpowder was first unleashed by experimentation in China in the mid-ninth century. The transfer of this technology to the western world means that gunpowder lies at the heart of useful concepts such as globalization (through, for example, its influence on international trade, especially in saltpetre and sulphur) and colonization (associated, for example, with settlement in the New World). Systems of manufacture were developed in what were to become the largest factories of their time in both the European nations (as at Waltham Abbey in Britain and Frederiksværk in Denmark) and overseas (as established by the Portuguese at Goa in India and by the Spanish at Lima in Peru). Surviving sites offer the possibility of interpretation and restoration. Gunpowder's destructive military use may have excluded it from any pantheon of the agents of progress, but its technological and scientific history, the evidence of early factory production and its civil use in mining and civil engineering all demonstrate a heritage which may be revisited and re-used in a positive way.

INTRODUCTION

The title of this paper echoes that of the ICOHTEC symposium at which it was presented, in Tampere, Finland, 2010. This innovative conference was held jointly with TICCIH (The International Committee for the Conservation of the Industrial Heritage), whose commitment to studying and where possible preserving the culture and remains of our industrial past provides a theme that is well-worth investigating within ICOHTEC's wider academic concern with the history of technology. I intend to examine the subject with reference to the 'gunpowder heritage' in particular. The concept will be interpreted to mean not just the surviving sites and structures that can

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be studied to provide physical evidence of their earlier and probably original use, but also documents such as letters, financial accounts, legal papers, plans, maps and printed matter, which can be applied beyond their initial purpose to facilitate the understanding of the gunpowder world. Used with discretion, it may be claimed that both of these proofs of evidence are as acceptable as any required in an academic context.

In my conference Abstract I drew together several of the general aspects of the subject, but in reflecting on this paper it has come to seem proper that it should have a more personal content, thus I share my own experience of the importance of both physical and documentary evidence for our understanding of the past. This linking of the two approaches grew from my postgraduate research into a subject far removed initially from gunpowder history, that of financial investment and capital formation in the eighteenth century. My attention was focussed on the Bristol region of the west coast of Britain where I lived with our family, but here I found documents relating not only to the expected investment in agriculture, mining and transport, but also evidence regarding a range of industries – especially gunpowder-making, details of which were hitherto little known or indeed unknown in this or other regions. It was an industry that went, for example, unmentioned in the otherwise ground-breaking study by Angus Buchanan and Neil Cossons of *The Industrial Archaeology of the Bristol Region* (1969).[1] The best and most complete set of financial accounts and correspondence that I could find on any industry came in the papers of the Strachey family, deposited at the Somerset Record Office and relating quite fortuitously to powder mills at Woolley.[2] I could see from the documentary evidence that this had been an active centre of gunpowder manufacture in the eighteenth century, but where were these powder mills? It was by a chance conversation at a meeting of the Newcomen Society that I learnt that Woolley was a small village, only some three miles north of Bath. The industry that had flourished there in the eighteenth century had declined and the land had reverted to agricultural use. That gunpowder had been made at Woolley so close to Bath seemed extraordinary, especially as in those same years this resort had been the fashionable magnet for wealthy aristocrats and landed gentry in search of improved health and a suitable marriage. It had never to my knowledge been mentioned in histories of the city, or in the many novels based there. But the family of my informant, Malcolm Tucker, had bought and restored a property on the site, and over the years he had built up a splendid portfolio of drawings whilst knowing little more than the rumour that gunpowder had once been manufactured there. We combined our expertize and published an article in the *Industrial Archaeology Review* of 1981, entitled 'The Manufacture of Gunpowder: A Study of the Documentary and Physical Evidence Relating to the Woolley Powder Works near Bath'.[3] I was to learn that Woolley was only one of the manufacturing sites established in the countryside in the eighteenth century as the demand for gunpowder outstripped that which could be supplied by small-scale manual operations within the cities. But simple as they were, the gunpowder-making practices followed in these small urban domestic workshops are worth studying because they were basically the same as those employed in the later larger powder mills established in the countryside.

Figure 1. Workmen making gunpowder by pestle and mortar. Engraving from Hanzelet's *Pyrotechnie* of 1630, reproduced by Oscar Guttmann, *Monumenta Pulveris Pyrii* (London, 1906).

An engraving from Hanzelet's *Pyrotechnie* of 1630 (Figure 1) provides the material for an understanding of the basic procedures of gunpowder-making. The date 1630 is highly appropriate because at this time the central government was trying to regulate the domestic production of gunpowder in Bristol, afraid that not doing so might threaten provincial stability.[4] The engraving shows the scales necessary for the weighing of the ingredients in their correct proportions. These hang on the wall alongside the coarse riddle through which the materials would be sieved. The workman on the left holds a pestle with which he pounds the saltpetre, sulphur and charcoal within the large mortar. The process of incorporation will take several hours, during which time a little water will be added to facilitate this mixing under pressure. The resulting paste will then be 'corned' by the second workman, using the 'rolling pins' to press the mix through the stretched animal skin of a finer riddle, punctured with holes appropriate to the size required. If as is very likely the holes become clogged, there is a small twig at hand on the corner of the table to clear the way. Perhaps the term 'corning' was coined because of the similarity between these grains of powder and the seeds of corn and other familiar cereals. It marked a very significant development in gunpowder-making because it prevented the ingredients separating out again and gave some protection against damp. The grains would be dried in trays, out in the sun if possible, or on the table, before being tested in the 'trier' that stands there, its open lid perhaps indicating recent use.

THE WOOLLEY POWDER MILLS

This explanation of the processes depicted in the engraving must be conjectural because it is based on a personal interpretation of what is shown there. It will be followed by further informed speculation about the lay-out at the Woolley Powder Mills. But first, this move to the countryside in the early-eighteenth century was in part the result of the growing urbanization that led town-dwellers to complain about neighbours who were pursuing dangerous 'domestic industries'. An investigation of a house in London in 1639 by the authorities for example, revealed 'all things necessary' for making gunpowder.[5] But perhaps more significantly than these anxieties, the move was a response to the market, for the valleys in the countryside could offer a better location for an increasingly important industry. Here, taking advantage of the improving transport facilities provided by turnpike roads, river navigations and canals to carry raw materials and the finished goods, there was the security provided by a degree of isolation, a supply of charcoal from the wooded hills and water power from the flowing streams that was crucial to the engineering of a great increase of scale in the production. This can be seen clearly at Woolley, my first case study, where the mill ponds and leats provide almost the only surviving evidence of the former industrial activity in what has since reverted to farmland.

The extraordinary and still largely surviving measures that were taken to bring water to this steep-sided valley of the Lam Brook where gunpowder-making began in the 1720s, are shown in Figure 2. The features are numbered on the sketch map, which shows the lower mill pond (1), supplied by a leat that can be traced back to a weir (2). This source of power was not immediately available to the gunpowder partners since it supplied corn mills that were first recorded on this site in the Domesday Book (1086). Instead, power was to come from the very substantial upper mill pond (3), supplied by the now grassed-over leat (4) that ran back to a dam on the stream. There are references to the securing of this waterway in Strachey papers of the

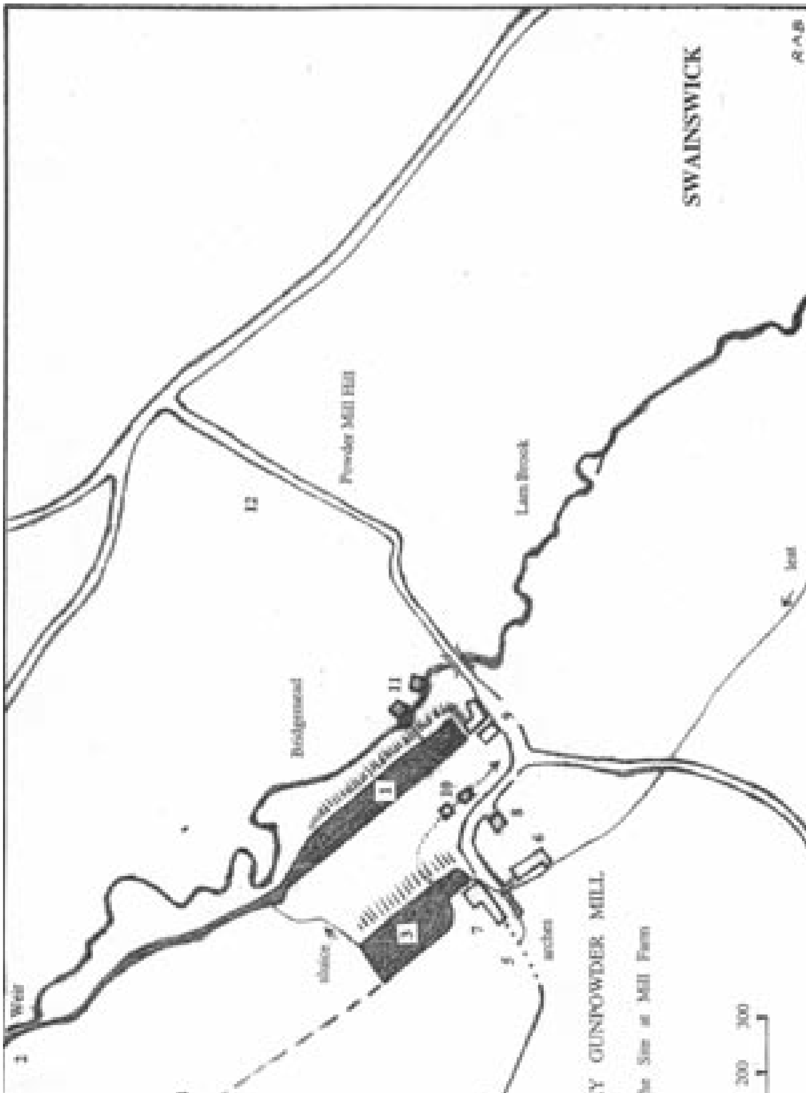


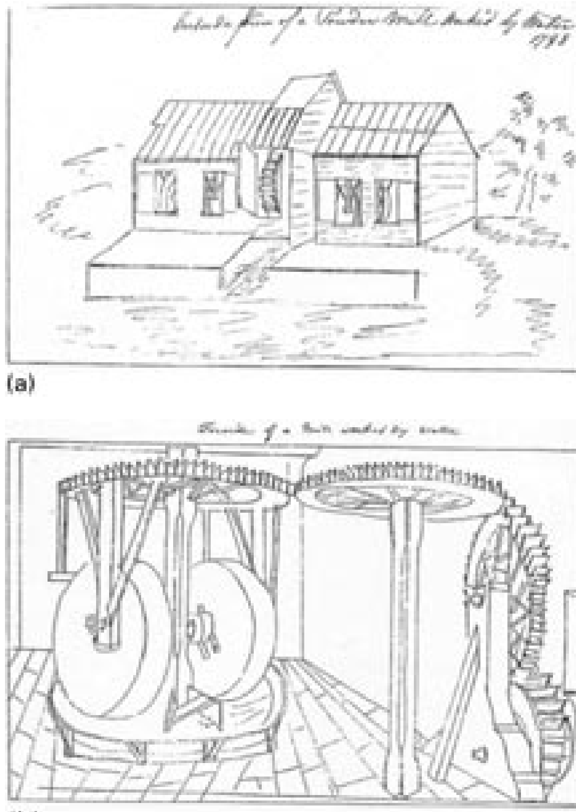
Figure 2. Plan of the Woolley Gunpowder Mills based on documentary and physical evidence. Drawn by R. Angus Buchanan (2005).

1720s. Lastly, fresh water from springs was brought to the western side of the site by pipes and an aqueduct (5). The comment by the managing partner in this enterprise, made in March 1801, that the annual stock-taking took place in June because then '... our Mills usually stand still for want of Water'[6] places this intricate system in perspective, whilst also demonstrating the value of being able to bring together both the documentary and the physical evidence.

The managers of gunpowder works often lived on the site, to maintain control over matters such as the lengthy timing of the incorporation process, and it is likely that this accommodation was provided at Woolley by the now-restored Mill House (6). As we know from the annual accounts that saltpetre and sulphur were stored at the works in both a rough and a refined state, it seems likely that the processing and storage which this implies probably took place in what are now farm buildings or their predecessors (7), accommodated near the manager's house because though unpleasant these were not dangerous procedures. Nor was the crushing of the charcoal that probably took place in what was to become a stable (8), but where traces of this substance have been found in grooves in the walls. No physical evidence has yet been found of the incorporation and corning of the gunpowder, probably because these were dangerous processes in which stray sparks could cause an explosion. Such workshops were often demolished when production ceased as they could not be entirely cleansed of powder grains.

In the absence of physical evidence, the location and arrangement of the incorporating mills at Woolley led to heated discussions with my colleague Malcolm Tucker, especially with regard to the interpretation of a Memorandum of 1747/49, found in the Strachey papers. This noted that there were four mills at Woolley, each capable of 'grinding' 25lbs in two hours, using water that was 'worked twice over'. I felt this could be best explained by the conjecture of two sets of mills, each with a central waterwheel supplying powder to mill stones on either side, arranged in sequence on sloping ground, probably that lying beneath the upper mill pond. The water could thus be used twice over to power the four mills. Two illustrations have since helped to confirm this suggestion.

The drawings in Figure 3, dating from late 1790s and attributed to John Ticking, Master Worker at the Faversham Gunpowder Mills,[7] serve a dual purpose. What is most immediately obvious is that they confirm that the pressure traditionally exerted by the pestle in the mortar has been replaced by that of edge runners, usually of stone, trundling over a base of the same material, on which the raw constituents prepared for incorporation have been spread. At Woolley, the documentary evidence relating to the purchase of such stones shows that this method had been in use from the earliest days, as the mills were established on a 'green field' site and so could more easily adopt a new technology than longer-established businesses, which had invested in the older method and thus were slower to adapt. But more important for the present investigation is the evidence the drawings provide as to the arrangement of these mills. Figure 3a shows an external view of the workshop with a central water wheel supplying power to two mills, one on either side. The adjacent internal view shows one set of the edge runners turning on their bed. The water runs away in a central channel, and having worked the first two mills it goes on to work two more. Here, surely, the water is being used twice over to power four mills. The poorly drawn gearing suggests this is a student copy of what must have been a more skilful representation by Faversham's Master Worker.



(a) (b)

Figure 3 a and b. Water-powered edge runner incorporating mills, from John Ticking's Notebook of the late 1790s, reproduced by E.A.Brayley-Hodgetts, ed., *The Rise and Progress of the British Explosives Industry* (London, 1909).

The next illustration is from a more professional hand, that of the surveyor Robert Whittlesey who was employed by Oriel College, Oxford, to prepare a plan showing property they owned in the parishes of Swainswick and Batheaston. This survey dated 1729 has only come to light relatively recently in the archives of the college. The appropriate section is shown in Figure 4 overleaf.[8]

'The Powder Works', as Whittlesey names them, were not part of his commission. But working in the parish of Swainswick he must have looked over the hedge into the adjoining parish and seen something intriguing he

Figure 4. 'The Powder Works' at Woolley, as sketched by Robert Whittlesey when surveying parish land in the estate of Oriel College, Oxford, 1729. Reproduced by kind permission of the Provost and Fellows of Oriel College, Oxford.

thought worth recording. The workshops are depicted simply as a cluster of buildings, whose function was perhaps unidentifiable, but two structures sit astride a water course, and it is not too fanciful to see these as the four incorporating mills, operated by water that was being used twice over. Perhaps Whittlesey recorded this because he had not seen this configuration before, or perhaps he thought Oriel College might have some interest in the waters being drawn from an upstream dam. In Figure 2 (*supra*), the mills (10) have been placed as suggested by Whittlesey's survey. The magazines (11) in which the powder would be stored before being collected by wagons are shown a safe distance away from the mills, as indicated on a sketch map drawn by another surveyor, Thomas Thorpe, whose 'Map of Five Miles around Bath' was published in 1742. Close by is Powdermill Lane (9), which led away from the site and up (12) to the turnpike road leading to Bristol, some fifteen miles away.

The site has been re-used for agricultural purposes since the early nineteenth century, but the interpretation of its history can tell us a great deal about this region. In particular the link with Bristol was the most significant feature, because this and many other businesses in the countryside were financed by the capital investment of creditworthy Bristol merchants, able in the case of powder mills, to import the saltpetre and sulphur required through the trading networks of which they were part. Some of the finished product went locally to the mining industry, but most would be exported (as the port records show) to Ireland, the trans-Atlantic colonies and, for slaving purposes, the west coast of Africa.[9] The decline in the trans-Atlantic trade, as powder works were set up in the United States, and in the slave trade, as this was made illegal, led to a fall in the prosperity of the gunpowder industry of the Bristol region. In the early decades of the nineteenth century, small businesses were bought up by larger national concerns, moth-balled and then allowed to close, with much of the countryside resuming its agricultural torpor.

GUNPOWDER MILLS STUDY GROUP

The publication in 1981 of Buchanan and Tucker's work on the Bristol region in the national journal devoted to industrial archaeology (see note 3), coincided with the growing interest of Alan and Glenys Crocker who found themselves living near the overgrown and largely derelict Chilworth Powder Works in Surrey. Founded in 1626 by the East India Company, these had survived several owners before becoming an Admiralty cordite factory, closing in 1920. Those thought to be interested in gunpowder-making were contacted, and we met and formed the Gunpowder Mills Study Group. From the mid-1980s, we held both an annual meeting and a field trip. The latter took the form of expeditions throughout Britain, exploring and recording such sites of gunpowder manufacture as we were able to find, often drawing on documentary evidence and local knowledge to help us discover these physical features. With contributions by our members these powder mills were entered into a gazetteer of sites, the compiling of which was the work of Glenys Crocker. This was the first survey of British gunpowder mills to be documented.[10]

As a Group we spent a most enjoyable amount of time beating about in the undergrowth from Cornwall to Scotland. On one occasion we were exceptionally lucky for we arrived by arrangement at the Ardeer works at Ayr, on the south-west coast of Scotland, to find that the black powder mills at the rear of the site were to be dismantled. The documents pertaining to them were threatened with dispersal. As our number included Miles Oglethorpe, then with the Royal Commission for Historic Monuments in Scotland, we argued successfully that the documents should be saved, and some were carried away immediately for the Royal Commission's archives, with Miles returning later to complete the rescue mission. The Ardeer works had been established by the British Dynamite Company in 1872 on a site chosen by Alfred Nobel, becoming part of the Explosives Division of ICI in 1926. Black powder was made here from 1935–1977, providing a fall-back facility that might have been called upon in wartime. What I did not know then but discovered later when undertaking research for my paper on charcoal (presented at the ICOHTEC Symposium in Victoria, British Columbia, 2008, and published in *ICON* of that year),[11] was that acting through the Ministry of Defence the British Government was so anxious to maintain access to a supply of black powder, even in the last quarter of the twentieth century, that with the planned closure of Ardeer an order for powder was placed with a German company. To aid production, machinery was sent from Ardeer to Germany, yet despite this, the gunpowder produced was unsatisfactory. The problem was found to lie with the quality and reproducibility of the charcoal. This led to the setting up of a research project at the Northern Carbon Research Laboratory of the University of Newcastle in the early 1980s. It is from the reports of this research group and the reference to the link with Germany that it has become possible to understand more fully what was happening when we made our visit to Ardeer.

ICOHTEC'S GUNPOWDER SECTION

Useful and enjoyable as this work was at both the local and the national level, the importance of learning more about gunpowder in its international context was becoming apparent, and after talking about this to members of

ICOHTEC for several years, the opportunity to organise a first meeting of a Gunpowder Section came with the holding of the 22nd International Symposium at the University of Bath in 1994.[12] I had to contact and persuade those international scholars who, from their writings, I knew had an interest in aspects of powder production, to come to Bath. The response was excellent, especially as many had felt themselves working in isolation, and our enthusiasm was such that twenty-four papers became available. Our concluding dinner at the University of Bath was followed by a display of musket and small cannon firing by a society based at the Old Wardour Castle, damaged in two sieges in the English Civil Wars of the 1640s. This provided a vivid demonstration of our interest in the celebratory and practical aspects of gunpowder history, as well as in the academic and theoretical.

