TICCIH2000

THE INTERNATIONAL COMMITTEE FOR THE CONSERVATION OF THE INDUSTRIAL HERITAGE MILLENNIUM CONGRESS

TRANSACTIONS

From Industrial Revolution to Consumer Revolution:
international perspectives on the archaeology of industrialisation

De la Révolution industrielle à la Revolution de la Consommation :
perspectives internationales sur l'archéologie de l'industrialisation

edited by Marilyn Palmer and Peter Neaverson

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Editors of *Industrial Archaeology Review*

On behalf of

TICCIH2000

The International Committee for the Conservation of the Industrial Heritage Millennium Congress

THE ASSOCIATION
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INDUSTRIAL ARCHAEOLOGY
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TICCIH2000 CONGRESS TRANSACTIONS

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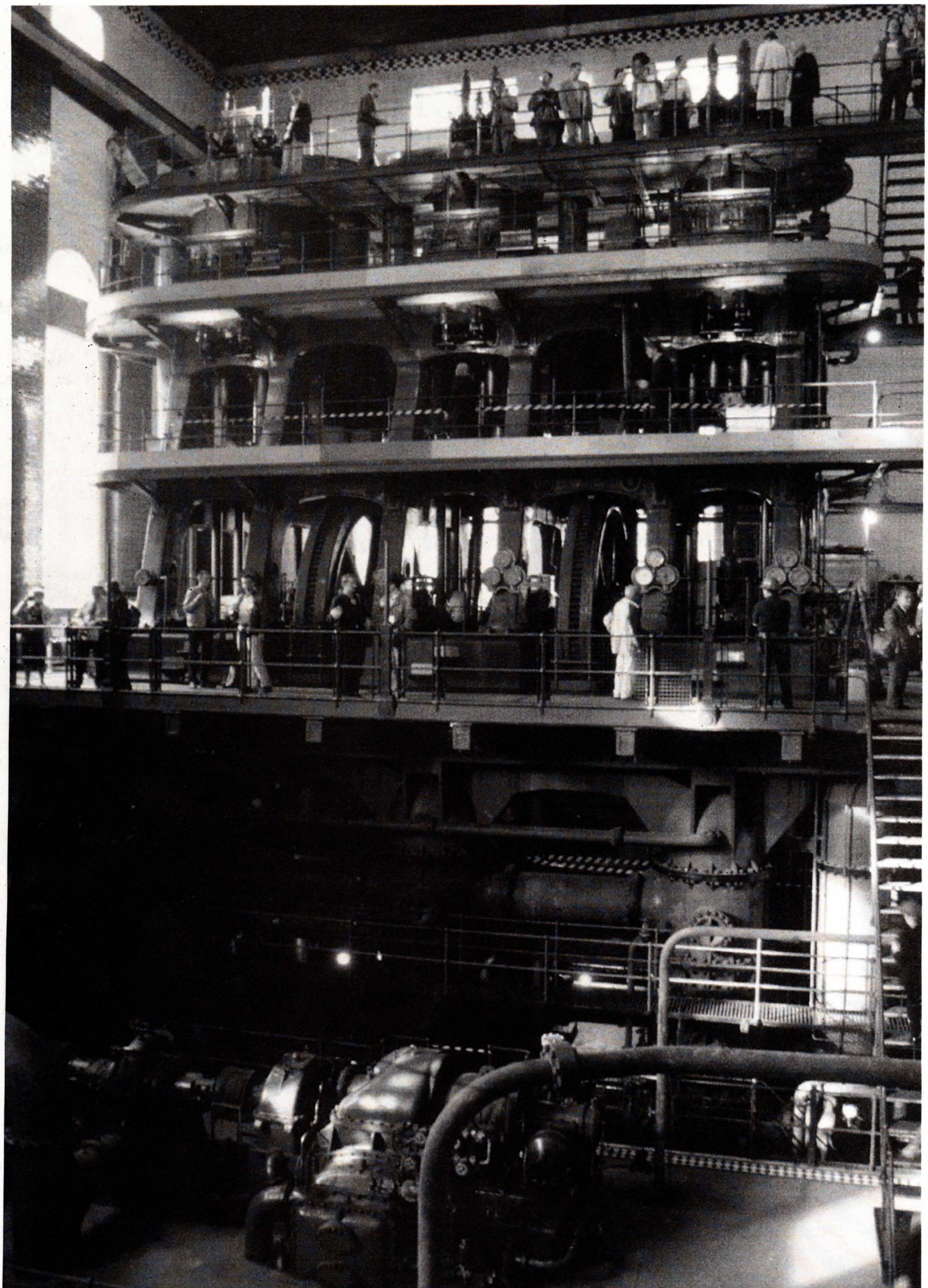