Only two years later, a volume containing our twenty-four ICOHTEC papers was published by Bath University Press. Entitled *Gunpowder: the History of an International Technology*, the book was well- and widely-reviewed, and having sold out, it was reprinted in a soft-cover version a decade later. All the articles broke new ground, but two, concerned with the technology of powder production at specific sites, are of interest to the present study – at Waltham Abbey in the UK and at Ballincollig in what is now the Republic of Ireland. It may also be mentioned that our introductory chapter was by Robert Howard of the Hagley Museum in Delaware, USA, an organisation long associated with the DuPont Powder Works and a leader in the presentation of the practicalities of powder-making.[13] The Gunpowder Section of ICOHTEC continued to meet regularly, and a second volume was published by Ashgate Press in 2006, with chapters drawn from the following symposia: Budapest (1996), Lisbon (1998), Belfort (1999), Prague (2000), Granada (2002) and Bochum (2004).[14] Leicester (2006) was a special year, as it was then possible to present to the Symposium both the second volume and the reprint of the first, already mentioned. Since then, the Group has met within ICOHTEC at Copenhagen (2008) and Victoria, British Columbia (2010). Some 130 papers have been presented at ICOHTEC symposia, of which 44 or about one-third have been published in the two books. Several more have been published in ICOHTEC's journal, *ICON*.[15]

The physical aspects of gunpowder manufacture, with accounts of the sites involved, received even more notice in the second volume than the first, with chapters on production at Venice in Italy, Barcarena near Lisbon, Torsebro in Sweden, the Portuguese overseas factories at Goa in India and Rio de Janeiro in Brazil and, in what had become the warring states of America, at Augusta, Georgia in the south and the DuPont mills near Wilmington, Delaware in the north.

THE WALTHAM ABBEY ROYAL GUNPOWDER MILLS

Out of all the sites studied in both volumes, I shall now focus on the Waltham Abbey Royal Gunpowder Mills (WARGM). It is an ideal case study, for three good reasons: first, because of my own long commitment to the site, having spent ten years as one of four Foundation Trustees. Second, because of the counterpoint that Waltham Abbey provides to the Woolley Mills described earlier. Both were established as private concerns, but whereas the Bristol powder-makers tried but failed to secure government contracts in the mid-eighteenth century and production ceased for commercial reasons in the early nineteenth century, the Waltham Abbey Mills, helped in part by their proximity to London, became favoured government suppliers from the mid-seventeenth century. Eventually purchased by the Crown in 1787, they became so important a supplier of explosives to the government and later such a significant centre of research that the site was not de-commissioned until 1991. And third, because unlike the site at Woolley that is now divided up amongst private owners, Waltham Abbey is in effect public property, thus providing us with a great opportunity to study the re-use of an industrial site of this integrity and complexity.

This account begins with a visit by the Gunpowder Mills Study Group when we heard of the impending closure and sale of this very large and important site. Just north of London, it was located on the River Lea and so in easy contact with the capital and its docks for the supply of raw materials and the dispatch of gunpowder and later cordite, twenty-three tons per week of the latter according to an account of 1899.[16] We felt that at least a record of the site should be made, and through Angus Buchanan, then a member of the Royal Commission on the Historical Monuments of England (the RCHME, now a part of English Heritage), this was agreed. A team of which Wayne Cocroft became the effective leader began work on an archaeological and architectural field survey in 1993, and it was this on-going task that formed the basis for the paper presented by Wayne and his senior colleague Paul Everson at the ICOHTEC Symposium in Bath the following year, and for the chapter in the book published in 1996 noted earlier.[17] But this may have remained an academic exercise had there not been political support both locally and nationally for the idea of saving the core of the site from the threatened housing or factory development. Even this backing would not have been enough had not the support of the Ministry of Defence also been secured. A Steering Committee was formed and after many legal and other negotiations a Charitable Foundation Trust was established with a board of four trustees in whom the land, buildings, and chattels or goods were to be vested, together with a very handsome investment fund which, with the addition of a further large sum from the Heritage Lottery Fund, was to finance the restoration of the site (no easy task given the degree of contamination) and its presentation to the public. The four trustees were to be nominated by the Ministry of Defence, English Heritage, English Nature and the Science Museum of London. I was invited by the Science Museum to become their nominee and served until 2007.

We began our work in 1997, with the de-contamination already underway. One of the professionals involved, Steven Chaddock, agreed to present a paper on this subject at the ICOHTEC Lisbon Symposium of 1998. It was entitled 'The decontamination of the Royal Gunpowder Factory at Waltham Abbey, and gunpowder-related discoveries made during the remediation process'. Our meetings on this large site of 71 hectares with its 300 structures in widely varying degrees of dilapidation were held in a cold building (no central heating, but one could always tell where the single-bar radiator was because that was where the lawyers cleverly congregated). We reached our meeting place by following pathways where yellow markings indicated areas in which it would not be wise to allow one's foot to slip because of the dire chemical consequences. For any exploration of the site, hard hats were worn.

As required by our Deeds of Settlement, we had to set up an Operating Company, composed of volunteers who would run the site according to an annual Management Plan devised by the Company but accepted by the Foundation Trust. In the meantime, a Design Company was appointed to devise the introductory film and static displays that were to prepare our visitors for the unusual nature of the site they would be free to explore. The qualities brought by any design team to such a largely unknown and secretive industry could not realistically have been expected to include knowledge of gunpowder production, so Wayne Cocroft and I found ourselves with the heavy voluntary burden of checking through and advising on everything that was to be presented to the public. Fortunately an engraving (see Figure 5 overleaf) of the Waltham Abbey Mills by John Farmer, published in 1735, proved to be a most welcome resource for understanding this and other early gunpowder sites.[18]

The period indicated by this date was a very significant one in light of the move to the countryside of our previous case study, the Woolley Mills near Bath; however, whereas at Woolley we had to rely on a good sequence of documents to interpret the site, here we had an excellent depiction of the layout of the works and the buildings involved. Most immediately we can see that, whilst at Woolley the buildings had to be accommodated rather awkwardly on a site where the prime position had been pre-empted by ancient corn mills, at Waltham Abbey the process buildings were set out along the watercourse, permitting an economical use of the energy available and a rational arrangement of the sequence of operations to be followed. Nevertheless, Woolley had the advantage of being new-built as a powder mill

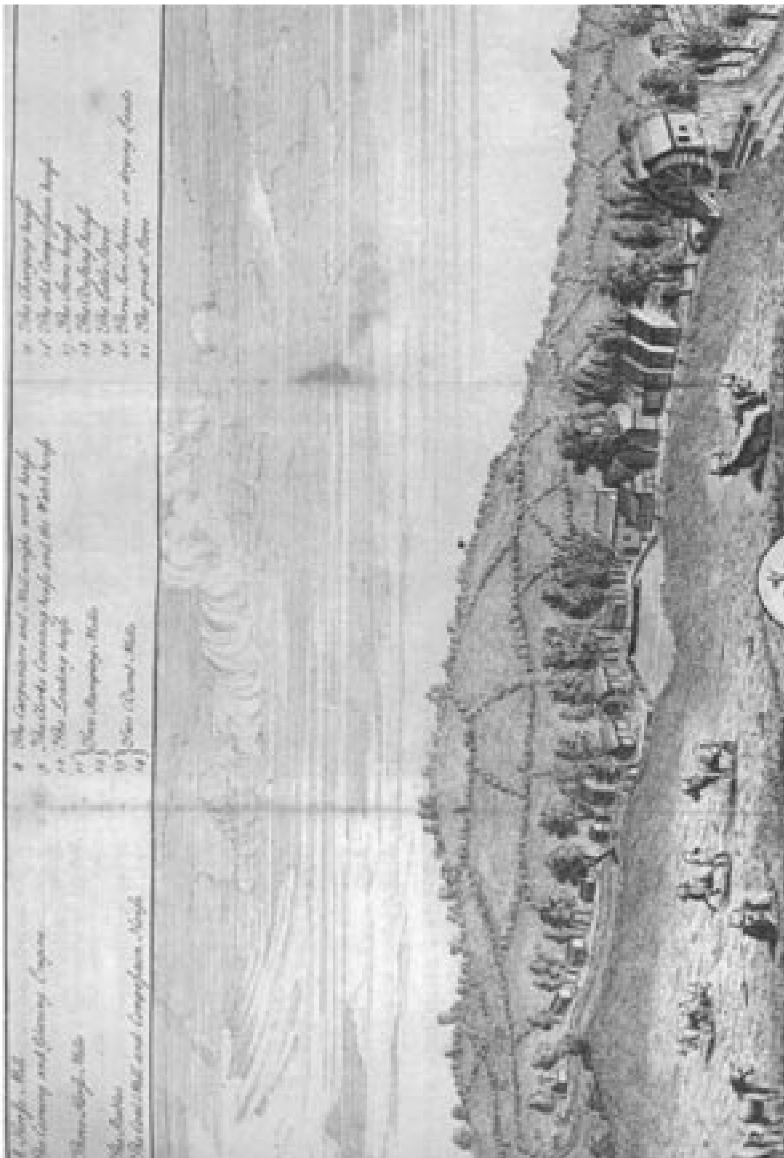


Figure 5. Engraving of the Waltham Abbey Powder Mills by John Farmer *History of Waltham* (1735), viewed from the west and identifying by names and numbers the structures involved in the production of powder in the 1730s.

on a new site with implications for the machinery installed that included the introduction of edge runners as described earlier. At Waltham Abbey in contrast, an oil mill on an existing site had in the mid-1660s been converted to gunpowder production following pressure from officers of the Board of Ordnance. This adaptation of machinery to meet different purposes was not unknown, especially in an industry like that of gunpowder production where demand fluctuated according to military and civil requirements. In the present case, the conversion was influenced by the shortage of powder during the Second Dutch War of 1664–67, and the officers of the Board were required to 'impresse soe many Mills for ye makeng of gunnpowder for his Matie [Majestys] Service as they shall think fitt'. A contract with the Board of Ordnance was signed by Ralph Hudson of the Waltham Abbey mills in February 1665 and a further deed of 1669 gives us a splendid picture in words of this mill, converted from the production of oil to that of gunpowder, whose layout we see in the engraving. The deed refers to:

> All that Mill heretofore an Oyle Mill and now lately converted into two Powder Mills ... with all necessary outhouses for grinding boyling corning & drying of powder ... now in the tenure or occupation of Samuel Hudson [brother of Ralph] or his undertenants.[19]

Here boiling must refer to the refining of the ingredients, grinding to their mixing or incorporation, corning to the creation of separate grains and drying to the slow process in the sun or to the more rapid procedure of the gloom stove, in which heat from an external fire was conducted as warm air into an adjoining separate room where shelves were filled with trays of powder.

This range of procedures, taking place in the two 'Powder Mills' and 'outhouses' described in the deed of 1669, suggests the sequence of buildings depicted some sixty years later in Farmer's engraving. Here our understanding is assisted by the provision of a key that relates the numbered buildings to the production process. The raw materials go through the preparatory stages and on to their incorporation under pressure in two powder mills, shown in the engraving as the two 'Stamping Mills' numbered 11 and 12. Stamps, worked on the pestle and mortar principle described earlier, remained the main method of incorporation until outlawed by Act of Parliament in 1772 (12 Geo. III c.61) as a fire and explosion hazard because of the danger of overheating. But some of the new mills like Woolley had, as already noted, anticipated this legislation by being built with edge runners rather than stamps, and it may be that the puzzling 'dumb mills' at Waltham, numbers 13 and 14, were also the new style, safer and quieter (hence the name) edge runner mills. Further upstream were the numerous drying rooms, from where the powder was put in barrels and transported to

London in vessels such as that shown here moored next to the loading house, number 10 in Figure 5 at the later-named Hoppit Pool (centre of the drawing).

As demand increased old incorporating mills were replaced and new ones built further upstream at Waltham Abbey. When called in to examine these, the eminent engineer John Rennie referred in his Report of 1806 to the earlier works as the 'Old Establishment'. As I read these words in Rennie's Report in the archives of the Institution of Civil Engineers, they seemed to be so appropriate that I thought it worth reviving them to describe the oldest part of the powder works, which was bought by the Crown in 1787.[20] Following this royal acquisition, as the development of new chemical explosives ran in parallel with improvements in gunpowder-making, the powder mills at Waltham Abbey went on to become the most important centre in Britain, and probably for a time in the world, for the production of explosives and for research into these energetic materials. The complexity of the site resulting from these developments may be illustrated by the selection of one example, the twin Head Mills, shown in Figure 6. These are probably on the site of the 'Two Stamping Mills' numbered 11 and 12 in Farmer's engraving (Figure 5), perhaps built after stamps were outlawed in 1772, or after the site was purchased by the Crown in 1787, and certainly before 1806, when Rennie referred to them as a pair with waterwheels of identical dimension, fifteen feet in diameter.[21]

Figure 6. The site of the twin Head Mills at Waltham Abbey Royal Gunpowder Mills, probably the earlier position of the 'Two Stamping Mills', 11 & 12 on Farmer's engraving (Figure 5). Photographed by R. Angus Buchanan (1998).

The members of the Newcomen Society for the Study of the History of Engineering and Technology were meanwhile showing great interest in the dramatic developments now underway and because of their enthusiasm to explore this hitherto secret and inaccessible site, a day-long visit was organised for members. My introductory talk on the early history of the site was to be developed and published in the *Transactions* of the Society (1998–9, see note 20), in an article which was in a sense complementary to that already published in the *Transactions* (1995–96) and based largely on my continuing research on the Woolley Mills (see note 9). Wayne's talk on the later history of the Waltham Abbey works was to form part of the book based upon his professional archaeological expertize and the experience of working on the site. It was published by English Heritage with the title, *Dangerous Energy: The archaeology of gunpowder and military explosives manufacture*.[22]

The impending visit of the Newcomen Society made the production of a leaflet about the site a matter of urgency. We needed something that would convey the unusual interest and significance of the powder mills and chemical explosives works, whilst being at the same time concise enough to hold in the hand as the visitor explored this seventy-two hectare site of great complexity and of confusing waterways and numerous near-derelict buildings in a large area of parkland. So seriously had the Foundation Trustees considered the prospect of losing people in the woodlands and waterways that the introduction of name tags was discussed. It was suggested that visitors should 'clock in' as if coming to work, returning the badge as they left, but instead the problem was solved by discouraging visitors from entering the large area designated as being of Special Scientific Interest, with its nesting herons and herds of small deer. After much discussion, Wayne Cocroft and I produced a flyer on an A4 sheet of glossy paper, folded, with a plan of the site on one side and a short account of its history on the other. Wayne's plan showed the complexity of the site, and to aid recognition of important features the layout was surrounded by photographs of significant buildings, with pointers to their location on the sketch. These included for example the mixing houses from *c.* 1790, shortly after the government acquired the site, a hydraulic gunpowder press house of 1879 and a guncotton drying stove of 1897. On the outside of the flyer, there was a splendid aerial photograph and my short account, which set it in the context of the history of gunpowder and later chemical explosives, but with a brief reference also to the men and women who worked here, the dangers they faced, the skills they developed and the research they undertook.

For some time this well-produced document was used as the general publicity flyer for the site, circulated to attract possible visitors and placed in the hands of those who came to the powder works. Over the years it has been replaced by other documents, such as that for 2010. With an invitation to enjoy 'a summer of family fun', visitors were encouraged to visit the Royal Gunpowder Mills for weekends of, for example, aircraft displays, classic car shows and medieval jousting. They were to come for spectacle rather than scholarship.

CONTRASTS IN SITE MANAGEMENT

From the contrasting approaches embodied by the two flyers for the Waltham Abbey Royal Gunpowder Mills, some generalizations pertinent to our subject may be drawn. The first is that they embody two entirely different concepts of re-use and heritage. The focus in 1998 was on encouraging visitors to explore and understand the site and its significance; in 2010 the focus was on providing an entertaining and lively family day out. The need to generate revenue has played a great part in the changing pattern and this requirement must be respected, but a consequent danger must also be acknowledged – that although the site and many of its buildings may be saved, their meaning may be lost. The physical aspects may survive, but not the full 'heritage' of understanding. Perhaps the early aims were too academic, too unrealistic, the notes on the flyer reading too much like an essay on the subject. It was not easy to condense an accurate account and interpretation of the site into something that could be read by people on the move. The flyer survives now as a 'museum piece', providing evidence that the early work of interpretation and the work of bodies like the Academic Advisory Board (set up to produce papers on, for example, the conditions needed for the satisfactory storage of archives), has been overtaken by financial needs. But to remain academically sound as well as becoming financially secure, a venture such as this requires a professional support system, and after a few false starts this was not forthcoming at the Waltham Abbey Royal Gunpowder Mills.

Why this was so constitutes the second observation. The differences of approach embodied in the two flyers (the academic and the popular) probably reflect the way the trusteeship and management of this site was organised. In recent somewhat similar cases, bodies of trustees had spent their funds too freely, and so at Waltham Abbey the Foundation Trustees, all four as already noted, nominated by public bodies, were invested within strict legal terms with the ownership of the land, buildings, chattels and funds of the Waltham Abbey Royal Gunpowder Mills. But they were obliged to set up an Operating Company that would manage but not own the property, receiving revenue from the funds invested. Three of its number would, by election, join the Foundation Trust. The Operating Company was to be selected from volunteers, many of whom would of course come from the locality, perhaps knowing the site from having worked there. This seemed an admirable arrangement, but it was bound to create a separate influence on future development. The initial funds provided handsomely for the decontamination and capital works, and the presentation of the site, especially through the introductory film and the museum display, together with some continuing help towards major tasks. But the problem of raising revenue to add to that provided annually by the Foundation Trustees from their investments, placed an inevitable strain upon the resources of the Company and inhibited the development of a professional team. If the priority is to keep the site open and functioning, then perhaps the laying on of spectacular events must be supported, otherwise, what the future holds may be seen in the sad example of the Ballincollig works near Cork in Ireland, also formerly owned and operated by the British Board of Ordnance, which suffered a decline since figuring in the first Gunpowder Book. The Ballincollig restoration was the subject of an optimistic chapter by Brendan Kelleher (see note 13), but the momentum he described could not be maintained, and the site has now reverted to parkland, the impressive edge runner mill has been shuttered away and the visitor centre, designed through international competition, has been closed. [23]

My third observation is that perhaps, especially in times of economic difficulty and political change, we may have to settle for a sliding scale between the academic, professional approach and the popular, voluntary arrangement. The emphasis between the two may then shift according to improvements in funding and in the appreciation of the importance of such sites. But it is important that the sliding scale does not shift too much towards the popular, or we shall be in danger of losing not the site, but the understanding of its significance and, perhaps too, any sense of its mystery and grandeur. In the context of these difficult circumstances and perhaps indicative of some recent movement in the sliding scale, reference must be made to the team of volunteers at Waltham Abbey working to bring together and classify as much archival material as possible that was not dispersed to national and county archives when the site was prepared for de-contamination. Also, a new series of booklets by volunteers at WARGM has been initiated, of which three have been published since 2009. Averaging some sixty pages, these attractive publications have colourful photographs and maps but, sadly, no references and little in the way of a bibliography to aid the more enquiring reader.[24]

CONCLUSION

On the basis of the experiences described above, what operational criteria can be suggested as essential to the successful conservation and interpretation of our historic monuments? I suggest seven principles. They are:

1 The whole matter of ownership, funding, endowments and revenue needs careful consideration in the light of experience.
2 The question of the separation of powers as embodied in the legal documents also needs to be revisited.
3 It is essential that professionals in numbers appropriate to the size of the project should be appointed, which could mean a single chief executive or a small team of curators. This emphasis may seem strange in a Continental or North American context, but the voluntary principle remains very strong in the United Kingdom. This leads to the fourth point.
4 Great thought should be given to the organisation of volunteer participation, so this may be integrated within the general development plan.
5 The historic and academic authenticity of the site must be preserved. Any dilution of its impact must be prevented.
6 Commercial viability is essential, making the question of what can be justified to raise and maintain income all the more important. We must define the essence of the site in order to decide what if any land can be sold, buildings converted and functions held.
7 Lastly, we come to the matter of entropy, the idea (appropriated from thermodynamics as it appears in physics and engineering) that there will come a point where the energy generated by the system will not be great enough to be converted effectively into the work required to sustain the operation. And, when this happens, we have choices: to let the site go, to mothball it until better times (perhaps as required under the terms of a trust), or to accept as much continuing change and adaptation as is needed to preserve its 'essence'.

The last few decades have been quite a 'Golden Age' for the funding and presentation of major national explosives sites. So much has been achieved, but as this account of Waltham Abbey shows, fortunes may fluctuate. Barcarena in Portugal, Frederiksvaerk in Denmark, and the Elutherian Mills at Hagley in the USA are all fine examples (the first two visited in the course of ICOHTEC Symposia), but what may happen to these and others if, in the present economic climate, the circumstances of funding change or visitor numbers decline? Should there be closure, as at Ballincollig, then the surviving record of archaeological and documentary research becomes all the more important But it is also possible to retrench and still provide an enlightening experience. I cite the case of the magazines at Purfleet, down the Thames Estuary and once the major point of despatch of government explosives around the world, especially barrels of gunpowder. Now only one magazine survives, yet this provided our Gunpowder Group with an authentic experience, because after perhaps unwisely holding our day's meeting there we were all chilled, but we had learnt exactly what it was like to be stored in the low but steady temperature required for the maintenance of gunpowder quality. This was an authentic sensory experience in a massive magazine that survived as one out of the five formerly on the site after construction began in the mid-eighteenth century. It demonstrated that loss of scale may not necessarily mean loss of meaning.

I do not know how generally my seven principles can be applied, but my own experience suggests in particular the desirability of a united body of trustees and the appointment of a skilful and trained professional officer.

And perhaps an eighth principle should be mentioned – the Pleasure Principle, coming from the enjoyable pursuit of this whole subject with interesting and lively groups of colleagues and friends. Unfortunately, such groups are themselves subject to entropy. Our Gunpowder Mills Study Group first widened its base to become the Gunpowder and Explosives Group, before recently becoming an e-group which may be contacted through the website of the Waltham Abbey Royal Gunpowder Mills; and our ICOHTEC Gunpowder Group has now become part of the Social History of Military Technology section organised by Barton Hacker, to whom we are grateful for this home.

These fluctuations of fortune do not, of course, invalidate the general principle of the continuing significance of gunpowder history and the importance of studying both the documentary and the physical evidence relating thereto as particular examples of the 're-use of the industrial past'. Nor does the admission of physical evidence where available and appropriate dilute the high standards of traditional academic research implicit in the papers and publications of ICOHTEC, especially as the evidence must, in both approaches, be assembled, worked upon and interpreted by the scholar. It is of particular significance in this context that, at Tampere, ICOHTEC shared a conference with TICCIH, a society whose commitment to studying and preserving where possible the culture and surviving evidence of our industrial past, provides a reminder of aims that are well worth considering within the academic context of the history of technology.

NOTES

1 R.A. Buchanan and Neil Cossons, *The Industrial Archaeology of the Bristol Region* (Newton Abbot, 1969).

2 Somerset Record Office (SRO), Strachey papers, in particular DD/SH Box 27.

3 B.J. Buchanan and M.T. Tucker, 'The Manufacture of Gunpowder: A study of the documentary and physical evidence relating to the Woolley Powder Works near Bath', *Industrial Archaeology Review*, 5: 3 (1981): 185–202.

4 See for example the following papers in The National Archives (TNA), Kew: S.P. Dom. Charles I, vol. cc, no. 26, 1631; vol. cciv, no. 9, 1631; vol. ccxi, no. 79, 1632.

5 TNA, S.P. Dom. Charles I, vol. ccccviii, no. 69, 1639. Here were found eight hundredweight of saltpetre, about ten bushels of small coal (or charcoal), some sulphur, four mortars of wood and pestles, two brass pans, six bushels of wood ashes, and one searcher or sieve.

6 SRO, Strachey Papers, Letter from George Dyer in Bristol, managing partner, to Henry Strachey in London, 11 March 1801.

7 E.A. Brayley Hodgetts, ed., *The Rise and Progress of the British Explosives Industry* (London, 1909).

8 I would like to thank Oriel College, Oxford, for allowing me to study the plans relating to the Manor of Swainswick and the notes relating to the same. A special word of thanks to Mary Stacey for drawing my attention to this plan.

9 Brenda J. Buchanan, 'The Technology of Gunpowder Making in the Eighteenth Century: Evidence from the Bristol Region', *Transactions of the Newcomen Society*, 67 (1995–96): 125–159; and 'The Africa Trade and the Bristol Gunpowder Industry', *Transactions of the Bristol & Gloucestershire Archaeological Society*, 118 (2000): 133–56.

10 *Gunpowder Mills Gazetteer. Black Powder Manufacturing Sites in the British Isles*, compiled by Glenys Crocker. First published for the Gunpowder Mills Study Group by the Wind and Watermill Section of the Society for the Protection of Ancient Buildings, Occasional Publication No. 2, 1988. Second edition with corrections and additions compiled for the Gunpowder and Explosives History Group and deposited with the Mills Archive, Reading, 2006.

11 Brenda J. Buchanan, 'Charcoal: "The Largest Single Variable in the Performance of Black Powder"', *ICON: Journal of the International Committee for the History of Technology*, 14 (2008): 3–29.

12 I wish to thank Angus Buchanan for his willingness as President of ICOHTEC to include a new section on the technology of gunpowder-making in the programme for the Symposium at Bath in 1994. His continuing support of gunpowder studies over the years, especially the field work, is much appreciated.

13 Robert A. Howard, 'The evolution of the process of powder making from an American perspective', 3–23; Brendan Kelleher, 'The Royal Gunpowder Mills, Ballincollig, County Cork', 359–375; Paul Everson and Wayne Cocroft, 'The Royal Gunpowder Factory at Waltham Abbey: the field archaeology of gunpowder manufacture', 377–400, all in Brenda J. Buchanan, ed., *Gunpowder: The History of an International Technology* (Bath, 1996, repr. 2006).

14 Brenda J. Buchanan, ed., *Gunpowder, Explosives and the State: A Technological History* (Aldershot, 2006).

15 These include, for example, Henk Reitsma and Arti Ponsen, 'The Leiden Disaster of 1807', *ICON: Journal of the International Committee for the History of Technology*, 13 (2007): 1–18; and Yoel Bergman, 'The Moulin-Blanc Nitrocellulose Plant in France', *ibid.*, 19–34.

16 Frederick G. Engelback, 'Her Majesty's Ordnance Factories', *The Army and Navy Illustrated*, 1899, Part I, 105–107.

17 Everson and Cocroft, 'The Royal Gunpowder Factory' (n. 13 above).

18 I am grateful to Malcolm McLaren, formerly librarian at the Waltham Abbey Ministry of Defence Establishment, for his advice and for allowing me to study his copy of Farmer's engraving.

19 Quotations from Keith Fairclough, 'Early Gunpowder Production at Waltham', *Essex Journal*, 20 (1985): 11–16.

20 John Rennie, 'Report Presented to the Honourable Board of Ordnance, 18th September 1806', vol. 4 of Rennie's Papers (9th Dec. 1805 to 20th Oct. 1807), Archives of the Institution of Civil Engineers. I am grateful to the staff for enabling me to study this document.

21 For a more detailed study see my paper, 'Waltham Abbey Royal Gunpowder Mills: "The Old Establishment"', *Transactions of the Newcomen Society*, 70 (1998–99): 221–250.

22 Wayne D. Cocroft, *Dangerous Energy. The archaeology of gunpowder and military explosives manufacture* (Swindon, 2000).

23 The meeting of the Association for Industrial Archaeology in Cork, Ireland, 2011 provided the opportunity for a visit to Ballincollig. We met and commiserated with Brendan Kelleher, who as Chief Planning Officer of Cork County Council had given great support to the venture.

24 Richard Thomas, *The Waterways of the Royal Gunpowder Mills* (Waltham Abbey, 2009), and by the same author, *The Explosions at the Royal Gunpowder Mills* (Waltham Abbey, 2010); Peter Blake, *Gunpowder Men: Military Superintendents of the Royal Gunpowder Mills* (Waltham Abbey, 2011). Work on 'The Listed Buildings at the Royal Gunpowder Mills Waltham Abbey' by Les Tucker (Honorary Archivist) is well underway.

Interpretation of Defence Heritage in Japan:

A Survey of Its 'Neglect and Reuse' and Future Potential as Significant Landscape

Okada Masaaki*

Reuse of defence heritage sites and structures has been a contested topic within the general field of preserving industrial heritage in Japan. Various opinions inevitably have accompanied their evaluation and reuse, some of them seeing opportunities for education and leisure time, some of them couched in antiwar sentiments and seeing such sites as symbols of failure. In Japan there has been a transition since the early 20th century from an attitude of neglect of defence heritage to one of seeing value in the reuse of defence sites and structures, and this transition provides a window into Japanese cultural changes in the past century as well. This paper surveys defence heritage in Japan since 1920 and makes the case for further preservation and reuse of defence heritage sites and structures.

INTRODUCTION

Defence heritage has been paid little attention in the past, even though, as have other examples of industrial heritage, it has contributed greatly to our daily life. Yet, because defence heritage also tends to be related to the concept of 'military affairs', in post-World War II Japan, people have expressed strong opinions when defence heritage sites and structures are re-evaluated. At present, there are two approaches concerning Japanese defence heritage. One is a relatively positive approach, which sees fortress heritage as an academic interest focusing on military history or civil engineering technology;[1] this approach also sees defence sites as places for adventure. The other approach is negative and regretful and sees defence heritage as an icon of historic 'failure'; it is based on antiwar ideas.[2]

This paper traces the history of social attitudes toward the defence heritage in Japan, and analyses some case studies of the new social interpretation, which could be observed as a historic transition from 'neglect to reuse' of defence heritage.

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* Japanese names are given in the Japanese order; i.e., family names precede given names.

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ICON: Journal of the International Committee for the History of Technology, 17 (2011): 94–106.

DEFENCE HERITAGE IN JAPAN: 1920–45

Defence Heritage as National Historic Sites

Perhaps the first example of seeing abandoned defence facilities as 'valuable heritage' in Japan was the listing of such facilities as 'National Historic Sites' in the 1920s and 1930s. Most of the listed defence heritage sites then were ones built before Japan's modernization during the middle of 19th century; they were ancient or medieval ruins. Their historic significance was acknowledged, and most of them also were designated and opened to the public as local or national treasures. Matsumoto Castle in today's Nagano prefecture, for instance, was built in 1504 by Daimyô (feudal lord) SHIMADACHI Sadanaga. It was listed as a National Historic Site in 1930 and designated as a National Treasure in 1936. The area surrounding the Castle is now developed as a park, and people can easily access the site (Picture 1, left). Similarly, *Nishijin genkô bôrui* (literally 'defence stonewall against the Mongolian invasion at Nishijin'), was built in 1274 on the coastline of today's Fukuoka prefecture in Northern Kyûshû. This bulwark against the intrusion of the army of the Mongolian Yuan Dynasty was uncovered in 1920, listed as a National Historic Site in 1933 and, in 1969, excavated and opened to the public (Picture 1, right).

Picture 1. Defence Heritage built before the modernization in Japan. *Left:* Matsumoto Castle, Matsumoto, Nagano prefecture (built in 1504), listed as a National Historic Site in 1930. *Right:* Nishijin Genkô Bôrui Bulwalk (against the mongolian army of the Yuan Dynasty) in Fukuoka (erected in 1274), listed as a National Historic Site in 1933.

In 1919, S*hiseki meishô tennen-kinen-butsu hozon-hô* was enacted (the *Law for the Historic Site, Places of Scenic Beauty and Natural Monuments*), which resulted in the listing of many temples, ancient tombs or medieval gardens as national heritage sites. Most of the defence heritage sites listed in the *Historic Site, Places of Scenic Beauty and Natural Monuments Record* in 1937 were ones constructed before the modernization; however, it included several modern coastal defence heritage sites, some of which were constructed after modernization as protection against possible intrusion by the United States and other great powers. American Commodore Matthew Galbraith Perry's arrival in Japan in 1853 with western style military warships had greatly intimidated the Japanese.

The Charter of National Heritage recommended the listing of 'Historic Sites evidently related to politics and military affairs', and it must have supported the listing of modern coastal defence heritage,[3] such as the fort built by the Maruoka fief in today's Fukui prefecture (constructed in 1852 and listed in 1930), the fort in Nishinomiya in today's Hyôgo prefecture (constructed in 1866 and listed in 1922), the fort at Cape Wadamisaki in Kôbe (constructed in 1864 and listed in 1921) and the Shinagawa forts in Tôkyô Bay (constructed in 1853 and listed in 1926) (Picture 2).

Picture 2. Modern coastal defence heritage listed as National Historic Sites in the 1920s and 30s. *Above left:* Fort of the Maruoka fief in today's Fukui prefecture (constructed in 1852 and listed in 1930). *Above right:* the fort in Nishinomiya in today's Hyôgo prefecture (constructed in 1866 and listed in 1922). *Below left:* fort at Cape Wadamisaki in today's Hyôgo prefecture (constructed in 1864 and listed in 1921). *Below right:* Shinagawa fort Number 3 in Tôkyô Bay (constructed in 1853 and listed in 1926).

Defence Heritage as Public Parks

In 1928, fort Number 3, one of the seven Shinagawa forts, was redeveloped as an historic park, with replicas of cannons that still exist on site; for the most part, it was opened to the public (Figure 1). Likewise, Ôhama Park in the city of Sakai, near Ôsaka, was developed by converting a fortress built in 1879. The site was originally the property of the Department of the Army, and even after being developed as a park, emphasis of its past existence as a defence facility resulted in its being a site used to enlighten visitors about the significance of national defence. In 1910, this park was also used as an army parade ground. The *History of Sakai*,[4] published in 1920, introduces Ôhama Park, describing its older uses as a defence facility, noting 'many reminiscences of the fortress in the north', 'reminiscence of the moat', an 'old place for gun powder' and the 'remain of the embrasure'.

In a booklet about the Sakai, Ôhama Park, published in 1937, one finds mention of new modern amusement facilities, such as an aquarium, seawater-spa and amusement pier. At the entrance of the park, one small cannon was installed, probably to be fired as a 'noon gun' to signify the time at midday. Here one may read the connection of the cannon's existence to the park's history as a defence heritage site (Figure 1).

Figure 1. Defence Heritage developed as an historic park in 1920–30s. *Left:* Shinagawa fort Number 3 (developed in 1928 as an historic park with replicas of cannons) *Right:* Booklet of Sakai Ôhama Park (1937).

Social Background in the 1920s and 1930s

Fifty years after the Meiji Restoration of 1868, Japan saw itself becoming more and more modernized in Western terms. It was about to join the great powers, but in reality it was still a developing country aiming to learn new technology from the western countries in the 1920s and 1930s and become as rich and powerful as them. The 'Western-style' was an admired fashion for people in general, and during these years western civilization arrived and influenced people's concepts of value. There were many icons of modernization; however, most of them lacked any serious depth. It is quite interesting that literary critic MAEDA Ai (1931–87) defined the culture of this period as a 'Time of Surface and Suppression'.[5]

In 1925, radio broadcasting (with the station call sign JOAK) started in Tôkyô, and the daily newspaper *Asahi Shinbun*'s company started an airplane service to Europe – named *Hatsu-kaze* (First Wind) or *Tôfu* (East Wind) – to bring 'brand-new' news from advanced foreign countries (Figure 2). Until then, for the Japanese, 'Western' ideas had been something far away; now it became accessible through mass media and the airwaves, even though the information obtained was quite superficial. Along with news, consumer culture from western countries also started to arrive via movies and advertisements.[6] Though this 'modern' culture was later derided as just something 'frivolous and superficial' gained by copying western style, aspects of new popular culture were born, such as modern western fashion, European-styled cafés, western dishes and the *mobo* and *moga* (the fashion of western style 'modern boy' and the 'modern girl', the latter pronounced in Japanese *gaaru*).

In fact, through the 'General Election Law' and 'Maintenance of Public Order Act', both enacted in 1925, the government undertook a sort of thought control. On the one hand, freedom of speech began to be restricted, while, on the other, new cosmetic products like 'Club cosmetic powder' and 'Shiseidô Cold Cream' were put on sale in 1910 and 1922 respectively. It seemed that people started decorating their surface skin rather than cultivating their minds (Figure 2).

Figure 2. Popular Culture in the 1920s to 30s. *Left above:* Flights to Europe by Japanese newspaper companies' airplanes (1925).[6] *Left below:* advertisement for Shiseido Cold Cream (1922).[7] *Right:* Western style architecture in Tôkyô.[8]

After the great earthquake of September 1, 1923, most of the old architectural structures in Tôkyô were destroyed, and rebuilding began with new reinforced concrete structures whose façades were comprised of western-styled textures, which provided a modern, advanced atmosphere (Figure 2).

In this period in popular culture, the 'surface' or icon tended to be more emphasized than content; however, the surface was intensely real and impacted on people's minds. In this context, the contemporary way of using defence heritage as an icon to emphasize the significance of defence itself corresponded perhaps to the popularity of popular culture in the 1920s and 1930s.

Between 1920 and 1945, defence heritage sites developed as parks or listed as national heritage sites were considered to have been reused as material for people's enlightenment about national defence itself, though these unused ruins were useless in terms of defence. Nevertheless, these spaces were used as 'sign' which superficially and directly meant 'defence' as a great achievement.

DEFENCE HERITAGE IN JAPAN: 1945–2000S

Neglected Defence Heritage

Many defence facilities had been built following the period of modernization and on through to the end of World War II, and after the war, most of them were no longer in military use. Some were reused as pleasure parks, but most of them were simply neglected.

After the war ended and Japan had lost, social values suddenly reversed, almost as a value-revolution. KATÔ Norihiro (1948–), a Japanese literary critic, aptly pointed out this drastic change in sense of values in his book *Haisen-go-ron* (Since Defeat):

> In general, the dead people of war had been always respected all over the world since ancient times and in different cultures. However, after World War II, people started hesitating to respect the dead people of the war in Japan. This phenomenon was quite unique.[9]

KATÔ engendered much discussion and argument among his contemporaries, but the fact is that Japan also suddenly stopped respecting defence heritage and started ignoring it after the war. With only a few exceptions, defence sites built at the end of the 19th or the beginning of the 20th centuries were 'hidden' or more or less ignored until the 2000s.

For instance, after the war, fort Takagarasu-dai was redeveloped as Takagarasu-dai Park in Kure, near Hiroshima. This site is well-known for its connection with the famous medieval warrior TAIRA no Kiyomori (1180–1244). In 1967, a statue of Taira was erected with a signboard explaining his history and that of the Takagarasu-dai Park. The plinth of this statue was constructed right on the old fortress, probably because this location could offer the best panorama of the ocean landscape of the Inland Sea (bounded by Honshû on the north and east, Shikoku on the south, and Kyûshû on the west). However, the signboard tells nothing about the defence heritage site under the statute; it seems to reflect respect for regional ancient or medieval history but none for modern military history, even though there was an army fortress on this site, built in 1897, that later was used as an anti-aircraft battery during World War II. Ruins of the building have been left and can be visited in Takagarasu-dai Park (Picture 3).

Picture 3. Ignorance of Defence Heritage. *Above:* Statue of the medieval warrior Taira no Kiyomori (1180–1244) in Takagarasudai Park in Kure, Hiroshima prefecture, and the 'ignored' fortress underneath. *Below:* Hinoyama Observatory Deck in Hinoyama Park in Shimonoseki, Yamaguchi prefecture, and the 'ignored' fortress underneath.