TICCIH2000 Congress delegates aboard one of the two triple expansion steam engines at the Kempton Park Pumping Station of the former Metropolitan Water Board. They were built by Worthington Simpson of Newark (Nottinghamshire), commissioned in 1928 and were in use until 1980. The Kempton Great Engines Trust was formed in 1996 and has now nearly completed the restoration of one engine to working order (Photo: Marilyn Palmer).

Foreword and Acknowledgements

This publication brings together the papers given in the plenary sessions of the TICCIH2000 Congress held in London in August–September 2000. There were two plenary sessions, each including six papers and entitled respectively, 'The Industrial Revolution of the Eighteenth Century' and 'Mass Production and Consumerism, 1850–2000'. The plenary papers were selected from over 100 abstracts of papers received by members of the Academic Panel which is listed on the inside front cover and were given in Imperial College, London, on 31 August and 1 September 2000. They have since been revised for publication and one additional workshop paper, that of Michael Mende, added. The Editors have provided an Introduction which draws together some of the themes of these papers.

The languages of the Congress were English and French. In this publication, English and French summaries are included, but all papers apart from that of J.-F. Belhoste are presented in English. The Editors are extremely grateful to Paul Smith of the Inventaire Général in Paris for providing the French summaries.

The publication of these papers is dedicated to Dr Michael Stratton, an outstanding British industrial historian and archaeologist who died in April 1999. Michael had long been a regular delegate to TICCIH conferences, and an appreciation of his life and work has been provided by Dr Barrie Trinder, to whom the Editors are grateful not only for this but also for his Chairmanship of the Academic Panel of TICCIH2000 and his help and advice in editing these papers.

The Editors acknowledge financial subventions towards the cost of this publication from the Association for Industrial Archaeology, the British Academy and English Heritage.

Marilyn Palmer
Peter Neaverson
University of Leicester

Michael Stratton: A Memoir

Barrie Trinder

The loss of Michael Stratton was much remarked at TICCIH2000 in London. He was only 45 when he died in April 1999 but his invigorating presence had been part of TICCIH for as long as all but the most seasoned delegates could remember. He would have contributed much more to the conservation of the industrial heritage both in England and internationally. The Steering Committee of TICCIH2000, responding to calls at the conference to acknowledge Michael's achievements, resolved to dedicate this volume of proceedings to his memory. This memoir attempts to evaluate his contribution to scholarship, his advocacy of the value of conserving artefacts, buildings and landscapes as a way of understanding our past. In his opening address to the conference, Sir Neil Cossons reminded delegates of the need constantly to explain to a wide public the rationale for conserving the industrial heritage. Michael Stratton had done this for more than 20 years. He stood in a long tradition of English scholars and artists who have changed our ways of looking at our inheritance from the past.

Michael was born and went to school at Barnet in North London near to the Great Northern Railway main line, and developed a lifelong love of railways. One of his strongest childhood memories from the 1950s was the majestic sound of the Canadian whistle that had been fitted to Sir Nigel Gresley's streamlined pacific locomotive No. 60010 *Dominion of Canada* as it made its way into King's Cross station. He studied Geography at the University of Durham from 1972–75, after which he did Master's degrees in Town Planning at the University of Sheffield and in Victorian Studies at the University of Leicester. One of his teachers at Leicester was Professor Tony Sutcliffe who suggested in 1978 that he might apply for one of several doctoral studentships at the University of Aston, which were to be based at the Ironbridge Gorge Museum. His application was successful and under the supervision of Professor Jennifer Tann he began a thesis on the terracotta industry, for which he was awarded the degree of Doctor of Philosophy in 1983. In 1980 he was appointed to a temporary lectureship at the University of Birmingham with a brief to develop postgraduate teaching at what was then called the Institute of Industrial Archaeology (it was re-named the Ironbridge Institute in 1985) based at the Ironbridge Gorge Museum. I was appointed to lecture part-time at the Institute, combining it with other work in Shropshire, and met Michael in the summer of 1980 when we first considered a strategy for developing a programme of teaching and research.