A similar example can be found in Hinoyama Park in Shimonoseki, Yamaguchi prefecture. This site was fortified in 1890 and had been wholly closed to the public. In 1956, the site was included as part of a National Park. Some years later, a ropeway (1958) and a youth hostel and observatory (1960) were constructed. The observatory deck was erected on the fortress in 1960, but without any signboard telling of the site's earlier history. The role of abolished fortress as a foundation for the observatory deck remains unexplained (Picture 3).

Spontaneous 'Reuse' of Coastal Defence Heritage

But there are some examples of defence heritage sites, which spontaneously were 'reused' for different reasons, although unfortunately without any consideration of their history, such as Fort Kada in the city of Wakayama.

Wakayama is located at the mouth of Ôsaka Bay and is a very critical point for the defence of the Ôsaka area. Fort Kada was built in 1906, and in 1974 converted into the Wakayama City Natural Camping Site for children. Originally the site was laid out for defence purposes in such a way that defenders could observe the location of their enemy easily, with few blind corners and without being seen by them. Today, it still keeps its distinctive layout and spaces such as semi-underground pathways, inclined dykes and plinths. The British geographer, Jay Appleton, defined this site as a 'Prospect-Refuge Space',[10] a landscape with an aesthetic satisfaction. In fact, the Fort Kada area includes a 'Family Square', where children can observe insects or enjoy courage testing or hide-and-seek, which may essentially accompany the sense of a 'Prospect-Refuge' property. It is quite intriguing that this new reuse reflects the space's property of old military use, even though its history has not been explained with signboards or leaflets (Picture 4).

Picture 4. Spontaneous 'reuse' of coastal defence heritage (lacking historic emphasis). *Left:* Fort Kada in the city of Wakayama. *Right:* Pillbox used as an anchor in Totoikki, Hokkaidô (originally built 1944).

Nonetheless, many sites have not undergone reuse. Most of the numerous pillboxes constructed in the 1940s, for example, remain only as debris today. Only one in Toitokki, on the northern island of Hokkaidô, built in 1944, is an exception. It has been used as an anchor for a fixed-shore fishing net since the war, and a small shrine was added next to it as a prayer site for the local fishermen (Picture 4). For its new role, the property's stable weight was well applied, although, here too, its defence history seems to have been forgotten.

Spontaneous 'Reuse' of Inland Defence Heritage

Many aircraft shelters were constructed around military airports before World War II, and though most of them have already been or are being demolished, some still exist. Other than just a few examples listed as local heritage sites, most of them are neglected; however, some were reused as agricultural or industrial warehouses (Picture 5).

Picture 5. Aircraft Shelters built during World War II and reused as Agricultural or Industrial Warehouses. *Left:* An Agricultural Warehouse in the city of Yao, Ôsaka. *Right:* An Industrial Warehouse in the city of Fuchû, Tôkyô.

In another case, a flak tower in Ôsaka, built in 1944 by the Japanese Army to protect the surrounding industrial district and a water purification plant, was occupied as a residence right after the war and is still used for this purpose. Now there is a plan to demolish it to construct a road on this site, but a citizens movement is seeking to preserve it as an historic monument (Picture 6).

Picture 6. Flak tower, Ôsaka, converted into a residence.

Additionally, there are defence structures such as social clubs, weapons works, arsenals, pillboxes and observation rooms for rifle training. Only a few are reused as museums or reference libraries; most of them are entirely neglected (Picture 7).

Picture 7. Defence Architectures (reused or neglected). *Left:* The old Kure Army Work #9 (now reused as Dai-Kure Industrial Work #2, Hiroshima prefecture). *Right:* The old Tempaku observation room for rifle training in Toyohashi, Aichi prefecture (neglected).

DEFENCE HERITAGE IN JAPAN: 2000S–

After 2000, a new defence heritage movement began in Japan. The government and a group of civil engineers started re-evaluating defence sites that reflected an obvious change in the societal recognition of defence heritage. Some heritage sites have been reused for historic-educational, recreational or even artistic purposes. Defence heritage has assumed a sort of romantic or mysterious atmosphere in its spaces or landscapes, and this has attracted artists or photographers to create fascinating works related to the sites' superficial properties, perceiving them as 'charming ruins'.[11]

In 2000, the Japan Society of Civil Engineering (JSCE) established the Institution of Selected Civil Engineering Heritage to appeal to society in general as well as to civil engineers for regional planning that would take into consideration the significance of civil engineering heritage. Fort Sarushima in Yokosuka, in Kanagawa prefecture, was listed in 2000 by this group as a civil engineering heritage site, and through to 2011, over 300 other civil engineering heritage sites, including defence heritage sites, have been listed, among them: Fort Ôshima in Ehime prefecture (2001), Fort Tomogashima in Wakayama prefecture (2003), Ôtsushima launch-training base in Yamaguchi prefecture (2006), Takuma Navy Slip in Kagawa prefecture (2006), Ôshima Channel Defence in Kagoshima prefecture (2008), Fort Mitakayama in Hiroshima prefecture (2009) and Fukaura torpedo boat base in Nagasaki prefecture (2011).

Also, since the 1990s the Japanese Agency for Cultural Affairs has designated three defence heritage sites as important cultural properties: the old Kanazawa Army Weapon Warehouse in Ishikawa prefecture (1990), the old Maizuru Guardian Warehouse in Kyoto (2008) and the Hario Radar Towers in Nagasaki prefecture (2011). Local governments also have made similar

Picture 8. Defence Heritage as 'Cultural Heritage'. *Above left:* JSCE selected civil engineering heritage site Fort Ôshima in Ehime prefecture (listed in 2001). *Above right:* JSCE site Fort Tomogashima in Wakayama prefecture (2003). *Below left:* Agency for Cultural Affairs Important Cultural Properties site the old Maizuru Guardian Warehouse in Kyoto (2008). *Below right:* the Agency's Hario Radar Towers site in Nagasaki prefecture (2011).

designations, such as the City of Yukuhashi registering the Inado Shelter in Ôita prefecture as a heritage site (2002) (Picture 8).

On another civilian level, the 'Fun-club of Tôkyô Bay Fortresses' was organized in 2002 by local people and history scholars in Tôkyô. Despite its 'Fun' name, they have been working on the excavation of modern defence history in this area, including the man-made islands 'Kaiho' in Chiba prefecture, which were built with reference to Fort Spitbank (built in 1859) in the UK and the Kronstadt's forts in northern Russia. The Fun-club has been arranging various kinds of events, such as a symposium for local people, walking tours and publication of the *Construction History of Fortress #3 in Tôkyô Bay*.[12]

CONCLUSION

There has been a significant change in social recognition of defence heritage sites since the 1920s. It moved from being an icon that superficially and directly meant 'defence as great achievement' to something to be ignored or to be forgotten in the years immediately following World War II. Then, as the war receded into the past, recognition of defence heritage gradually gained social value as something important in the telling of modern history as well as something that was perhaps exotic and romantic. Today the Japanese people have started to see defence heritage in a more objective and realistic way.

There are still disagreements among interested Japanese on how to deal with the defence heritage of the period of modernization, of the World War II era and even of the post-war years and present day national defence. I believe the most important thing is that Japan should have more interest in its defence heritage sites and not neglect them. We must keep defence heritage alive for the next generation so as to give them a chance to consider all aspects of their history. If we eliminate or simply neglect defence heritage, people have little chance of really knowing what happened in our recent history. In most western countries, such as Great Britain, defence heritage sites are preserved and successfully made use of in celebrating national defence history as a great achievement. There should be continued discussion in Japan on this topic.

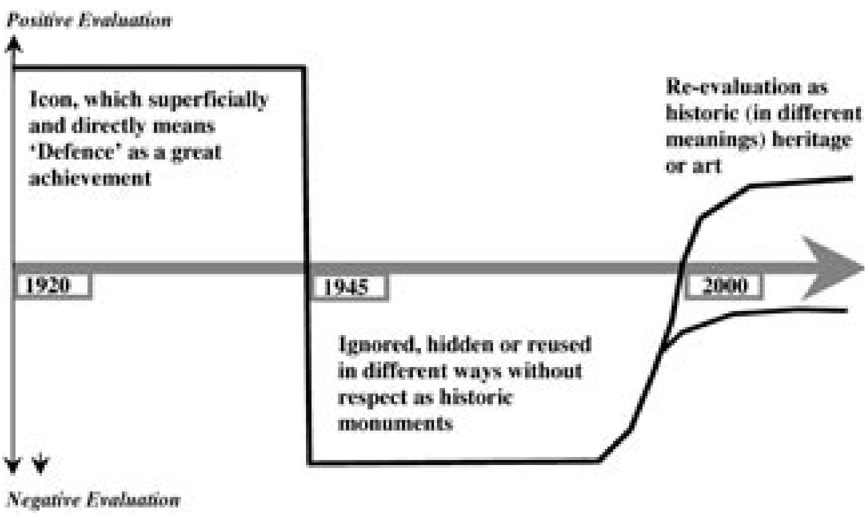

Figure 3. Conceptual Diagram of Interpretation of Defence Heritage in Japan.

NOTES

1 Gakken, ed., *Nihon no yôsai – Wasurareta teikoku no jôsai* (Japan's fortifications – The forgotten imperial fortresses) (Tôkyô: Gakushu kenkyû-sha, 2003) (in Japanese).
2 Nihon kikan-shi kyôkai, Ôsaka Branch, ed., *Ôsaka no sensô iseki guidebook* (Guide Map of War Heritage in Ôsaka) (Ôsaka: Nihon Kikan-shi shuppan center, 2001) (in Japanese).
3 SATÔ Masao, *Shinagawa daiba-shi kô* (Examination of Shinagawa forts) (Tôkyô: Rikôgaku-sha, 1997) (in Japanese).
4 City of Sakai, *Sakai shi-shi* (History of Sakai) (City of Sakai, 1920) (in Japanese).

5 MAEDA Ai, 'Tôkyô 1925nen' (Tôkyô in 1925), in Gendai shisô *Tôkyô 1920 nendai no hikari to kage* (Tôkyô in the 1920ies – light and shadow), Vol. 07-07, No. 980 (Tôkyô: Seidô-sha, 1979), pp. 72–80 (in Japanese).
6 MAEMA Takanori, *Asahi Shinbun hô-Ô dai-hikô* (Great Flight to Europe by the Asahi Newspaper company) (Tôkyô: Kôdan-sha, 2004) (in Japanese).
7 Shiseidô Corp., *Shiseidô hyakunen-shi* (100 Years History of Shiseidô) (Shiseidô Corp., 1972) (in Japanese).
8 Hakubunkan Editorial Board, *Fukkoku-ban: Dai-Tôkyô shashin annai* (Picture Guidebook of Greater Tôkyô, Reprint) (Tôkyô: Hakubunkan Shin-sha, 1990) (in Japanese).
9 KATÔ Norihiro, *Haisen-go-ron* (Since Defeat), (Tôkyô: Kôdan-sha, 1997), p. 60 (in Japanese).
10 Jay Appleton, *The Experience of Landscape* (London: John Wiley, 1975).
11 KOBAYASHI Shinichiro, *Haikyo Hyôryû* (Ruins Drifting) (Magajinhausu, 2001) (in Japanese); also Group PRIDE, *Kyo* (Ruins) (Tôkyô: Bunka-sha, 2003) (in Japanese).
12 Tôkyô-wan dai-san kaihô kensetsu-shi kankô-iinkai, eds., *Tôkyô-wan dai-san kaihô kensetsu-shi* (Construction history of Fortress #3 in Tôkyô Bay) (Tôkyô: Kokudô kôtsû-shô [Ministry of Land, Infrastructure and Transport], 2005).

Book Reviews

BOOK REVIEWS

Ahmad Y. al-Hassan *Studies in al-Kimya': Critical Issues in Latin and Arabic Alchemy and Chemistry*. Texte und Studien zur Wissenschaftgeschichte, Band. 4. Hildesheim – Zürich – New York: Georg Olms Verlag, 2009. Pp. x + 320. Index + illustrations. €48.00.

Even the most innocent reader would immediately realize that this book was written by a chemical engineer, deeply committed to industrial engineering (a full chapter is devoted to industrial chemistry), and in this case also committed to the history of Arabic/Islamic technology. Despite the fact that the book's title characterized the eight studies gathered together between its two covers as being an exploration of *al-Kimiya*, a term taken to designate what was once known as alchemy in ancient and medieval times, and in modern Arabic simply refers to the discipline of Chemistry, this book is not about alchemy per se – although it contains a short chapter that defines the discipline – nor about the history of Chemistry.

Instead, it is a collection of separate articles, consciously and coherently grouped together in order to serve two main purposes: the first is to document the Arabic origins (whether published or in manuscript form) of several Latin texts sometimes attributed to the legendary Geber, who was often claimed to have been different from his Arabic-writing namesake Jâbir b. Hayyân (thought to have lived during the first half of the ninth century). Or at times, those Latin sources were attributed to anonymous writers who did not wish to reveal their identity on account of the sensitivity of their subjects. After all, they were supposed to have been engaged in transforming base metals into gold, or to have sought the elixir of immortality. In both cases this book gives incontestable proof that those major Latin texts, long thought to have been obscure and mysterious medieval fabrications, were indeed either direct translations from still extant Arabic sources or were inspired by them. The author even supplies detailed technical terms in tabular form (e.g., pp. 103f) to illustrate the transparent dependence of those Latin texts on their Arabic predecessors.

The second purpose – and that is where the book demonstrates its originality and far-reaching scope – is to engage in re-writing a much better history of technology in Islamic civilization. Here the book uses a variety of primary alchemical and literary sources that are still regrettably unexploited properly in western scholarship. By ploughing through them extensively, and by reading them critically – hence the reference to critical issues in the title – Dr. al-Hassan documents for the first time such industrial processes as soap mass

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production, glass and gemstone production, glass colouring, dyes, pearl manufacturing, perfumes, petroleum products, metallurgical operations involving gold, silver, and copper amongst others, and the military and social use of gunpowder. As a byproduct of this investigation the book also manages to debunk several widely-accepted myths such as the claim that wine and alcohol-distillation were not known in Islamic civilization on account of the religious prohibition on drinking alcohol, or the claim that the city of Damascus only played a transitory role in the production and distribution of Damascene steel, instead of being the point of origin of such steel.

For historians of technology, those eight studies will prove to be a veritable trove of fresh material which has been uncovered by the now regrettably late Dr. Al-Hassan. The same reader can find more of the same brilliant detailed documentation of Arabic sources on the website that was maintained by Dr. al-Hassan, when he was alive, and by his son Ayman, and where some of the same studies in this book were continuously updated. The site can be reached at the following link: http://www.history-science-technology.com/default.htm (accessed on 8/2/2012).

George Saliba, Columbia University, City of New York, USA

Glenn Stephen Murray Fantom, José María Izaga Reiner and Jorge Miguel Soler Valencia. *El Real Ingenio de la Moneda de Segovia: Maravilla tecnológica del siglo XVI.* Madrid: Fundación Juanelo Turriano, 2006. Pp. 374. €40.

El Real Ingenio de la Moneda de Segovia is an account of the Segovia mint, a group of buildings designed by Juan de Herrera with the collaboration of German technicians. This mint is a fine example of 16th century technology transfer between two countries, the aim of which was to curb the widespread fraud of clipping coins. Philip II of Spain sought help from his cousin, the Archduke Ferdinand of Tyrol, who dispatched a team of German technicians from the mint at Hall near Innsbruck to Spain. The mint was located in Segovia and was funded by the Fugger bankers. The mint, which is well conserved, continued to operate until the 19th century. In 2004, it was designated as the oldest example of industrial architecture in Spain by TICCIH (The International Committee for the Conservation of the Industrial Heritage). Subsequent archaeological works at the site were awarded the García-Diego International Prize in 2004 and the Europe Nostra Prize in 2009.

Although the book is a work of three authors (Glenn Stephen Murray Fantom, Jorge Miguel Soler Valencia and José María Izaga Reiner), it is Glenn Murray, a recognized specialist in mints, who has written two thirds of this book (chapters I and II). The two remaining chapters are by Jorge Soler and José María Izaga, experts on industrial heritage.

In his introduction, Murray highlights the importance of the mint and provides a background to clipping and milling coins around the edge to prevent fraud. The first chapter is devoted to the history of the Segovia mint and alludes to the historical reference that attributes the original design of the mint to Juan de Herrera. Murray provides some interesting insights into coin manufacture and describes the advanced technology used at the Segovia mint whose adoption of a production line was ahead of its time. For this reason, the Segovia mint served as the model for the restructuring of other mints in Spain in the 17th century. According to Murray, the omission of the initial of the assayer on the coins from the Segovia mint was a measure adopted by Phillip II to detect counterfeiters. However, another explanation not considered by the author could be a deliberate policy of the monarchy to debase the purity of the gold coins.

The third chapter deals with the three rooms occupied by the hydraulic system: foundry, rolling room and coining room. Jose Miguel Soler travelled to the mint at Hall to meet Werner Heinz and Moser Nudiing of the Mint Museum and consult some ancient reports dispatched by the German technicians. As a result, he was able to corroborate the existence of ten water wheels housed in these rooms.

The last chapter focuses on the attempt by Joseph M. Izaga to reconstruct the machines at the Segovia Mint. To this end, he calculates the speed of the water wheels, the power of the flow and provides some explanatory drawings.

The passion for their subject leads the authors to consider the monument to be the finest example of industrial architecture in the world. However, considering that this technology was transferred and that a mint dating from the 14th century is conserved at Kremmica (Slovakia), this claim seems somewhat far-fetched. There is no doubt that the Segovia mint is an important Spanish monument on account of its size, its advanced technology and its excellent conservation.

As regards the book, there is a lack of homogeneity in the treatment of references: in the first two chapters, the footnotes refer only to archive documents whereas the last two chapters contain secondary bibliography that is much too general. Additionally, a quotation is repeated on pages 30 and 248.

The book is profusely illustrated and is aimed at a general readership, which may account for these editorial shortcomings. Overall, this work is a valuable contribution to the knowledge of mint technology and will appeal to those interested in the cultural heritage of Spain.

Francesc X. Barca-Salom, Universitat Politècnica de Catalunya, Spain

Francesc Xavier Jufre Garcia, *El artificio de Juanelo Turriano para elevar agua al Alcázar de Toledo (S. XVI). Modelo con escaleras de Valturio*. Lleida: Editorial Milenio; Madrid: Fundacio´n Juanelo Turriano, 2008. Pp. 241. €20.

Francesc Xavier Jufre-Garcia's study on the Artificio de Juanelo is a highly relevant contribution to the understanding of the hydraulic machine constructed in the mid-1500s by Juanelo Turriano. Jufre-Garcia is a mechanical engineer who uses his technical knowledge to study again the scarce evidence on the extraordinary device designed and constructed by Turriano for the city of Toledo and for the King of Spain.

Born in 1501 in Cremona, the Duchy of Milan – at that time part of the Spanish Empire – Juanelo Turriano entered into the service of Emperor Charles V in 1529 as Court Clock Master. After Charles V abdicated in favour of his son Philip II in 1556, Turriano spent the last one and a half years of the Emporer's life with him in Granada. Following Charles' death in 1558, Turriano was named Major Mathematician to the King and placed in charge of several relevant engineering projects. While living in Toledo, he designed and constructed one of his most original inventions, the so-called 'Artificio', a system to carry water from the river Tajo to the top of the hill on which Toledo stands. He died in Toledo in 1585.

The Artificio constructed by Turriano solved the water supply problem for the city of Toledo as well as for the city's royal castle – Alcázar. Previously, water had been transported from a dam along a Roman aqueduct, but because maintaining the aqueduct proved almost impossible, containers of water were transported by animals and carts up 90 metres in elevation from the river to the city. After using a model to persuade the Municipality of Toledo and the King of the soundness of his complex hydraulic device, Turriano contracted with the Municipality of Toledo and the King to construct it: he would pay for construction, and if the Artificio was able to provide an agreed quantity of water, the King would pay 9,000 ducats and the Municipality would pay 1,900 ducats annually to him and his descendants. Construction of the Artificio was completed in 1569, and it exceeded expectations by supplying 50 per cent more water than forecasted. This success led to the approval of the construction of two more artificios adjacent to the original one; work on the second began immediately.