One of Michael's main achievements was the postgraduate programme in Industrial Archaeology which was developed at the Institute from 1982, but which, sadly, was discontinued from 1996. The programme provided training for a generation of industrial archaeologists, many of whom now occupy responsible positions in conservation and recording agencies, national and local government departments, museums and archaeological consultancies, not only in Britain but in Australia, Canada, Denmark, Germany, Greece, Japan, the Netherlands, New Zealand, South Africa, Spain and the United States. Michael was also much involved in the planning of the Institute's postgraduate programme in Heritage Management, the first of many

Michael Stratton at Friedrichshafen en route to TICCIH1987.

to be established at British universities, which was launched in 1985. He was designated Director of the Ironbridge Institute in 1989.

Michael Stratton had subtle diplomatic skills. He succeeded in establishing respect for the Ironbridge Institute and for the discipline of Industrial Archaeology in the face of hostility within the University, a task in which he was sustained by the support of the late Professor J.R. Harris (president of TICCIH, 1978–84). He negotiated funding from the Wolfson Trust for the extension of the Institute's accommodation in the Long Warehouse at Coalbrookdale, and from the Nuffield Foundation for a study of the archaeology of the Ironbridge Gorge, which added to the Institute staff two talented graduate researchers. In 1989 Michael married Annabel Pears, a former student. By 1994 they had a baby son, and changes within the University of Birmingham seemed to threaten the future of the Ironbridge Institute. On New Year's Day 1995 he took up a post at the University of York, as lecturer in the Institute of Advanced Architectural Studies. With his experience both of industrial archaeology and of building conservation he did much to facilitate the subsequent incorporation of the Institute into the Department of Archaeology. He was appointed Senior Lecturer in Conservation Studies in the department in the summer of 1998.

Michael's other principal achievement at Ironbridge was to involve the Institute in consultancy projects, some of them concerned with interpretation or conservation policy, and some with the academic evaluation of particular structures. The first, in 1986, was concerned with the future role of a late 17th-century transit shed in the Riverside area of Exeter, a building which was subsequently adapted, as the Institute report had recommended, into a visitor centre, providing guidance both for those who wished to explore the ancient port, and for those intending to ascend to the city centre and the cathedral. Michael showed much skill in negotiating a way through the city's tortuous conservation politics, an experience put to good use a few years later when the Institute was concerned with the seemingly intractable problem of the future of the Saltford Brass Mill near Bristol, where, perhaps as a result of the report, the roof was restored a few years later. He was also concerned with a series of reports which helped to lay the foundations for English Heritage's Monuments Protection Programme, in as far as it relates to industrial monuments.

Perhaps his most important contributions to the development of Industrial Archaeology were projects relating to particular buildings or industries. Stanley Mill in Gloucestershire had been lauded in many books describing the industrial heritage, but it was not until the Institute's report on the mill in 1986 that its significance as a unique building within its region and an unusual building within the broader context of the textile industry was recognised. Michael and I worked together during the summer of 1991 on a study of Fazeley, the textile community established by Sir Robert Peel 200 years previously. He had injured his ankle and I well remember his determination to walk in some pain and at the height of the season for hay fever, from which he suffered, across several fields to the point where Peel's workers had begun to dig the leat that powered Fazeley's mills. He undertook for English Heritage and with the assistance of Paul Collins a study of the buildings of the British motor industry, following it with a parallel investigation of buildings used for the manufacture of aircraft. Involvement in such work was of incalculable benefit to an institute concerned with the training of postgraduate students. It led to a clear appreciation of what was happening in the field of conservation practice, and of the knowledge and skills that were appropriate to students seeking careers in that field.

Michael also developed the international presence of the Ironbridge Institute. He energetically sought students from overseas, encouraged British students to work as interns with the Historic American Engineering Record, and developed links with a conservation project at Briançon in the French Alps which enabled students of both Industrial Archaeology and Heritage Management to gain valuable experience. He contributed to the *Blackwell Encyclopedia of Industrial Archaeology*, which I edited from the Institute. He was a supportive member of the editorial board, and was responsible for the articles on ceramics, on Italy, a country where he had travelled extensively and for which he had great affection, and on Greece, where he had provided valued advice on the conservation of industrial monuments. The article on Athens epitomises his enthusiastic approach to the exploration of cities. As well as discussing the city's 19th-century buildings, its railway stations and the plans for its gasworks, he draws attention to a restaurant located in three railway freight wagons and duly recorded their makers and dates of construction. In more recent years his interests had extended even further. He led a party of students from York on a tour of the republic of Georgia, and took a leading part in a conference in Hong Kong.

Terracotta was the subject of Michael's doctoral thesis, and, building on earlier work at Ironbridge on the decorative tile industry, he enlarged our understanding of architectural ceramics. His great achievement in his book, *The Terracotta Revival*, which incorporated much research undertaken after the completion of his thesis, was to demonstrate the close links between the manufacture of terracotta in Britain and the United States. The book reflects the thorough understanding that he had gained of the technology of terracotta production and his profound knowledge of architectural history. It is also evidence of his determination to achieve his objectives and his capacity for hard work. His research in the United States was sustained by a Hagley Fellowship, a Winston Churchill Fellowship and a grant from the US Embassy in London. He studied the Blashfield correspondence in Boston, Mass., and spent some considerable time working on the archives of the Gladding McBean terracotta works at Lincoln, California. He also did much to promote the study of architectural ceramics, and when the Tiles and Architectural Ceramics Society was formed in 1981 he became its first secretary.

Michael Stratton's other principal historical interest was the study of 20th-century Industrial Archaeology, the subject of a paper presented to the TICCIH conference in Austria as early as 1987. He became an authority on the manufacture of motor cars and aircraft, and produced a book on the power stations at Ironbridge that takes a much broader view of the history of electric power generation than the title suggests. It was his ambition to produce a comprehensive study of 20th-century Industrial Archaeology in Britain in time for TICCIH2000. Michael sought sponsorship for the volume, we had planned it in some detail, and in December 1998 we spent two days planning illustrations at the National Monuments Record at Swindon. Within less than a month he was stricken with the illness from which he died, and it was left to me to write most of the book, although, with characteristic determination, Michael provided incisive comments on some draft chapters, and completed one draft chapter himself only a few days before he died.

Michael also published extensively on conservation, particularly during his time at the University of York. He developed links between his department and the Institute of Railway Studies, a joint venture of the University and the National Railway Museum, and with Sue Taylor was responsible for a database of conservation and regeneration projects in Britain and Ireland that is now the starting point for any study of the subject. He was a valued member of the English Heritage Industrial Archaeology Advisory Panel from 1985-89 and from 1993 until his death. As a panel member he was particularly concerned with the project which resulted in the publication in 1998 by PLB Consulting of the report *Public Access to England's Preserved Industrial Heritage*.

Michael Stratton attended the TICCIH conferences in Lyons and Grenoble in 1981, in Lowell and Boston in 1987, in Vienna and Styria in 1987, in Brussels in 1990, in Barcelona and Madrid in 1992, in Montreal and Ottawa in 1994, and in Athens and Thessaloniki in 1997. He presented papers at all but the first, and jointly wrote the national reports for the United Kingdom between 1981 and 1994. He made many friends through TICCIH, and exchanged information with scholars from other countries on many topics. He enthusiastically explored cites where he happened to be staying, often undertaking pre-breakfast rides to the extremities of tramway systems. He took the opportunities offered by conferences to experience cities and buildings en route, and many of his friends can recall journeys that were enlivened by his knowledge, inquisitiveness and capacity for delight. I travelled with him to the TICCIH meeting in Vienna in 1987. We each had long agendas for the four-day journey. Leaving Ironbridge in mid-afternoon we travelled on the Glasgow-Harwich boat train and observed a new generation of supermarkets being built all round the northern rim of London. After crossing to Hook of Holland we travelled the length of the *Schwebebahn* at Wuppertal, and spent the night at Worms, where Michael was anxious to photograph the sculptures on the cathedral that had inspired the Victorian architect Alfred Waterhouse and was impressed by the surviving portal tower of the Niebelungen bridge. We moved on to Ulm, from where we took an evening trip to Munich, where Michael was anxious to locate terracotta buildings that he had made arrangements to visit on his return journey. The following day we travelled to Friedrichshafen, where we enjoyed the Zeppelin museum, and participated in the boisterous celebrations of the 140th anniversary of the opening of the railway from Ulm. A steamer took us along Lake Constance, enabling us to enter landlocked Austria by water, and after a night at Bregenz we spent nine hours of the following day travelling the length of Austria by train. In the Viennese capital we experienced the Ferris wheel before taking Wiener Schnitzel and Sachertort in a café near the Rathaus that had changed little since the end of the Habsburg Empire.