Unfortunately, the economics of the venture were not successful. The King failed to pay any money towards the project, while at the same time his Alcázar monopolized all the water. Furthermore, the Municipality refused to pay its share if there was no supply of water for the city. Turriano wrote numerous letters seeking to resolve the situation, and in 1575, a new agreement was drawn up in which the King agreed to pay for the second Artificio, which was completed in 1581. The difficulties continued, however, and only just before his death in 1585 did Turriano receive any money from the King. Despite debts left to Turriano's heirs, they nevertheless operated the artificios for several years. In fact, the original Artificio remained in operation until 1605, when attempts were made to modernize it, but finally it was dismantled in 1639. Remnants of it, including the original wheel, could be seen in Toledo until the end of the 19th century, after which it disappeared.

Juanelo Turriano's Toledo achievements became known worldwide, and there are many references to him by contemporary visitors to Toledo in many technical texts. Without precise information on Turriano's design of the Artificio, hypotheses have been advanced, the oldest probably by Luis de la Escosura in a paper published in 1888. Theodor Beck developed models proposed by Escosura in 1899, and two generations later, in 1967, Ladislao Reti offered another design hypothesis from which Juan Luis Peces constructed a scale model. In 1987, Julio Porres designed yet another version, and in the 1990s, Nicolás Garcia Tapia modified some details of this model.

Not surprisingly, Jufre-Garcia presents here a new model of the Artificio. After analysing a 1575 description by Ambrosio de Morales, Jufre-Garcia concludes that the Artificio used a mechanical device known as the Roberto Valturio stairs or scissors. For Jufre-Garcia, this model is the one that conforms most closely not only to Morales' description but also to the references contained in several manuscripts. His arguments are quite convincing, and he offers a new detailed design of all the parts of the Artificio. On his website, one can find his reconstruction of the whole device plus some multimedia reconstructions: http://www.artificiodejuanelo.org.

The book also includes detailed calculations for the whole complex system, and the result is very interesting from the perspective of what one might call practical or technical history. From an academic view, however, Jufre-Garcia's work has important weaknesses: the presentation of the text is confused, the bibliographical references are repeated and the quotation of sources is inexact, all problems that could have been resolved with a general revision of the text. In addition, however, the historical background is not always convincing. Arguing on behalf of Juanelo Turriano's abilities, Jufre-Garcia refers to the study made by the Italian engineer on Giovanni de Dondi's Astrarium, in which devices like the Valturio stairs were used. In an appendix, Jufre-Garcia presents the mechanical operation of De Dondi's Astrarium, with an introduction to the cosmological systems of antiquity, but in this section, Jufre-Garcia´s lack of historical background is most evident.

In sum, Jufre-Garcia offers an interesting proposal for the mechanical operation of Juanelo Turriano's Artificio, but his model could be better contextualized from a historiographical point of view. This might have been attained if Jufre-Garcia had collaborated with historians focusing on Renaissance technology in Spain.

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Ignacio González Tascón and Isabel Velásquez. *Ingeniería romana en Hispania. Historia y técnicas constructivas.* Madrid: Fundación Juanelo Turriano, 2005. Pp. 542. €50.

Ignacio González and Isabel Velázquez take the reader on a journey through time and space as they describe Roman engineering in Hispania. First, they show and explain a large number of materials and works, and then define over 1,500 Latin terms to their topic. After a brief history of Hispania, the authors' first chapters provide examples and narratives of authorities in ancient architecture, such as Vitruvius, pointing out the development of materials and construction techniques. Subsequent chapters concern the planning and building of numerous works; from roads, their pavements and wells to aqueducts, ports and domes. However, this is not a kind of catalogue. Rather the authors write with a smooth and pleasant pen, which is well illustrated in their description of the technical importance of the keystones to make sturdier arches, as well as in their explanation of the development and application of concrete and other materials.

Moreover, the author's take the reader on a trip, if you will, from one city to another, where seeing these works permits one to know something about everyday life, as well as the economic and political configuration of Hispania. They reveal the existence of specialized technicians who met the different needs of Hispania. For example, they offer a careful description of the steps needed to perform a hydraulic work which includes location of sources, the design of methods to deal with topography and distance, concern for the durability of the structure and, if the water was intended for human consumption, the purity of the liquid.

Thus, Roman engineering is reflected in this book not only through their material works, but also equally through durable prints that act as words. The Latin terms that accompany the reading help us to know the names of ancient cities and workers at each stage of construction. There is a very large glossary of people and their activities in civil engineering, the entries of which are, in most cases, accompanied by a quotation in Latin and Spanish that illustrates more about the use.

This study is supported by direct observation, review and analysis of material remains and an extensive bibliography of ancient narratives and contemporary studies. The photographs and other images are of high quality; however, they could have broader notes. Finally, I think the book would be better if the historical overview were integrated into the main text and not as a separate chapter in the beginning.

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A. M. Bernal, A. Florencio Puntas, R. M. Madrid Calzada and J. I. Martinez Ruiz. *Ingenieria Industrial en Andalucía. La labor de AICIA (1982–2007).* Sevilla: Association for Research and Industrial Cooperation of Andalucía, 2007. Pp. 228. €10.

This book was written in the context of the AICIA's celebration of its 25th anniversary. AICIA, the *Asociación de Investigación y Cooperación Industrial de Andalucía 'Francisco de Paula Rojas'*, is a research institution created, in 1982, to encourage the establishment and development of a firm and extended relationship between the academic and the industrial worlds.

According to Javier Aracil, author of the prologue and member of the committee in charge of the commemorations, the aim of the book is to support debate on the achievements of AICIA by giving readers an historical perspective of the role played by industry and industrial engineers in Andalucía's economy. Antonio-Miguel Bernal, who coordinated this four author volume, reaffirms the same goal in his presentation.

Although the title may point to a very contemporary and focused approach (AICIA, 1982–2007), the book presents a *longue-durée* perspective, going back to the middle of the 19th century. In fact, four out of the six chapters deal with the time span of 100 years from around 1850 to 1950. Based on a strong collection of data and information, sometimes a little too dense, the authors raise a set of questions, which interests particularly historians (coming from different subfields, but mainly Economic History, Industrial History and History of Technology), but also interests some sectors of the general public.

As stated by the authors, there are a few studies available on the industrial context of Andalucía and almost nothing on the topic of local industrial expertize. From both an Iberian and European perspective, this theme is of extreme relevance: on the one hand, it complements the more widespread studies of successful industrial regions such as Catalonia and the Basque Country; on the other, it establishes a very fruitful comparison with the Portuguese case, which shares some of the main characteristics of Andalucía. These are industrial breakthroughs that prevailed over a steady and continuous industrialization process, excessive dependence on foreign expertize and machinery, a weak economy, and a particularly feeble industrial sector.

After a first chapter featuring general classical topics concerning European industrialization, the authors move to the detailed analysis of the training of local industrial engineers and how its ups and downs are intertwined with Andalucía's history of industrialization (chapters 2, 3, and 4). The last two chapters (5 and 6) focus on the creation of local industrial expertize in Andalucía, first with the *Escuela Técnica Superior de Inginieros Industriales de Sevilla* (College of Industrial Engineers of Seville), in 1963, within a more general agenda of decentralization; later, in 1976, with the Laboratorio de Ensayos e Investigación Industrial (Industrial Research Laboratory), which was a semi-failed experience; finally, in 1982, with AICIA that took the place designed for the *Laboratorio*, that is the research dimension of the *Escuela Técnica Superior de Inginieros Industriales*. At the end of chapter 6, and after the presentation of data concerning AICIA, the authors present five-pages of important concluding remarks, enabling the reader to recover the general picture behind this case study.

Maria Paula Diogo, New University of Lisbon, Lisbon, Portugal

Alejandro Ricart Cabús. *Pirámides y Obeliscos, transporte y construcción: una hipótesis* Madrid: Fundación Juanelo Turriano, 2008. Pp. 298. €28.

This book presents a complete analysis of archaeological remains, documents, studies and experiments with models utilized and made by Alejandro Ricart Cabús to solve the problems of moving large monoliths in the construction of the iconic Egyptian pyramids. It begins with a chronology of ancient Egypt's historical periods, from 3000 until the mid-third century BC, a time-frame that includes the construction of many important buildings. The text is accompanied by maps and a summary table.

After a thorough review of sources, similar experiences and mathematical calculations, the second chapter deals with earlier insufficient explanations as to the transport of the great monoliths. Ricart deems them insufficient because the challenges solved by the Egyptian builders in different times required them to possess complex construction techniques that demanded even more elaborate knowledge than Egyptologists usually accept. He then analyses the proposals of different scholars who sought to explain how pyramids were built, and after detailing the advantages and disadvantages of each one, Ricart concludes that the pyramids are not simply the product of a single constructive method, and he shows why ramps must have been used as well as other machines, such as levers and pulleys. Even more, he leaves aside the traditional interpretation that chambers and interior passages were only for funerary use. Rather, he proposes that they were perhaps the heart of the constructive system and describes the role they played. Up to a certain height, the builders used ramps to elevate monoliths, but a system of machines comprising of pulleys set into the chambers pulled, with the aid of counterweights, ropes that led through the passages, raised the stones upwards on the outside of the pyramid. Thus, the location of the passages and chambers was not, as generally assumed, the result of astronomical dispositions. While he applies this hypothesis to some ancient pyramids, he also points out how engineering knowledge and building technology evolved and was not the same when the earliest pyramids were constructed compared to later ones.

Obelisks are the subject of the fourth chapter. Ricart first describes their location and meaning and then reviews the problems implied in each phase: construction, extraction at the quarry, transport and erection. Again, he discusses the assumptions of other scholars and even studies the ways in which some obelisks were removed and taken to other cities. His analysis takes into account the material, the necessary workforce, distance and terrain type and integrates everything at each phase. In the case of the final erection of an obelisk, Ricart shows the procedure in a model.

Pirámides y Obeliscos is thorough and pleasant reading, and it contains a large bibliography, some summary tables, three appendices and good images. Ricart constantly confronts other scholars' works and the general problem at hand with a deep knowledge of mechanics, which permits a whole reinterpretation of Egyptian construction methods. His work shows that the study of technique is essential to having a more complete view of other societies. My only criticism is that Ricart could have provided more detail in explaining why he thinks that high costs alone might be the reason to reject other hypothetical building systems Additionally I would have liked to have seen more images employed in the descriptions of the various construction procedures.

María Elena Ramírez, Universidad Nacional Autónoma de México, Mexico

Robert Carvais, André Guillerme, Valérie Nègre and Joël Sakarovitch, dir. *Edifice & Artifice. Histoires constructives*. Paris: Editions A. & J. Picard, 2010. Pp. 1272. £62.32.

The event detailed in this book comes as a result of the decisions taken in the first French-language conference on the 'History of Construction' that took place in Paris in 2008. There have been previous conferences in the French-speaking world on the history of construction, but they tackled specific issues, such as large-scale projects, or specific periods such as the Middle Ages. But this work, which brings together over 120 contributors, attempts to portray the significant stages of the act of building throughout history, through the use of an original chronological and thematic structure: project design, materials used, the actual building work itself, the initiation of works and the evolution into heritage status. Above all, it presents itself as a kind of manifesto, arguing in favour of scientific recognition for a historical subject that has been overlooked for too long. It takes an interdisciplinary approach (from archaeology to the history of techniques and crafts, via economics and law) plus a global approach (from the technical conditions of the art of building to architectural composition), and it draws on wide-ranging sources (object, layout, oral history, iconography). For young researchers, it paves the way in a fertile field of research set to bring about new-found understanding of the changes affecting our built-up environment.

Robert Belot, Belfort, France

William R. Shea, ed. *Science and the Visual Image in the Enlightenment.* Sagamore Beach, MA: Science History Publishers, 2000. Pp. 240. $39.95.

This is an important, if imperfect book. It is important in that we finally have a work that reflects a genuine attempt at an interdisciplinary approach to the subject of science and the visual arts. However, the book suffers from some flaws, especially an unevenness in the quality of the essays.

The focus of *Science and the Visual Image in the Enlightenment* is on the eighteenth century, but it would be good to see this choice of era explained, or at least the promise of subsequent companion volumes; e.g., one on the fifteenth century, an era which saw the introduction of radical new concepts in terms of the anatomical illustrations, 'exploded' views of machinery and the use of visualizations to solve problems in the physical sciences. One could imagine a similar volume for the nineteenth century, which saw a profusion of scientific illustrations for the popularization of science, and a volume for modern science (with, for example, Feynman diagrams). The book would benefit from some acknowledgement, à la Needham, of the use of visual images in science in Chinese culture, not just the West.

The book is divided into two parts: the first concerns the use of images in the Enlightenment, and the second looks at images of nature in botanical works, natural history studies and astronomical books. The division is somewhat peculiar, and the Enlightenment is never fully defined here. The volume is a series of essays, most of which look at the use of images in discussing scientific themes, but there are a few, such as Werner Busch's piece, which stray from this. His contribution, on Joseph Wright of Derby, is interesting but is more about artists' *portrayal* of science in fine art, which is different from the use of visual images for the systematic exposition of scientific ideas. On page 32 and page 83, for example, we see two famous eighteenth-century paintings that include scientific apparatus, but these are quite apart in significance from an image such as that on page 41, which is a didactic illustration of a machine using weights.

The book has a preface, but lacks an introduction; the latter is certainly needed, to explain the overall approach of the book, to provide a definition of 'visual imagery' and note the source of these essays. On this last: some of the essays seem to have been designed as scholarly articles, while others appear to be more conference papers. Moreover, the 'List of Contributors' provides virtually no information about the authors' specialties or scholarly interests.

Reading through *Science and the Visual Image in the Enlightenment*, one finds key issues discussed, although in an irregular fashion: why scientific illustration flourished during this period, what purposes visual images served in early scientific works and what influence the practice of illustration and image-creation had on the philosophical foundations of science. Indeed, the concept of the 'visual image' in science brings up multiple issues and themes: didactic, investigatory, artistic and aesthetic, even religious. Interestingly, however, there is nothing on maps here, even though the Enlightenment saw a huge growth in the creation of empirical maps and charts, wonderful examples of the visual image in the service of science.

The essays make a number of interesting points. William R. Shea notes that scientific illustration had a legacy stretching from antiquity all the way to the time of Diderot's eighteenth-century *Encyclopédie* (p. 39). Marco Beretta's essay looks at the use of iconography in early works of alchemy and chemistry, and the connection of this practice to more modern illustrations (pp. 57 ff.). Lucia Tongiorni Tomasi's piece on the foundations of naturalistic illustration explains how animals came to be depicted in their natural habitat and the rise of '[v]eracity and didactic clarity' in the new wave of scientific illustration (p. 112).

One of the most interesting essays is Fernand Hallyn's, in that it explores what visual images in science actually *do* in semiotic terms (p. 89). Hallyn, in discussing Leibniz, makes the vital point that 'we [may] take the representation for the object itself' (p. 91); thus the use of visual images in science may affect how we actually think about scientific phenomena. The other pieces in this volume do not match Hallyn's level of analysis, which brings critical philosophical examination to the subject. Indeed, this essay would have been better placed at the beginning of the collection, to set an analytic and thematic tone for the whole volume.

In sum, there are a number of intriguing and important ideas explored in *Science and the Visual Image in the Enlightenment*, but one would like to see an expanded, re-organized, and more selective (in terms of relevance of the contributions) edition.

Benjamin B. Olshin, Philadelphia, Pennsylvania, U.S.A.

Martin Reuss and Stephen H. Cutcliffe, eds. *The Illusory Boundary: Environment and Technology in History.* Charlottesville and London: University of Virginia Press, 2010. Pp. 328. $29.50.

Over the past decade, scholars working in the seemingly divergent fields of history of technology and environmental history have increasingly discovered common ground, giving rise to a new interdisciplinary group sometimes termed Envirotech. Reuss and Cutcliffe's fine collection of essays is one of the first systematic attempts to explore some emerging fundamental ideas and methods in the field. At this early stage Envirotech has yet to fully crystallize as a coherent approach, but the resulting fluidity is rich with potential.

Indeed, one of the virtues of the collected essays is the way they capture the ongoing scholarly debates about the intersections between environment and technology. Some of the authors take a fairly straightforward approach by analyzing how technology and environment mutually affect each other, a process they generally see as mediated by complex socio-cultural forces. As James Williams notes in an introductory overview, technology stands at 'the junction between humankind and nature'. The essays by Joel Tarr, Craig Colten and William Rowley, demonstrate how technologies like cities and railroads are inextricably linked with or embedded in natural systems – often to the point that distinctions between the two become difficult to perceive. Other chapters take this blurring of the boundaries between technology and environment (or more broadly, humans and nature) as a more central topic of interest, thus suggesting intriguing new methodological and analytical approaches. Joy Parr, Sara Pritchard, Thomas Zeller, Edmund Russell and Ann Vileisis all offer examples of the insights to be had by probing the line between technology and environment itself. Clearly, genetically-engineered tomatoes remain 'natural' in some sense, Vileisis suggests in her perceptive essay. Yet, few would probably go so far as one proponent who argued, 'I don't see how man, in using recombinant DNA, is doing something unnatural when man is part of nature, too.'

All the authors offer evidence that the boundary between environment and technology is indeed illusory. Yet, to some the boundary seems illusory because it is highly permeable, while others see it as literally an illusion – that is, nonexistent. Both approaches are useful, though the second is clearly the more radical in its suggestion that historians of technology and historians of the environment are essentially studying the same thing. If Edmund Russell is correct in his essay's assertion that a domesticated cow is a technology, it makes little sense to speak of technology *affecting* nature – nature simply *is* the technology. Likewise, as Pritchard and Zeller assert in their contribution on the nature of industrialization, 'humans are still part of the natural world in the industrial age' and thus it is 'analytically questionable to separate humans and nature as neatly as it is often done'.

The Illusory Boundary offers a revealing snapshot of the present state of envirotechnical thinking that will be of great value to scholars in the two parent fields, as well as to the many scientists and policymakers whose work increasingly straddles conventional boundaries.

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Peter H. Kahn, Jr. *Technological Nature: Adaptation and the Future of Human Life*. Cambridge: The MIT Press, 2011. Pp. 240. $24.95/£17.95.

The relationship between humans and nature is a topic that by any measure is interdisciplinary. Historians, biologists, philosophers, sociologists and other scholars have weighed in on the topic. From the field of psychology, Peter Kahn's *Technological Nature* offers a provocative contribution to our growing understanding of the human/nature relationship.

In *Four Arguments for the Elimination of Television* (1978), American author and activist Jerry Mander argued that television had so mediated people's experience with nature that we would be wise to abandon the technology. Although Kahn does not suggest abandoning television, he too is concerned deeply about the mediating effects on the human/nature relationship of this and other technologies. Anecdotally, we know technology impacts our relationship with nature, and we suspect people are affected physiologically, emotionally and cognitively when nature is replaced by '*technological nature*: technologies that in various ways mediate, augment, or simulate the natural world' (p. xiii). In this book, Kahn, director of the Human Interaction with Nature and Technological Systems Laboratory at the University of Washington, presents the results of carefully crafted psychological experiments concerning these issues.

Recognizing that humans are a technological as well as a natural species, Kahn is persuaded that it matters for people's physical and psychological well-being 'that actual nature is being replaced by technological nature' (p. xvi). We are losing what he calls 'the Old Way' through a process of 'environmental generational amnesia', in which each generation accepts the natural world they encounter in childhood as environmentally normal, including the level of environmental degradation that then exists. The concept, he admits, is similar to the psychological phenomenon of 'landscape amnesia' advanced by Jared Diamond in *Collapse: How Societies Choose to Fail or Succeed* (1995). He also draws on the theory of biophilia – people's engrained predisposition to affiliate with nature – in arguing that people also have a disposition to affiliate with computers, robots and technology in general. Thus, as the natural world is degraded and technological nature replaces it, the human/nature relationship is diminished.