Michael had been involved with the planning for TICCIH2000 as a member of the Academic Panel, and contributed substantially to the determination of the topics to be discussed at the conference. He put forward imaginative ideas for excursions outside of conference hours, only one of which, to Smithfield Market, was eventually realised. Many delegates at the conference expressed their sense of loss. Michael was only 28 when he went to the meeting in France in 1981 and there was a widespread feeling that care should be taken that TICCIH meetings should always be readily accessible to young scholars. TICCIH gained much from Michael's participation. Its meetings provided him with opportunities to flourish as a scholar, and such opportunities should be readily available to succeeding generations.

The bibliography that follows summarises Michael's academic achievements, but these cannot be divorced from his personality. He was breathlessly enthusiastic, and charmingly loyal, glorying in sailing, mountain biking and kite flying. He recorded much of what he saw in tiny, leather-bound notebooks, accompanying his notes with sketches about which he was unjustifiably modest. His legacy remains in the achievements of his students as well as his publications, but above all in the positive influence he had on all who worked with him. Undertaking a project with Michael involved a commitment to unlimited hours of hard toil, but it also brought the promise of intellectual stimulation and a sense of fun.

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From Industrial Revolution to Consumer Revolution: an introduction

De la Révolution Industrielle à la Revolution de la Consommation: avant-propos

Marilyn Palmer & Peter Neaverson

Industrial archaeology grew from a perceived need in the mid-20th century to record and preserve the fast-vanishing remains of early industrialisation in Europe, America and further afield. In most European countries, the immediate priorities were the compilation of inventories of the industrial monuments which remained and obtaining for these some degree of statutory protection. For Britain, this process was admirably summed up in the papers in *Perspectives on Industrial Archaeology*, edited by Sir Neil Cossons and presented to delegates at the TICCIH2000 Congress.[1] Marilyn Palmer and Peter Neaverson have provided a short summary of similar activities in Europe and the USA in *Industrial Archaeology: Principles and Practice*,[2] while Barrie Trinder's *Blackwell Encyclopaedia of Industrial Archaeology* contains entries on the surviving material evidence for industrialisation in Europe and the USA.[3]

It is now, however, almost half a century since industrial archaeology was first recognised. The discipline has matured considerably in that period, and has perhaps moved in two separate but related directions. On the one hand, it has begun to formulate policies on the preservation and presentation of the industrial heritage and on sustainable development, which have influenced both central and local governments. On the other, it has developed into a period archaeology, including within its remit not just the physical evidence for industrial activity over the past 250 years or so but also that for the associated social, cultural and economic developments which accompanied the process of industrialisation. Important among these are the agricultural context of industry, expressions of religious activity in the form of chapels and cemeteries, changes in the relationships between entrepreneurs and their employees and the evidence for measures taken by both employers and the authorities to control a burgeoning workforce. The papers in this volume are concerned with the latter development of the discipline of industrial archaeology and jointly contribute towards a deeper understanding of the processes and outcomes of industrialisation.

In 1995, English Heritage characterised the field of industrial archaeology as one that was concerned with the 'classic constituents of the Industrial Revolution — capital investment, organised labour, technological development and the factory scale of production', while acknowledging that the crafts and industries of earlier periods paved the way for later achievements.[4] This is an acceptable definition as long as it is recognised that those 'constituents' are not thought of as taking place solely within a factory environment. Many of the papers in this volume indicate the longevity of outwork, although those who continued to labour at home were nevertheless part of an organised, capital-intensive system of production. Equally, the 'constituents' listed above could exist well before the period of the classic Industrial Revolution, particularly in enterprises which were state-financed. Jonathan Coad points out that the dockyards of the British Royal Navy were extraordinarily complex manufacturing centres by the 1760s, employing nearly 17,500 people in shore establishments which supported more than 900 warships. The dockyards pioneered the use of machine tools for mass production, were in the forefront of the use of cast and wrought iron for buildings and also experimented with fire-proof construction. It would be very interesting to compare these dockyards with those of other European countries to obtain some idea of the industrial scale of the shore establishments which supported both the naval and merchant fleets which had grown enormously in the 17th century.

Equally, in the 17th century and earlier, there was an extensive network of industry based in the countryside, making use of water power for various processes in the iron and textile industries as well as hand power.[5] Both Marie Nisser and Eva Dahlström point out the relevance of Franklin Mendels' concept of proto-industrialisation to the Swedish situation, where a self-supporting social structure or *bruk* grew up around the rural ironworks which were so prevalent in Sweden. Palmer and Neaverson show how, in both Britain and Europe, cloth-working centres developed around the fulling mills that had often been adapted from rural corn mills to make the best use of available water power. This well-established rural industrial network did not just disappear as new technologies were developed in the late 18th century, but adapted to new economic conditions. In the Eichsfeld area of Germany, throughout the 18th and early 19th centuries, thousands of woolcombers and spinners provided yarn for conversion into cloth in towns such as Gottingen, acting as an 'industrial backyard' (as Michael Mende describes it) to its more prosperous neighbours. Many of the *bruks* of Sweden adopted new technologies in ironmaking and built machine shops, but did not lose the paternalism which had characterised their social structure until well into the 19th century. The material remains of industry in the countryside strongly reinforce the argument that industrialisation did not automatically mean a rush to the towns on the part of the labour force: many chose to remain in their old habitations, even at the cost of long treks to the new sources of raw materials and markets.

Understandably, accounts of the process of industrialisation based on documentary sources such as diaries, topographical accounts, newspapers, trade journals and so on lay great emphasis on the importance of innovation and change, since it was the new, not the mundane, which attracted the attention of contemporaries. The surviving material remains help correct this view, placing the emphasis back where it really belongs, on the people who carried out the production processes. Perhaps the chief characteristic of the period of industrialisation in Europe is the great increase in the size of the workforce, and it is possible to argue that increased production, certainly in the late 18th and early 19th centuries, was achieved not so much by the introduction of new technology as the increased exploitation of this immense resource of human labour. In some ways, the long continuation of outworking rather than a vast increase in factory production was to the benefit of both employer and employee: the former did not have to invest capital in working premises, while the latter was still able to work within the family unit. However, the independence of these outworkers was illusory: they formed part of a system of organised labour, working within a capitalist system of production. Several papers in this volume support this view, notably those on aspects of the textile industries (Mende, Campion, Palmer and Neaverson) and the boot and shoe industry (Campion and Menuge). They also show that outworking became an urban as well as a rural phenomenon, the labour force operating within purpose-built or adapted domestic workshops in towns. This is a well-known phenomenon in British cities such as London and Birmingham, but J.-F. Belhoste shows that it also operated in Paris, which housed a host of small workshops such as those which produced articles of furniture in the faubourg Saint-Antoine.

The whole built environment of industrial production, not just the mills and factories which have traditionally caught the attention of the industrial archaeologist, is vitally important to understanding both the nature of work and the relationships between employer and employee in the Industrial Revolution. A major difference between craft and industrial production is that in the former the workman is responsible for the whole article: in industrial production, as often as not, he is responsible for only one aspect of the manufacturing process. One effect of this division of labour on the built environment is demonstrated in Menuge's article on the boot and shoe industry of Northamptonshire, where different processes are carried out in different types of buildings, the small factories where the leather is cut out being surrounded by the houses and workshops of the domestic workers who stitch together the leather uppers and attach the soles to them. Campion, too, shows how manufacturing processes in the hosiery and lace industries in the East Midlands of Britain were also split between the factory which produced yarn and the domestic workshop where stockings and shawls were made, being returned to the urban warehouse for marketing.

Although the survival of outwork might seem to indicate successful resistance to the factory on the part of the workforce, it was to some extent to the benefit of the employer who effectively exercised a policy of 'divide and rule' over his employees. Social control and surveillance of the workforce could be practised both inside and outside the factory. Both Mende and Palmer and Neaverson point out the often close physical relationship in the textile industries between the home of the employer and his working premises, reinforcing the practice of paternalism but also enabling a degree of surveillance over the workforce. Palmer and Neaverson also discuss the factory colonies in the cotton industry, where paternalism and social control went hand in hand, the former perhaps giving way to the latter in the late 19th century, as Dahlstrom also suggests happened in the Swedish engineering industry.