The bulk of Kahn's book, chapters 4–10, presents experiments conducted with adults and children using 'technological nature windows', Sony Corporation's robotic dog AIBO (**A**rtificial **I**ntelligence ro**bo**t) and web-based robotic 'telegardening'. Each of these experiments conducted over a period of years sought to discover the emotional, cognitive and physiological effects of people interacting with technological nature in comparison to actual nature, the 'benefits and limitations of experiencing technological nature', how technological nature might be better designed 'to enhance human well-being' and, in general, if can people 'flourish apart from actual nature'. Each chapter reports the experiments data in a readable fashion and provides a summary conclusion that, together, offers a summary of the book.

Although not a work of history, Kahn nevertheless attempts to weave the history of technology and of environmental history into his story. In his chapter 'The Technological Turn', he asks why humans, in their evolutionary history, 'began to create, use, and love technology' (p. 27). Noting that his answer can only be speculative because 'the historical data are too scant' – something most historians of technology would vigorously dispute – he embraces Louis Mumford's suggestion in *The City in History* (1961) that, when humans left the savannahs some 60,000 years ago, they followed a path either to the village or to the citadel, the latter which also particularly led them to technology. While he rejects technological determinism in favour of the 'primacy of the individual and the role of culture' in technological change, his grasp of the history of technology is truly disappointing. Similarly, in his chapter 'Environmental Generational Amnesia', Kahn draws on prosaic stories, such as the deforestation of the Scottish highlands and the demise of the passenger pigeon and the North American buffalo, and illustrates but a thin grasp of environmental history.

Nevertheless, I found this a worthwhile read. Kahn offers important empirical research into the human/nature relationship. His concept of technological nature is something historians of technology and the environment should find very valuable, as are his review of biophilia and his discussion on environmental generational amnesia.

James C. Williams, Stetson University, DeLand, Florida, USA

Christof Mauch and Thomas Zeller, eds. *Rivers in History. Perspective on Waterways in Europe and North America.* Pittsburgh: Pittsburgh University Press, 2008. Pp. 256. $27.95.

Rivers in History, edited by Christof Mauch and Thomas Zeller, offer different perspectives about the relation between rivers and the human communities built along them. The volume's nine essays provide ample geographical context, with contributors examining the construction of fluvial societies in the U.S. and Europe, from the eighteenth century to the very recent past. With the exception of Dorothy Zeisler-Vralsted and Charles E. Closmann who each compare rivers that have played a strategic role in the economy of specific territories, each contributor focuses on the life of a single water course, for the most part covering nearly the entire extent of their basins. Isabelle Backovche's contribution and that of three co-authors Timothy Collins, Edward Muller and Joel Tarr offer two interesting city-based cases about the artificial development and infrastructural revolution of a natural resource inside an urban context.

The value of this anthology is its originality and each case-study. In the first contribution, David Blackbourn points out how rivers have been an engine for advancements in civil and hydraulic engineering studies and a training school for the specialized technicians needed to built large infrastructures. Then Backovche discusses the centrality of the Seine River in the urbanization of Paris, the main European capital of the eighteenth century. Particularly interesting is her description of the social conflict for the management of docks between the private citizen, in defence of his property, and administrative authorities, who expropriated properties for public works. According to Collins, Muller and Tarr, in Pittsburgh during the nineteenth century, the investments in public water ways were essential to the industrial growth of the city. Zeisler-Vralsted compares the Volga and Mississippi rivers, with their tributaries, as great water arteries utilized successfully as mass transportation lines. Jacky Girel describes interventions between the eighteenth and nineteenth century on the Isère River, which were necessary to preserve the agricultural and human environment. Then, comparing public administration of the fluvial system in the Ruhr region of Germany and in Yorkshire, England, from 1850 to 1990, Closmann shows the importance of technical preparation and of clarity of objectives among the politicians called on to rule the waterways.

Thomas Lekan focuses his contribution on environmental issues, outlining the remediation policies implemented on the River Rhine during the second half of the 19th century. He presents an interesting example of international friction arising from the Netherlands' protest against Germans industrial wastes flowing into the Dutch portion of the Rhine. Ute Hasenöhrl presents the case of a Bavarian river, the Lech, in which he argues that rivers can find equilibrium with clean energy production (hydroelectricity) and tourism. Finally, Steven Hoelscher closes the volume with the case of the Gidden River in the American state of Wisconsin, in which he analyses the economic possibilities of green tourism along rivers running through lightly urbanized regions.

In the process of urban and industrial expansion, people have devised many systems and artefacts to make rivers function according to human needs: big bridges have facilitated transport and communications; docks have allowed the docking of boats; dams have optimized navigation, water supply and safety for populations living along river banks. Interacting with rivers, people have achieved greater intellectual capacities in agriculture, civil engineering and law. The use of rivers has been an engine of social development, and learning how to use rivers represented a great challenge for humankind's evolving technological knowledge. This anthology shows some excellent representative sketches of this challenge.

Francesco Gerali (Italy), Universidad Nacional Autónoma de Mexico, Mexico

Barton C. Hacker with Margaret Vining. *American Military Technology. The Life Story of a Technology.* Baltimore: The Johns Hopkins University Press, 2007. Pp. 232. $22.95

The US has been the leading world power for more than half a century. What formidable machinery helped to form this superpower? An answer is provided in the technological underpinnings of America's military history.

The text is studded with biographical data on some forty personalities who helped to break new ground in military technology. Women are not forgotten, even if they seem sometimes to be rather loosely linked to technology. Not so, however, with Grace Murray Hopper. She was involved in the development of the first US programmable computers in the 1940s and later the brain behind a programming language (COBOL), which served the nation (and others) for decades.

Among the men portrayed are hands-on inventors like David Bushnell and John Holland, both engaged in making prototype submarines. There is John Ericsson, with his revolutionary half-floating, iron-clad ship construction, *the Monitor*, and Richard Gatling, who mastered the technique of building machine guns. With the 20th century come more theoretical or systems-oriented people like Edward Teller of the *Manhattan* project – the scientific endeavour making nuclear weapons a reality; Vannevar Bush, coordinator of

World War II defence research, and Charles Hitch, engaged in systems analysis, which 'transformed national defence policy' in the 1960s.

The authors keep well away from a 'nuts-and-bolts approach' to technology. Their ambition is instead to relate weaponry to social context, which is laudable; yet, I would have liked to have seen a bit more nuts and bolts. While certainly not the only actors in a history of technology account, artefacts should not be withdrawn too far from the stage. The technological style displayed by nuts-and-bolts objects sometimes could shed light upon the path dependence between earlier and later technology. In fact, the screw propeller, as presented in the book, indicates that technological artefacts can be of some interest. The idea to use it for ship propulsion has been attributed to John Ericsson; however, we learn in the text that Richard Gatling proposed the same idea, and a reader can easily see this nuts-and-bolts item appearing in a drawing of Bushnell's much earlier submarine (p. 6). Indeed, this vessel had two (hand-driven) screw propellers – one for horizontal and another for vertical movement.

The history of military technology, like history in general, might flow smoothly for most of the time but may be equally influenced by war and crises. The two world wars influenced the technological landscape by creating new coordinating bodies like the National Research Council (World War I) and the Office of Scientific Research and Development (World War II). From the latter came radar technology and proximity fuses that made it possible for bombs to explode when close to the target.

Crises other than war have also influenced the technological landscape. One such event, noted in the book, is the Soviet launch of the first artificial satellite in 1957. It shook the American nation, whose leaders looked for ways to respond to the challenge. One response was to form the National Aeronautics and Space Administration. Another was to pass the National Defence Education Act, which provided 'immense sums of money' to those in science and technology willing to study issues of national security.

The shock of the Sputnik launch, a new technology of strategic importance in the hands of a principal foe, is thus reflected in the book. A shock less reflected in the pages of the book is the Vietnam War. There – in contrast to the Sputnik challenge – primitive technology seemed able to prevail against the high-tech weaponry and support systems by US forces. It was the shock of the old, so to speak. For example, in the air it was noted how cannon-equipped North Vietnamese aircraft matched their US counterparts equipped only with missiles. In the end, US interceptor aircraft had to be retrofitted with cannons in order to prevail. It was a lesson many were unwilling to learn, as it meant taking a step back with regard to technological modernity. Here I would have wanted a comment beyond the remark that 'although faith in technology ultimately proved misplaced, efforts to implement it led to striking innovations' (p. 140).

To a European reader the United States is a young nation and one more practical than philosophical. How this is revealed in admirable and awesome military technologies is well described in this book.

Petter Wulff, Stockholm, Sweden

David Edgerton. *Britain's War Machine: Weapons, Resources and Experts in the Second World War*. London: Allan Lane, 2011. Pp. 464. €9.99.

'Do we really need another book on Britain in the Second World War?' asks David Edgerton in the opening statement of this study. His 430-page reply amounts to a convincing, affirmative answer. The book is timely, cogent and well-written.

Those familiar with Edgerton's previous work will not be surprised that the book is packed with quantifications of tonnage carried and distances covered, with facts concerning striking power and destructive impact and estimates of casualties and consumption. In this book, the point of these (in many cases brutal) facts and figures is to describe the existence, origin, components and functions of the industrial and military war machine that enabled the British warfare state to fight the Second World War as a first-class industrial power and world-leading arms producer. This war machine was based on domestic military and industrial production as well as the continuous flow to Britain of raw materials, goods, equipment and trained personnel from within and beyond the British Empire. Thus, contrary to post-war myths Britain was 'never alone' in its war efforts – a small nation fighting a 'people's war'; on the contrary, Britain was a modern world empire fighting an international war while drawing on the resources of allied empires and states. In comparison to the poorer and less industrialized belligerents China and the USSR, Britain's industrial war machine ultimately proved capable of carrying a well-fed population through the war with low cost in wealth, lives and suffering. Moreover, as Edgerton convincingly demonstrates from a close reading of contemporary sources, at the outbreak of the war there was a supreme confidence (based on calculation) in Britain's ability to fight and win what was widely perceived as an industrial war – a fact that has since been obscured by influential post-war interpretations that cemented the image of Britain as a declining power unprepared for a new form of global conflict.

By reconstructing the powerful industrial war machine, Edgerton effectively challenges this 'declinist' view as well as a number of other widely held assumptions about Britain's war efforts. For example, by stressing that Britain fought not a national but an imperial and international war, Edgerton emphasizes that the defeats in Europe in 1940 were not as decisive as the imperial disaster in the east – epitomized by the capitulation of Singapore in February 1942 – which marked the point where Britain's position as a world power diminished irreversibly.

A number of Edgerton's other revisionist points concern the leaders of Britain's war administration including Churchill himself. Contrary to conventional wisdom, Churchill and his cronies in the administration were not antediluvian romantics dismissive of expertize, technology and invention. Rather, they encouraged and eagerly contributed (often amateurishly) to the development of new components and gadgets for the war machine on the underlying assumption that only through industrial prowess and expertize could Britain fight and win the war. In this respect, Edgerton emphasizes the importance of struggles between different forms of expertize, and his analysis of the role of scientific and technical experts during the war is the most far-reaching aspect of the book. He argues convincingly that the importance of academic science to what misleadingly has been labelled 'the physicists' war' generally has been highly overrated compared with the ubiquitous influence of industry, business and engineering. Moreover, what stands out very clearly is that scientists and engineers – whether in academia or industry – were not lured into taking part in the war or 'betrayed' into thinking that they were working for the people. On the contrary, as Edgerton notes in a central passage 'the immensely powerful and creative warfare state, its scientists, its technicians, were generally not working for a transformed world; they were not betrayed. It was the old world which had created the new worlds of war – from the airfields to the bombers, the battleships to the tanks, and the research laboratories and new weapons' (p. 231).

Britain's War Machine raises a number of issues that call for further scrutiny, particularly in relation to the Britain that emerged from the war. For example, Edgerton shows that the process by which Britain's war came to be seen as a national matter began immediately after the war had ended. Yet, in the decade after 1945 there was a strong commitment to the idea that in the new post-war world order Britain would be the 'third world power' and maintain a strong imperial position despite the loses in the east. Retrospectively, this outlook – which by no means was merely a Churchillian fantasy but which held sway both among Labour leaders as well as Conservatives – has usually been diagnosed as blindness to the almost self-evident military and economic realities that faced the faltering world power. However, rather than regarding it as a sentimental view maintained under the seductive influence of past glory it needs, possibly, to be seen as based on calculations of Britain's industrial and military capabilities – calculations that were informed by interpretations of the overall success of the war machine that enabled Britain to emerge very obviously as the most successful Western European power. This is but one issue of many and generally our knowledge of how Britain's national, imperial and international role was perceived in Britain in the period immediately after the war remains patchy. Further discussions of the outlook and priority of post-war Britain will do well to study Edgerton's analysis closely – and hope for a sequel to this fine book.

Casper Andersen, University of Aarhus, Denmark.

Don Leggett and Richard Dunn, eds. *Re-inventing the Ship: Science, Technology and the Maritime World, 1800–1918*. Surrey: Ashgate, 2012. Pp. 218. £65.

The cultural turn has come to maritime history. The editors of *Re-inventing the Ship* present the papers collected in this thin volume as antidotes to 'the three dominant models of technological change in maritime studies: the heroic inventor, the evolution of technology, and technological determinism' (p. 5). They drew the papers from the Three Societies Meeting of the British Society for the History of Science at Oxford in 2008 and a symposium on 'Steam, sail and science: Making the Victorian and Edwardian maritime world' [*sic*] at the British National Maritime Museum in 2009, adding two papers by invitation. 'Re-inventing the ship' is a notional concept, using the material artefact – the ship – as an icon of all maritime experience through the long nineteenth century. Traditional narratives feature steam, iron and steel; the narratives presented here gaze out from the ship in many different directions.

The ship of this book's title is simply the core artifactual system at the centre of a web of institutions, communities, practices, beliefs and constructions that bound Britain (and the United States in William McBride's essay) to the sea. For example, Christopher Harvie writes on the symbolism of the ship in British literature; Crosbie Smith on the locus of authority in creating a network of packet ships to deliver British mail around the world; Oliver Carpenter on trust as an essential foundation of a successful shipping company; Don Leggett on trust, identity and agency in defining a British warship; Richard Biddle on the shipyard as a hazardous space; Anne-Flore Laloë on the ship as science laboratory; Richard Dunn on what Ruth Schwartz Cowan has called the 'consumption junction'; Duncan Redford on culture as doctrine; and William McBride on American exceptionalism in ship design. Andrew Lambert concludes with a brilliant epilogue that mixes seamlessly the traditional steam-and-steel narrative with the 'rich mix of technology, strategy, and identity in this collection' (p. 217).

This book, therefore, is not so much about re-inventing the ship in the long nineteenth century as it is about re-inventing maritime history in the early twenty-first century. The evolving ship of the nineteenth century appears clearly enough in the essays by Redford, McBride and Dunn, for example. But it is the nature and focus of maritime history itself that is being re-invented by Carpenter, Biddle and Laloë. All the authors move back and forth between the two undertakings, and Lambert succeeds in bridging the gulf between them. Collectively, it makes for a primer on the changing condition of Anglo-American maritime history.

Alex Roland, Denton, North Carolina, USA

Wayne D. Cocroft and Roger J. C. Thomas, edited by P. S. Barnwell. *Cold War: Building for Nuclear Confrontation 1946–1989*. Swindon: English Heritage, 2011. Pp. xvi + 281. £17.99.

This new edition of *Cold War: Building for Nuclear Confrontation* is a model example of comprehensive research in modern, contemporary industrial heritage. The military components of industrial society are rarely taken into consideration when the impact of industrialization on landscape, culture and society is discussed. Military facilities have always been a subject of secrecy – especially in the period under consideration in this piece, the Cold War, when the fear of communist spies was widespread, permanent and the result of an obviously imminent danger. The facilities examined in this volume tell of this perceived danger and many of the structures, instruments and buildings that were explained to a wider public for the first time when the book was originally published in 2003. This is the first achievement of the authors – to make a formerly inaccessible area of space and knowledge accessible. The second achievement, however, goes beyond the mere documentation of rarely revisited and frequently rather forgotten infrastructural projects, many of them on a scale of enormity hardly imaginable. The authors manage to frame a wide range of both military and civil infrastructure sites and production facilities in a greater political, social, economic and, most of all, cultural context. When the reasons and motivations for creating such a dense network of defence facilities in a single country in such a short period of time is examined, it turns out that cultural context is one of the most telling categories.

In eleven chapters, the story of the Cold War is told in immediate association with the industrial archaeological sites of British military infrastructure. After a short introduction into the scope of the book, the background of the Cold War and a sketch of its history provide the volume's starting point. Chapter 3 examines the traces of the nuclear arms race in the remnants of airfields, missile containers, aeroplanes and port facilities. Chapter 4 delves into the various outlines and infrastructural facilities of military airfields. Chapter 5 deals with technologies of air space surveillance and chapter 6 with the attempts to establish an effective early warning system. Chapter 7 gives an insight into the air defence measures taken, while chapter 8 shows the nationwide web of observational outposts and their technology. Chapter 9 impressively depicts the story of a society prepared for nuclear devastation and plans to survive such an attack. Chapter 10 analyses private and public research facilities and what happened to them after the end of the Cold War, a topic concluded in chapter 11, which, in turn, gives an account of attempts to conserve a range of sites in museums or elsewhere.

The book comes with summaries in three languages, a timeline, a useful register and a comprehensive account of source material. All chapters work in detail with maps, material regarding cultural context, detailed plans of buildings and their use as well as additional tables and figures. This volume is a great example of a narrative of the Cold War and its facets, told with the close help of industrial archaeology. The book can be recommended to anyone who is interested in the history of the Cold War, industrial archaeology, industrial heritage and military history or the history of technology.

Oliver Schmidt, TECHNOSEUM, Mannheim, Germany

R. Angus Buchanan, ed. *Landscape with Technology: Essays in Honour of L.T.C. Rolt*. Bath, UK: Millstream Books, 2011. Pp. 128. £7.50.

This edited volume is an homage to L.T.C. Rolt, edited by the 2007 Society for the History of Technology Da Vinci medallist R. Angus Buchanan, one of the *deans* of the history of technology in Europe. The title echoes three books authored by Rolt: *Landscape with Machines* (1971), *Landscape with Canals* (1984) and *Landscape with Figures* (1992).

L.T.C. Rolt was trained as an engineer, but after some years of practice, he decided to engage in a career as a writer and, subsequently, as a pioneer of heritage conservation and as an engineering historian. He was the first President of the Association of Industrial Archaeology, founded in 1973, a milestone for those who, all over Europe, wished to embrace this newly-born field of research. The University of Bath recognized the relevance of his work by awarding him an honorary degree and creating the Rolt Research Fellowship.

This book is, thus, a tribute written by former Rolt Fellows and members of the History of Technology Seminar of the University of Bath, which accounts for the heterogeneity of themes and time span, the only link being the professional trajectory of the writers, particularly the fact that they all joined, at some point, the University of Bath. In fact, the nine contributions are so different that they work perfectly well, if not better, when read as individual papers.

Apart from the introduction to the life and work of Rolt by Angus Buchanan, the essays may be grouped into two main sets: one devoted to topics related to Industrial Archaeology and the other focused on technical and economic issues of specific technologies. In the first group one finds the contributions of Keith Falconer, who presents a chronology of industrial sites inscribed as World Heritage sites; Mike Bone who deals with the distilling industry of Bristol and Bath, from 1775 to 1815, based on information from tax sources and newspapers; Peter Strokes, who uses his own life experience in aero-engine testing to shed light on the testing and restoration of historic machines (e.g., the Key Bridge engines, London); finally, Geoff Wallis discusses precisely the best way to preserve historic machines as living entities, by using the example of the Crofton Pumping Station.

The second group of essays hosts five contributions: Brenda Buchanan's essay on British gunpowder engineering in Tangier in the late 17th century, going from the details of the building plans to a two page conclusion presenting the big picture lying behind this episode; Owen Ward's case study is devoted to the discussion of critical issues in managing colonial estates, mainly related to the purchase of technology; Angus Buchanan's study on a less known aspect of James Nasmyth's professional life, related not with mechanics as one would expect, but with astronomy; Robin Morris's discussion on how traditional Anglo-Saxon engineering education should cope with new strong techno-scientific areas, such as microelectronics; and David Ashford's debates on how the Space Shuttle project shows the way preconceived ideas can affect its technical and economic efficiency and point to the near future of space trips at affordable prices.

Although this is not a work of reference, it is, nevertheless, a good introductory set of essays for undergraduate students and surely a worthy tribute to the intellectual interests of L.T.C. Rolt.

Maria Paula Diogo, New University, Lisbon, Portugal

Svante Lindqvist. *Changes in the Technological Landscape*. Sagamore Beach, MA: Science History Publications, 2011. Pp. 320. $55.00.

Svante Lindqvist has been involved in the history of science and technology since the 1970s with various publications and academic positions. He is associated with SHOT and was one of its first European members. This book gathers selected articles and conference presentations from the last 25 years, some of which were published previously only in limited circulation. The collection is not a defining retrospective but rather the cherished craftsman's works that Lindqvist would like to preserve. The essays are typically based on convincing historical case studies, together with reflections and conclusions. They address prevalent issues in the field such as technological determinism, differences between histories of science and technology and the social construction of science.

In the preface Lindqvist underscores his major conviction. He advocates for the examination of long term historic trends of a given technology over the current interests in micro-studies of actors and networks. This makes him admittedly 'semi-deterministic' in contrast with the 1970s/1980s vogue among historians of technology to 'jump on the band wagon of the sociologists of science that has just begun to move into our field.' Historians should first contemplate issues discussed by proper historians such as Fernand Braudel and Marc Bloch. Lindqvist's stance surfaces in the first and fourth chapters of the book.

The first chapter bears the same title as the book, 'Changes in the Technological Landscape', and it contains what Lindqvist claims as his single original contribution to the history of technology. Taking the development of various methods of producing steel in Germany 1800–1900 as his primary case study, Lindqvist demonstrates the need for exploring the whole technological landscape and not only technological changes and growth. Scholars lately have overemphasized these two parts of the landscape in their research because of the need to impress engineering schools and the business community and attract their financial support. In addition, the emphasis on changes in the history of science has led to a similar approach in the history of technology, even though the wide technological landscape changes much more slowly. It turns out that historians are studying only half of the history. If we choose a longer time span for evaluating significant technological changes, other and more important changes will appear before our eyes, such as the genuine share of a new technology in the market and its long-term consequences. Nevertheless, Lindqvist does not advocate a complete shift to macro studies of *la longue durée*, but rather a focus on micro studies that evaluate significant changes from a longer perspective. The financial pinch facing researchers is present also in a chapter on museums and is instrumental in recent decisions of many of these institutions to exhibit more recent technologies or promising new ones at the expense of the older ones.

Chapter four is another example of Lindqvist's argument with radical constructivists. In a series of examples on the rise and decline of traditional Swedish industries Lindqvist demonstrates that human agency and negotiations between actors had a limited effect on the trends. The industries, such as wood and pulp, steel or shipbuilding experienced an upward sales trend until the mid 1970s when foreign competition led to their inevitable decline. Managements predicted sales growth during the periods of rise was correct although too optimistic. When decline began, however, these predictions maintained an unwarranted optimism, although this optimism and new technical innovations in those industries could not prevent the downtrend. For Lindqvist, these cases remind us that there *are* constraints, long-term conjunctures that limit the freedom and effect the actions of the actors, whether individuals or institutions. Current fashion among historians of science and technology holds that every historical situation is a unique outcome of a power play between various actors in specific local contexts.

The less personal and more deterministic approach is also applied to the history of science. It has been agreed, for example, that the technology of instruments plays a key role in the progress of science, but historiography has placed too much importance on the feats of individual instrument developers. Lindqvist contends that it is the general level of technology at a given time that offers opportunities to scientists. His exemplary historic case is the interesting story of glassmaking.

Other chapters offer similar indepth examinations of diverse issues such as the role of science museums, initiations of History of Technology programmes in academia, technology transfers, the Nobel Prize as a mirror of 20th century science, the role of communication technology and the question of nationalism when it comes to scientific priorities. The reader is easily captured by Lindqvist's literary style, which is often intertwined with metaphors and personal experience and flavoured with candour and a mild sense of humour. To paraphrase the title of another recent volume, *A Companion to the Philosophy of Technology*, Svante Lindqvist's book might be regarded as *A Companion to the History of Science and Technology*.

Yoel Bergman, Herzliyya, Israel

Boleslaw Orlowski. *Powszechna historia techniki* [*Universal history of technology*]. Warszawa: Mowia Wieki, 2010. Pp. 308. €10.
Universal history of technology as seen from the periphery.

For those readers who have read Boleslaw Orlowski's previous books, *Polska przygoda z technika* and *Historia techniki polskiej* (*Polish adventure with technology* and *History of technology in Poland*) they see in his latest work, *Powszechna historia techniki* (*Universal history of technology*) that the author completely refrains from his normal use of the modifier 'Polish'. Boleslaw Orlowski, a scholar who has been indefatigably uncovering and popularizing the contributions of Polish engineers, technicians and inventors, working both nationally and abroad, challenged a problem of a different nature in this book: the writing of a universal and objective history of technology. Most such works, largely written by scholars from leading industrialized countries, discuss technological development from a Western perspective. A popular idiom states that the winners write the history, and it seems to apply to the field of technology and science. Authors from countries participating in the mainstream of technological change quite often fail to recognize contributions from the peripheries. Of course, there is no universal Western interpretation of how technological development progressed, and surely the French experience differs from that of the Germans or Americans. But commonly, historians barely recognize contributions to technology and science from other than Western Europe or North America. In his earlier works, Orlowski sought to fill this gap for Poland; however, he now has taken a more holistic approach.

The book is very readable and well organized, but unlike most works having the word 'history' in the title, one will not find it laid out in a chronological order, but rather a topical one. The author begins his contemplations emphasizing the importance of practising and promoting the history of technology, and this entreaty is a continuation of his activities as a scholar and educator.

In the second chapter, Orlowski analyses the origins and the role of innovation in the development of culture. He argues that technological breakthroughs played a key role in speeding up the process of human evolution. He also discusses the soundness of the history of technology as an academic discipline and refers to the theories and concepts shaping current research in the field. He also ponders the phenomenon of being an historian of technology. He notes the differences in origins of so-called hobbyists and enthusiasts and professional historians, although – quite naturally – he does not draw a line of demarcation between them when it comes to their scholarly achievements.

A little bit further on, he disputes the platitudes and truisms, which, in the popular version of the history of technology, are numerous. Such a discussion is not an easy task. The myths and misstatements repeated through generations have already rooted their way not only into the colloquial language ('a need is the mother of invention'), but also to works of recognized authors.

In subsequent chapters, Orlowski discusses the conditions that paved the way for technological change, but this time in chronological order. However, his narrative does not resemble the counting of milestone achievements, but it takes the shape of an in-depth analysis of the history of civilization. In his *Powszechna historia techniki*, the story of technological progress is told in the background of political, economic and social events. He analyzes, among other issues, the question of technological advantage, which enabled political, military, economic and cultural expansion of Europe in the 15th century. This was a phenomenon, he claims, which he believes for rational reasons, should not have occurred.

In the topical chapters Orlowski discusses the question of 'Harnessing the environment' (history of developing sources of energy from the water wheel to cold fusion), 'Improving nature' (material engineering, construction and water engineering, lighting), 'Conquering time' (recording images and sound, measuring time), 'Conquering distance and space' (optics, radar, communications, military technology, transportation). Within each subdivision he leads a fast-paced narrative by citing dozens of examples, indicating the reasons and driving factors that made them happen and explaining the implications they had on the social, economic and political life of humankind. This entire section is crowned by a debate on 'future prospects', in which Orlowski skips the typical optimistic vision of civilization prevailing over the laws of gravity. On the contrary, he foresees that more attention will be given to such banal yet important issues like improving safety on the roads or restoring a disturbed ecological balance.

Orlowski reels in the reader with his smooth and vivid narrative. He sums up the chapters and, at times, individual paragraphs very aptly, bluntly and humorously. The book comes with a timeline of events, and an index, which makes it much easier to navigate and transforms this piece into an excellent textbook, which will help prospective teachers to systematize their lectures. Orlowski invariably tries to harness others and infect them with his enthusiasm toward the history of technology. Both an average reader and experienced scholar would benefit from this particular literary work. It seems very important that *Powszechna historia techniki*, an objective and unbiased perspective on the history of technology as seen from the periphery, be made available to readers outside Poland. The history of technology would be well served if this latest Orlowski work were to be translated into English, joining many of his other books already translated into English and other languages such as Swedish, Hungarian and Georgian.

Slawomir Lotysz, University of Zielona Gora, Poland

Ruud Filarski (in cooperation with Gijs Mom). *Shaping Transport Policy.* The Hague: Sdu Uitgevers, 2011. Pp. 267. €41.50.

This book stems from a project commissioned by the Rijkswaterstat, the Dutch agency responsible for the country's major road and waterway infrastructure, to develop a comparative analysis of the historical development of various transportation systems of different countries. *Shaping Transport Policy*, with its telling subtitle, 'Two centuries of struggle between the public and private sector – a comparative perspective', concentrates on seven countries: the Netherlands, Belgium, Switzerland, France, Germany, Great Britain and the United States.

Separate chapters concentrate on railways (1830–1910), tramways/streetcars (1870–1920), buses (1920–1940), freight trucks (1910–2010), the automobile and national road systems (1888–1940) and the era of a mass motorization (1945–2008). With an extensive bibliography and case studies shared with over forty transportation historians, coupled with three workshops, the findings were vetted with scholars, with the results proof of the benefit of scholarly collaboration.

Using succinct prose, the book defines the issues associated with each transport mode analyzed within the political and regulatory framework of each country. Ruud Filarski narrowed the study to focus on principal 'dilemmas' governments encountered in shaping their transportation policies. These thematic issues can be summarized by the following: Should national governments be responsible for organizing a coherent rail or road network, or should this be left to regional or local authorities, or should free market forces be in control? Should government intervene in the marketplace to promote competition among transportation modes? What is the government's responsibility to the private motorist and how should it respond to issues of safety, environmental impacts, traffic congestion, and road building? While the issues were essentially the same across borders among the various modes, the responses varied, and the decisions implemented had long-term consequences for each country.

Regardless of the transport mode, in comparison to European countries, deployment of each public transport mode in the United States was typically characterized by a for-profit system which saw political corruption and outright bribery, the issuance of watered-down stock, and a concomitant need for companies to seek high profit returns to investors, which culminated in poor system maintenance and greater tendencies to compromise public and worker safety as a cost saving measure. On the other hand, the free market of the American system often allowed for quicker implementation of solutions compared to Europe's protected government-controlled systems, including the tendency to abandon rail lines when they proved unprofitable and a policy to allow for trucks to substitute for rail for faster freight delivery, thereby fostering further technological advancements to the benefit both to industry and consumer.

While technology is not a major theme by which the book is organized, the author reveals how evolving technology – for example, in the transition from horse-car powered to electric trams – played out differently among the countries studied, how society in this instance demanded technological innovation and how environmental considerations will likely drive future technological changes.

Interestingly, too, Filarski contends that in 1900, all governments looked backwards to their role in overseeing the development and regulation of railroad and tramway systems rather than forward to the emergence of automobiles, and thus each was unprepared for the defining mode of the twentieth century, which resulted in opportunities missed.

From a production standpoint, the book is nicely illustrated with both colour and black and white photographs throughout, and many tables integrate well with the narrative account. Abundant footnotes and bibliography attest to the enormous amount of material that the author tapped.

It is the contention of *Shaping Transport Policy* that many of the past issues surrounding transportation policy continue to hold relevancy today. To his credit, while implying the analysis of past policies may contribute better insight into present day policies, Filarski does not go so far as to offer lessons or predict future outcomes based on the historical inquiry he presents. That said, however, this book should profit anyone who wants to possess a basic understanding of the results of past government transport policies.

Gregory King, Transportation and Cultural Resources Historian,
San Francisco, California, USA

Robert C. Post, *Urban Mass Transit: The Life Story of a Technology*. Baltimore: Johns Hopkins University Press, 2010. Pp. 200. $27.

Few technologies have been the source of as much nostalgia, hostility and misinformation as the trolley. For decades, trolleys, or streetcars as they are also called, were the backbone of public transit systems throughout the United States. From the end of the 19th century to the first two decades of the 20th, they were indispensable facilitators of rapid urban growth, and as such they were the source of great fortunes for their owners. But in the succeeding decades they fell into decrepitude as the automobile displaced riders and diminished revenues. By the 1960s they were mostly gone, leaving in their wake the warm feelings of a few enthusiasts, the less pleasant memories of ordinary riders, and a widely believed conspiracy theory to explain their demise.

In *Urban Mass Transit*, Robert Post renders a concise yet comprehensive history of public transit in the United States. The story begins with horse-drawn omnibuses that were succeeded by vehicles that rode on rails but were still drawn by horses. In the 1870s, steam power began to substitute for horsepower, most successfully with vehicles that were pulled by cables powered by stationary steam engines. Although they still exist as one of San Francisco's many charms, cable cars had a number of drawbacks. A much better approach used onboard electric motors supplied with current drawn from overhead wires. Although Frank Sprague is often given credit for the invention of the electric trolley, Post describes several precursors while cogently explaining why Sprague succeeded where others had failed.

By the 1930s mass motorization along with misguided public policies resulted in the slow decay of many trolley systems and their replacement by buses powered by internal combustion engines. After a brief spurt in ridership during World War II, public transit continued to decline, as private automobiles solidified their position as the favoured mode of urban transit. Yet by the 1980s mounting problems with congestion, pollution and rising fuel prices put public transit in a new light. Trolley lines, re-christened as light-rail systems, along with improved buses, generated a renaissance in urban public transit.

Although the focus of *Urban Mass Transit* is the historical development of trolley and bus systems, one chapter is devoted to subways and elevated railways. As with the other chapters, it succinctly narrates the key phases in the development of the subway and 'the El' while at the same time outlining the contexts that shaped them. The provision of these contexts is one of the book's virtues. By delineating the political, economic and social forces that shaped urban mass transit, Post clearly shows that the lingering death of the nation's trolley systems during the middle years of the 20th century cannot be explained by The Urban Legend That Will Not Die, their alleged destruction by a consortium of General Motors, Firestone Tire & Rubber, and Standard Oil of California.

Well-illustrated and engagingly written, *Urban Mass Transit* is an excellent brief introduction to the history of public transportation in the United States. Although much of the book covers familiar territory, historians of technology, urban sociologists, and trolley aficionados will all make new discoveries while reading it.

Rudi Volti, Claremont, California, USA

Timo Myllyntaus, ed. *Thinking through the Environment. Green Approaches to Global History*. Cambridge: The White Horse Press, 2011. Pp. 296. $90.

Thinking through the Environment is a collection of articles based on papers presented at the European Society for Environmental History meeting in

Turku, Finland, in 2011. Structurally the book is divided into five parts offering a diversity of cases that present a variety of methodological perspectives on global environmental history. The aim of this collection is to highlight current research that elaborates new ways of comprehending interactions with people and the environment across time and space.

Part one, 'Approaching the Environment of the Past', offers two distinct methodologies. First, Fiona Watson explores one of the most challenging aspects of environmental history, which is its interdisciplinary nature. At the core of her article is the statement that interdisciplinarity understood as collaboration is a way to bridge the gap between science and the humanities. In order to develop the historians' explanatory power, researchers need first of all be sure of 'what our own evidence is telling us on our own disciplinary terms'. At least, this is the author's experience from studies of the interaction between humans and landscape. Second, Donald Worster focuses on the role of individuals in past environmental change. His approach is complementary to large-scale historical explanations, and particularly stresses that environmental history is theoretically open and indeterminate. A third and less specific contribution to the methodological toolbox, that this book 'ultimately assembles', is Frank Uekötter's essay 'The Nazis and the Environment'. It examines the relations between Nazi rule and the German conservation movement before World War II. While a highly interesting topic, the author's attempt to methodologically refine the Nazi/environment lacks specificity.

Sections two, three, four and five have in common, although in different ways, landscape, water and indigenous knowledge, which are all prominent topics in environmental historiography. Each section contributes to discussions of alternative interpretations of people's relationship with nature, bringing forward concepts such as environmental literacy and memoryscape. Each also attempts to critically discuss the complexity of reshaping and restoring lost environments. Of particular relevance to the book's ambition of elaborating methodological approaches, is Libby Robin's innovative chapter about using art to understand Australian lands and lifestyle, an approach that allows collaboration between science and the humanities, as suggested by Watson in her contribution. Robin takes spatial aspects of environmental history into consideration, stressing that knowledge is meaningless without its specific context; i.e., country and knowledge are inseparable, something often forgotten in western science.

Overall the book takes an important step towards discussing different understandings of the human-environment relationship, and it offers a number of approaches essential to the further development of global environmental history. A last critical comment, however, concerns the choice of very traditional research fields. Most welcome in a book about methodological approaches would have been a contribution about how humans modify and change the environment through consumption and unsustainable lifestyles.

Hilde Ibsen, Karlstad, Sweden

Johan Schot, Harry Lintsen and Arie Rip, eds. *Technology and the Making of the Netherlands: The Age of Contested Modernization, 1890–1970.* Zutphen, The Netherlands, and Cambridge, MA: Walburg Pers and The MIT Press, 2010. Pp. 635. $45.00/£26.95.

This is an extraordinarily ambitious book that culminates an equally ambitious series, the seven-volume *Techniek in Nederland in de Twintigste Eeuw* (*Technology in The Netherlands in the Twentieth Century*). The first six volumes deal with specific subjects, such as water management, mining, the chemical industry and construction. This, the seventh volume, serves to integrate and further analyze these subjects, and, translated into English, brings major themes and conclusions to a much larger audience. It should be added that the series itself continues an earlier multi-volume effort dealing with nineteenth-century Dutch technology. The entire enterprise required close collaboration, substantial financial support and extensive research. Participants and supporters alike should be gratified by the result.

Johan Schot contributed to three of the ten chapters in volume seven. Twelve other historians also contributed to the book, either as sole authors or co-authors of various chapters. The easiest way of understanding the volume's scope is by listing chapter titles: (1) Inventing the Power of Modernization; (2) Networked Nation: Infrastructure Integration of the Netherlands; (3) Site-specific Innovation: The Design of Kitchens, Offices, Airports, and Cities; (4) Scale Increase and Its Dynamic; (5) The Rise of a Knowledge Society; (6) Technology and the Colonial Past; (7) Technology as Politics: Engineers and the Design of Dutch Society; (8) Technology, Productivity, and Welfare; (9) Technology, Industrialization, and the Contested Modernization of the Netherlands; and (10) Between Sensation and Restriction: The Emergence of a Technological Consumer Culture. All the chapters are well-researched and footnoted, insightful and comprehensive.

The chapter titles suggest the obvious: to use an admittedly dated lexicon, this is unabashedly externalist history. Sometimes technology seems to drive events; at other times technology seems almost an after-thought, deeply embedded in political and, especially, economic context. Few details are provided about specific contributions to Dutch technology; no minute descriptions emerge about the evolution of machines or the actual construction of infrastructure. Instead, readers will find illuminating and detailed examinations of, for example, the private and public constituencies that mould technological development, of contested technological plans and the establishment of technological institutions and knowledge networks, of debates over standards and regulations, and of the technological impact on the Dutch economy and vice-versa. Earlier volumes go into more detail, and this volume is intended, as the editors write, 'to provide a twentieth-century history of technology in the Netherlands, and a contemporary history of the Netherlands through the lens of technology' (p. 8). The emphasis is on a modernization process that encompasses cooperation and competition, tension and harmony.