Although we have been arguing that the early phases of industrialisation in Europe witnessed resistance on the part of the workforce to enter the factory, as well as the reluctance of many employers to invest their capital in machinery when they had an exploitable workforce, it cannot be denied that considerable technological change also took place within the period. Nowhere was this more apparent than in the chemical industry, whose products supported so many other industrial processes. Colin Russell's paper indicates how mass production of sulphuric acid and soda affected the textile and glass industries, as well as pointing out how a by-product in the transformation of coal into coke, gas, transformed home life, education, crime prevention, theatrical performances and also working conditions in factories during the 19th century. Palmer and Neaverson discuss how the introduction of the power loom into textile mills by the 1830s created wholly new settlement patterns, dominated by the provision of speculative housing rather than paternalistic factory colonies. The physical fabric of a building can indicate the introduction of new technology, as in the Swedish engineering industry, where workshops were reconstructed as new machinery was introduced, yet retain sufficient of their original fabric to enable earlier processes of production to be deduced.

The transfer of technology from one country to another has long been of interest to both economic historians and industrial archaeologists, and several papers in the volume throw new light on the process. Marie Nisser shows how introduced technologies often needed adaptation to the different conditions existing in another country. Sweden, unlike Britain, continued to use charcoal rather than coke as a fuel in the smelting of iron, but this did not prevent the introduction into Sweden of the hot blast process or the use of blowing cylinders instead of bellows in Swedish iron furnaces, nor the method of forging iron which Gustav Ekman brought over from Lancashire in the first half of the 19th century. Two other papers reveal some of the cultural problems associated with technology transfer. Jan af Geijerstam is in the process of studying the reasons for the failure of ironworks built in India in the 1860s by two Swedish metallurgists, attributing their problems partly to the cultural differences between the introduced technology and the older traditions of Indian iron making and partly to the lack of a supporting technological system, since the British-dominated colonial government preferred British iron to be imported rather than iron to be manufactured on any scale in India. David Gwyn also looks at the cultural problems experienced in technology transfer in a very different environment, that of Gwynedd in north-west Wales. This area, described by the author as one of 'peripheral culture', was dominated by loyalty to the Welsh language and the traditions of Protestant dissent, yet was not immune to the processes of industrialisation which were experienced through the development of its mines and slate quarries as well as the construction of roads through the fastnesses of Snowdonia and across the Menai Straits. Technology transfer, however, took place not by formal scientific or technical training but through the medium of personal contact between individuals, many of whom were 'outsiders' who had to come to terms with the area's cultural make-up. David Gwyn argues that the processes of technology transfer can only be understood if the human agents of change are understood within the context in which they had to operate.

The majority of the papers in this volume deal with the context of the manufacture of goods rather than their consumption. However, Louise Trottier and Liv Ramskjaer take us from the 19th into the 20th century with their discussions of changing consumer demand. In both Canada and Norway, industrial production was revolutionised by the introduction of hydro-electricity which made possible the mass production of new materials such as aluminium and plastics. These were utilised for new appliances for the home, not only electrical goods such as irons, refrigerators, vacuum cleaners and cookers but also plastic goods such as floor coverings and kitchen units. However, these were at first totally unfamiliar to the consumer who had to be persuaded of the advantages to be gained by their use. Liv Ramskjaer uses the terms 'technology push' and 'demand pull', suggesting that the former rather than the latter was more influential in achieving sales for the new products. In both countries, aggressive marketing was necessary to change the habits of consumers and was aimed particularly at women. This was a wholly new development but one, of course, with which 21st-century consumers are now only too familiar.

The papers in this volume, then, throw new light on the ways in which the material culture of the past 250 years can add to our understanding of the complex nature of industrialisation. Their geographical range is limited, but they do indicate how the take-up of new technology varied in both introduction and intensity, reinforcing the idea that industrialisation was very much a regional phenomenon in the late 18th and early 19th centuries. Technological inertia is as much a feature of these pages as technological change: the very size and consequent exploitability of the labour force delayed the introduction of new technology into many industries. And, when new ways of doing things were disseminated between countries, the process was one of adaptation rather than wholesale adoption: not only the economic but also the cultural differences between countries needs to be taken into account when studying the process of technological transfer. Finally, the last two papers in the volume suggest that consumer demand for the everyday domestic appliances that we all take for granted had to be created: new technology pushed rather than demand pulled. The Editors hope that the many ideas raised in these papers will be of interest to the international delegates who attended the TICCIH2000 Congress, as well as to other readers, and encourage more of the comparative research which is greatly enhancing our understanding of the processes and outcomes of industrialisation.