As the sub-title of the volume suggests, the authors chose as their principal organizing theme the idea of 'contested modernization'. Johan Schot and Arie Rip argue in chapter one that the debate centred on 'mass production, mass consumption, and economies of scale' (p. 41). In essence, how much of each was a good thing, and how much could lead to undesirable social, political and environmental consequences? The argument has not been completely settled in The Netherlands or, for that matter, in most other nations. In fact, this emphasis on modernization may serve as a useful methodological and organizational tool, but in itself it does not do much to differentiate the role of technology in The Netherlands from that of most other Western nations. Irene Cieraad's chapter, 'Between Sensation and Restriction', helpfully analyzes some of the ways in which Dutch culture and technology modified one another, but in general the chapter authors sacrifice a discussion of what of the past remains in the present to an examination of how and why contested modernization led to specific results.

The authors show a fine grasp of American technological history and refer to it more often than to, say, German or French technological evolution. A convincing case is made that much Dutch twentieth-century industrialization used a template imported from the United States, but did this result from a unique Dutch fascination with America or did other European countries share this enthusiasm? Other questions will occur to non-Dutch historians. In what ways did The Netherlands' relatively small size affect its technological development? Given the decisive influence of The Netherlands' six largest industries (Royal Dutch/Shell, Unilever, Philips, DSM, Akzo and Hoogovens) on the Dutch economy, to what extent did those companies dominate Dutch politics? The book contains several illuminating vignettes relating to the impact of the Dutch 'pillarized' social system (i.e., Catholic, Protestant and Socialist ideological blocs) on technological development, but this subject probably deserves more analysis.

This volume has so much to commend it that it may seem churlish to point out some editorial issues, but I do so in the hope that other volumes may be translated. First, the translation, obviously a challenge, could have been improved had a native English-speaking editor done a thorough, professional, review of the entire manuscript. The examination could – or should – have caught numerous misspelled words, grammatical mistakes and, in a few cases, awkward sentence construction. One particularly unfortunate mistake was to misspell the names of the ecologists (and brothers) Eugene and Howard Odum (not 'Ogdum'). Second, an English summary of the contents of the first six volumes, or at least a list of chapter headings, would have been very useful.

Technology and the Making of the Netherlands synthesizes a great deal of recent Dutch technological history in an insightful, indeed path-breaking, manner. Not only do the authors display impressive knowledge, but the carefully chosen and well-captioned illustrations and photographs skilfully complement and elucidate the narrative. This is a scholarly enterprise to praise and emulate.

Martin Reuss, Palmyra, Virginia, USA

Etienne Benson. *Wired Wilderness: Technologies of Tracking and the Making of Modern Wildlife*. Baltimore: The Johns Hopkins University Press, 2010. Pp. 264. $55.

The tracking of wild animals by radio and satellite technologies is a fundamental tool in wildlife management and research today, and the tranquillizer dart-gun and telemetry animal collar are give-away signs of wildlife biologists. These technologies have become such internal and self-evident components of wildlife biology that it is easily forgotten that they were first adopted from space age technology by funding, in part, from cold war era military institutions. As Etienne Benson shows in his new book *Wired Wilderness*, it was the Sputnik launches in the fall of 1957 that triggered the first concrete research programme concerning the use of radio telemetry in studying wild animals. The American ornithologist who initiated the programme still remembers realizing that '[t]he Russians put the dog Sputniks up there, and they're having telemetered back to the Earth both physiological and ecological data on the capsule, and physiological … data on the dogs … We haven't even done that out the window here' (p. 6).

Etienne Benson traces in impressive detail the history of tracking technologies from the time of the Sputnik launches to the 1980s when they became widespread tools of wildlife management and research. He draws in particular on the subfields of environmental history and the history of science and technology in following four more or less distinctive groups of wildlife biologists in their early efforts to develop and use tracking technologies. Benson sets out to tell the messy story of the origin and early development of the technologies, and his extensive use of archival material and interviews reveals a plenitude of personal, political, economic, institutional and other influences, in addition to the technical improvements that shaped the technologies. Among the highlights of the book is the debate in the 1960s and 1970s over the appropriateness of attaching radio collars and tags to bears in the national parks of Yellowstone and Mount McKinley, which reveals divergent understandings of wilderness among its enthusiasts and defenders.

Though much of the quality of this book is grounded in its descriptive narrative, readers not familiar with the inner workings of American nature management and research funding might at times feel overwhelmed in tracking the great number of persons, places and institutions involved. Further, the book would gain from incorporating more analytical perspectives in tackling the main issues. For example, research and management of wildlife was transformed as tracking technologies came to define its methods and practices. Although this is shown in Benson's narrative, some explicit discussion concerning the effects of the technologies on how we understand and manage wildlife would clarify and enlighten his story. This also would make for a discussion on how tracking technologies have transformed wildlife itself through changes in management and research, something that might be expected since the title promises to treat 'the making of modern wildlife'. In spite of these minor objections, however, Benson's *Wired Wilderness* is an empirically well-grounded study of a technology so defining of an important field of nature management that its publication should be of interest to many people.

Håkon B. Stokland, Trondheim, Norway

Gordon M. Winder. *The American Reaper: Harvesting Networks and Technology, 1830–1910*. Surrey: Ashgate Publishing Limited, 2012. Pp. 257. $119.95.

The standard narrative for the development of agricultural technologies calls on the history of small, localized companies that eventually went bankrupt or were subsumed into a handful of massive corporations that dominated the field. Gordon M. Winder's new work, *The American Reaper: Harvesting Networks and Technology, 1830–1910*, places the corporate model of the manufacture of reapers and mowers within the context of American business development, chronicling the important relationship between agriculture and the rise of American industry in the global market place. Much more than simply describing the history of grass-harvesting technologies, Winder's book delves deeply into the interconnectedness of the various manufacturing entities in the United States, as well as abroad.

The American Reaper traces the development of the harvester industry from localized manufacturers through the centralization of technological centres with better access to the means to mass produce and distribute products nationally and internationally. From an early point, local manufacturers contracted other firms for the right to use technological aspects and designs, leading to the eventual rise of larger corporations that centralized production and consumed smaller competitors. International business development in fact forms the heart of the second half of the book. Winder effectively uses the international growth of reaper manufacturing and distribution as an example of the rise of global business networks during the latter decades of the nineteenth century. McCormick takes a central role in this discussion, but Winder also utilizes the correspondence of New York manufacturer D. S. Morgan to illustrate the issues of transnational business management during the late 1860s, a decade before the triumphal European exhibitions and displays put on by the McCormick Company.

Winder's book is not for the casual scholar of history, nor is it for someone who seeks information about the field use and agricultural impact of these new technologies. Rather, this deftly researched and densely written work is better suited for advanced legal and economic historians interested in the growth of national and international markets and the industrial development of the latter nineteenth and early twentieth centuries. The author presents his audience with a grand view of the growth and development of a vital international industry, granting an important new scope to the dual rise of American industrial and agricultural prowess on the world stage.

Robert C. Welch, Macomb, Illinois, USA

Richard Vahrenkamp. *The German Autobahn 1920–1945. Hafraba Visions and Mega Projects.* Köln: Josef Eul Verlag, 2010, Pp. xi + 266.

Richard Vahrenkamp's study analyzes the planning, development and construction of the German autobahn between 1920 and 1945. Nowadays, motorways are commonplace and taken for granted. The network of motorways enables private citizens to commute or to travel long distance. It is also a backbone of long-distance cargo traffic. But back in the 1920s, the autobahn was simply an idea, a grand vision. Eventually the ideas on paper were put into practice in a time-consuming, capital-intensive and risky process.

The German Autobahn traces this process and thereby is able to reveal how modern expressways were constructed in Germany, as well as elsewhere in Europe during the interwar and World War II periods. It also reviews the various forerunner projects, the role of the HaFraBa association and of local actors in Kassel, Frankfurt and Darmstadt. The HaFraBa association (the Association for the Planning of the Hanseatic Cities–Frankfurt–Basel Motorway), for instance, was crucial in the planning of the autobahn during the interwar period. Its grand vision was the construction of a motorway that linked the Hanseatic port cities in northern Germany (Hamburg, Lubeck and Bremen) with the economic regions surrounding Frankfurt and Switzerland (Basel). In addition, Vahrenkamp traces the Italian roots of the expressway concept and how it was adopted and modified in the Weimar Republic and later under National Socialist rule. One highlight of this study is the analysis of the first section of the autobahn between Cologne and Bonn, which was opened by the Konrad Adenauer in 1932. After the National Socialist seizure of power, local projects were centralized leading to the 'The Autobahn Mega Project in the Nazi Era'. Finally, Vahrenkamp also analyzes the traffic density on the motorways as well as the experience of driving on the autobahn.

Vahrenkamp's study addresses a variety of topics and portrays numerous fascinating aspects that range from the emergence of the autobahn idea to the planning and construction of motorways. Despite the achievement of writing such an insightful study, I felt that most chapters seemed, to a certain degree, unconnected and, therefore, could have been published as separate articles. While Vahrenkamp's argument in general is solid, the chapters could have been more linked together. To be fair, I note that Vahrenkamp partially answers this criticism by revealing convincingly, for example, the continuity of traffic planning from the Weimar Republic, through National Socialist Germany and into the Federal Republic of Germany. Overall, this study should be of interest for anyone interested in the history of traffic in the Weimar Republic and National Socialist Germany.

Christopher Neumaier, Potsdam, Germany

Silva Suárez, Manuel, ed. *Técnica e Ingeniería en España: El Siglo de las Luces. De la ingeniería a la nueva navegación*, Vol. II. Zaragoza: Institución 'Fernando el Católico', Prensas Universitarias de Zaragoza; Madrid: Real Academia de Ingeniería, 2005. Pp. 624.

______________. *Técnica e Ingeniería en España: El Siglo de las Luces. De la industria al ámbito agroforestal*, Vol. III. Zaragoza: Institución 'Fernando el

Católico', Prensas Universitarias de Zaragoza; Madrid: Real Academia de Ingeniería, 2005. Pp. 576.

As part of the very ambitious multi-volume publication *Técnica e Ingeniería en España* promoted and directed by Manuel Silva Suárez, volumes II and III are devoted to the Spanish Enlightenment. Professor Silva started publishing this great work in 2003, with the first volume dedicated to the Renaissance.*

These two volumes form a unitary work that addresses the connections between technology and society in Spain during the Enlightenment from a polyhedral perspective. It is, in fact, a collective work carried out by recognized and prominent specialists. Although there are a few contributions by French and Italian scholars, most authors are historians of science and technology from Spanish universities.

With the subtitle 'From engineering to new navigation', volume II focuses largely on the technical corps of the State, its institutionalization, expertize and achievements. An extensive introduction to this volume, written by Manuel Silva, provides an overview that shows the consistency of the twelve chapters within. These chapters are structured in three parts: the first part deals with general issues that provide an overall framework (chapters 1–6); the second is dedicated to the civil and military public works (chapters 7–10); and the last part deals with the role of the navy and navigation (chapters 11 and 12).

Víctor Navarro Brotons opens the first part with a chapter entitled 'The renewal of scientific activity in seventeenth-century Spain and physico-mathematics subjects'. Navarro discusses the transmission and assimilation of physical and mathematical sciences developed by the 'novatores' at a time of decline. In Chapter 2, Siro Villas reflects on the connections between science, technology and power, showing the policy instruments used for modernizing the scientific and technical level of the kingdom. From Paris, Irina Gouzevitch and Hélène Verin, provide some fresh insights into the situation of European engineering in the third chapter. They analyze the institutionalization of engineering as a state corps and pose interesting considerations on the construction of the identity of the engineer in the eighteenth-century. In the next chapter, Manuel Silva tackles the institutionalization of engineering in Spain and related technical professions. He analyzes the creation of the engineering corps, subsequent jurisdictional conflicts and the differences among the regulated training mechanisms thereof. The first part closes with a chapter written by Pedro Álvarez de Miranda, which explores the evolution of technical language, and another by Arturo

* Other volumes of this work are scheduled for review in *ICON*.

Ansón, which studies the evolution and diversity of architectural language, with special regard to the conflict of jurisdiction between military engineers and architects.

The renowned historian Horacio Capel launches the second part of Volume II, which is dedicated to public works. He focuses on the extensive work done by the Army Corps of Engineers on defence, control, management and territorial development, showing the relevance of the contributions of military engineers to the urban morphology of cities in Spain and America. The involvement of engineers in the setting up of infrastructures (e.g., roads, channels and harbours) and in building design (e.g., hospitals, houses and palaces) is evident. The next chapter, written by Juan José Arenas, focuses on civil engineering and public works: roads, channels, aqueducts, locks, dams and harbours. Arenas stresses the coexistence of a rational attempt to structure the territory with a sort of operational disorder, especially in the case of the channels. In Chapter 9, Guillermo Pérez Sarrión deals with hydraulic works by Arenas by analyzing the policy used in the construction of three major waterworks channels. He points out that the interest in promoting commercial pathways and irrigation works also entailed mistakes in planning and execution. Fernando Cobos closes this second part with a chapter devoted to the art of Spanish fortification in the seventeenth and eighteenth centuries, which links this chapter with his contribution to the initial Renaissance volume Silva's *Técnica e Ingeniería*.

Finally, in the third part of volume II, devoted to the Navy, Manuel Sellés describes the situation of the Spanish Navy in the eighteenth century (Chapter 11). Sellés discusses the importance of the establishment of the School of Marine Guards in Cadiz, along with the gradual renewal of nautical training. He also highlights the efforts to transform and modernize the Navy, the improvements in instrumentation and mapping, the assimilation of modern methods to determine the longitude and the promotion of hydrographic expeditions to open new routes. The last chapter (Chapter 12), by Julián Simón, deals with the complexity of shipbuilding and how engineering allowed the passage from an artisan and empirical conception of a ship to another one based on scientific knowledge. In this sense, Jorge Juan epitomizes this transition in the Spanish case.

Volume III, subtitled 'From industry to agroforestry field', contains ten chapters. According to his introduction, Silva suggests that this volume can also be structured into three parts. The first deals with issues of industry, mining and machinery (chapters 1–5); the second focuses on the training of artisans, the renewal or innovation programmes in the country and the diffusion of technology among professional groups (Chapters 6–8); and the third studies the field of agro-forestry (chapters 9 and 10).

In the opening of the volume, Manuel Silva reflects on the languages of the new technique (language and neologisms, technical drawing and mathematics). Juan Helguera's opening chapter begins with the introduction of new techniques in eighteenth-century Spain. His is a study about technology transfer through the policy of hiring foreign technicians and the practice of industrial espionage. Helguera illustrates this with the project to introduce the steam engine to the mines of Almadén. In Chapter 2, Aurora Rabanal offers a case study on the typology of industrial architecture and the new type of construction that the factory represents. She analyzes the most important buildings of the Bourbon monarchy, namely, the royal manufactures, which she classifies into four areas: textiles, luxury goods, metallurgy and state monopolies (including tobacco, liqueur and saltpetre). Juan Ignacio Cuadrado and Marco Ceccarelli show an overview of innovation in the design of machines and classification of mechanisms (Chapter 3). They emphasize the impact of the work of Lanz and Betancourt, *Essai sur la composition des machines*, and the new Theory of Machines. They also analyze the contributions of Betancourt to the problem of dimensions of the articulated quadrilateral in Watt's mechanism to achieve the rectilinear guidance. In the next chapter, Antoni Roca examines the role of scientific and technical training in Barcelona, a city with no university at the time. Roca emphasizes the role of the Board of Commerce of Barcelona, which established a collection of free technical schools. Two of these are studied in depth in the chapter: the school of Chemistry (1805), directed by Francesc Carbonell, and the school of Mechanics (1808), promoted and directed by Francesc Santponç. The former enhanced winemaking and contributed to the improvement of dyeing substances, which turned out to be fundamental in the Catalan calico industry. The latter appeared as a consequence of the construction of the first double-acting steam engine in Spain, designed by Santponç. This first section ends with a study by Julio Sánchez Gómez of mining and metallurgy in Spain and Spanish territories in America during the Enlightenment (Chapter 5). Gómez shows major technical innovations introduced in the mining-metallurgical field, such as the use of steam to bail water, the transportation of ore wagons on rails, the protection of lighting fixtures, the improvement of planimetry underground and the use of gunpowder. He studies a number of mines, renewal attempts, accidents, faulty approaches and difficulties encountered in Spanish mining.

The second part of Volume III begins with Chapter 6, written by Siro Villas and devoted to guilds, that is, artisan corporations. Villas addresses social and economic patterns developed by the guilds, as well as the differences between the guilds in the Crown of Aragon and those in Castile. He examines their history until their first administrative extinction in 1813. In Spain, the guilds were restored during the absolutist period but were definitively abolished in 1836, three years after the death of Ferdinand VII. In the next chapter, Jose Francisco Casals and Antonio Manuel Moral study the *Sociedades Económicas de Amigos del País* (Economic Societies of Friends of the Country). Taking the *Sociedad Bascongada* (Bascongada Society), founded in 1764, as a model, the state fostered the creation of similar societies throughout the Spanish territory. The aim was the development of industry, agriculture and trade, but it was met with unequal success. The authors pay special attention to the *Sociedad Matritense* and examine the attempts to structure an educational system during the reign of Carlos III. In Chapter 8, Julio Sánchez Gómez focuses on technical publications for professional communities. He compiled and analyzed Spanish publications of Enlightenment related to agriculture, livestock, fisheries, mining, metallurgy industry, machinery, construction and public works. Among them, those related to agriculture and textiles were notable.

The last part of volume III is carried out by Jordi Cartañá and Vicente Casals. While the former analyzes the agronomy in eighteenth-century Spain (Chapter 9), the latter studies scientific and technical innovations with regard to forestry and promotion of mountains (Chapter 10). Cartañá focuses his research on technological change and the establishment of institutions for the promotion of agriculture in Spain, in keeping with the European agricultural revolution. His work delves into the mechanisms for disseminating and teaching new agronomic ideas (publications, botanical gardens, schools, introduction of new crops, modern farming methods, proposals for mechanization, etc.) and into the technical contributions of Spanish agronomists. Meanwhile, Casals focuses on the policy for forests and plantations, based on the Bourbon programme of reforms and its subsequent legislative impact. In addition, he shows the French influence on Spanish forestry (especially of the work of Duhamel du Monceau), and he gives a full account of the slow introduction of silviculture, based on the science of botany, which replaced the 'arboriculture', based on peasant traditional practices.

It is unfortunate that the two volumes do not include indices other than one for illustrations. However, at the end of Volume III, there is a remarkable section on 'Biographical Notes'. The reader finds here the biographies of 179 important figures that appear throughout both volumes. Furthermore, it is worth stressing the rich graphical content of both volumes, which contain many colour illustrations. This magnificent iconography proves to be very useful since it adds, in many cases, valuable information to the work.

In short, these two volumes comprise a documented, rigorous and collective work that presents a new approach to the history of technology and engineering in the Spanish Enlightenment. They include chapters on topics that have been little studied before, thus making a very innovative work. In addition, the fact that these volumes refer to the Spanish context and its American territories makes them unique. Finally, these volumes are quite homogeneous despite being written by 23 different specialists. This is clearly the result of the thoroughness and permanent supervision of the director-editor. Through carefully thought-out presentations, Manuel Silva manages to show the interconnection of the different parts and to articulate them into a consistent unit.

To sum up, these two volumes have the necessary ingredients to become an indispensable reference work for historians of Enlightenment technology. The volumes not only have an undeniable interest for historians of technology, but it will also be appreciated by engineers and a large segment of the public interested in connections between technology and society. The publication of this book is good news for the history of technology and engineering.

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