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THE INDUSTRIAL REVOLUTION IN THE 18TH CENTURY
LA RÉVOLUTION INDUSTRIELLE DU XVIIIE SIÈCLE

A Swedish response to the Industrial Revolution of the 18th century

Marie Nisser

Sweden witnessed a considerable growth in iron-making during the first part of the 18th century. Technological change made it possible to switch over from the traditional, so-called German forging based on an old welding process, to a new method called Lancashire forging. The scarcity of coal in Sweden ensured the continued use of charcoal as a fuel for both the blast furnace and forging processes. The Swedish metallurgist Gustaf Ekman studied a prevailing forging process based on charcoal in Lancashire and managed to adapt it to Swedish conditions. In 1845 he designed his welding furnace, which made it possible to produce iron of high quality at reduced production costs. In the 1850s konsul G.F. Göransson successfully carried out experiments with Henry Bessemer's converter for making steel. This initiated the restructuring of Swedish iron-making which in the latter part of the century led to large-scale operations in modern iron and steel works and the closing down of hundreds of smaller charcoal blast furnaces and forges.

The paper will deal with technology transfer from England to Sweden and will add some new knowledge to the growth of iron-making in Sweden. At the same time some outstanding sites of the two processes — Lancashire and Bessemer — will be presented.

Une réponse Suédoise à la Révolution Industrielle du XVIIIe siècle

Dans le domaine de la production sidérurgique, la Suède a connu une croissance remarquable au cours de la première partie du XVIIIe siècle. Des progrès technologiques ont permis le passage des procédés traditionnels d'affinage du fer — la technique dite allemande, fondée sur des procédés de corroyage — vers une méthode nouvelle dite la méthode de Lancashire. Etant donné la pauvreté du pays en ressources en charbon de terre, les entreprises décidèrent au début du XVIIIe siècle de continuer d'employer le charbon de bois, à la fois pour les hauts fourneaux et pour les fours d'affinerie. Gustaf Ekman, métallurgiste suédois, étudia un procédé d'affinage au charbon de bois utilisé dans le Lancashire et s'employa à l'adapter aux conditions suédoises. En 1845, il introduisit un four à corroyage qui permettait la production de fer de bonne qualité à des prix réduits. Dans les années 1850, le consul G.F. Göransson entreprit des expériences avec le convertisseur d'Henry Bessemer pour la production d'acier, expériences couronnées de succès. Ce développement fut à l'origine d'une restructuration profonde de l'industrie du fer suédoise ; à la fin du siècle, celle-ci comportait de grandes usines sidérurgiques intégrées mais voyait en même temps la fermeture de plusieurs centaines de petites unités — hauts fourneaux et forges — utilisant le charbon de bois. Notre communication traite de ce transfert de technologie de l'Angleterre vers la Suède, et apporte des éclaircissements inédits quant au développement de la production du fer en Suède. Des sites remarquables utilisant les deux procédés — Lancashire et Bessemer — sont présentés.

Aspects on the Industrial Revolution of the 18th Century

It is commonly agreed that the Industrial Revolution marked the boundary between the modern period of economic growth and earlier periods of human experience. For the first time continuous technological change became the dominant force in economic growth.[1] Britain was the pioneering nation in the period between *c.* 1760 and 1830 to 1850. The sustained process of industrialisation that started in the mid-18th century spread to Western Europe and America some decades later.

There is no shortage of books on the subject and new data and interpretations are constantly being added. Today, we are in the midst of a period of transformation, which many scholars identify as the Third Industrial Revolution, centred on information technologies, the formation of a global economy, and transition to a new society.[2] The Industrial Revolution of the 18th century is the first one. The second is the Industrial Revolution begun by the introduction of new technologies and new forms of organisation in the latter part of the 19th century, including the advent of mass production. The three 'Revolutions' are frequently being discussed and compared today.[3] One important question is in what sense the present 'technological paradigm shift' is different from the two earlier ones?

From the early classical descriptions through Toynbee and Mantoux to the more recent standard works of Ashton, Dean or Mathias, the British Industrial Revolution has been treated as a single national phenomenon.[4] Most of the economic historians have concentrated on the 'macro-economic' features of the Industrial Revolution, writing about aggregated economic categories such as patterns of economic growth, capital investment and development. David Landes's *The Unbound Prometheus* (1969) was an impressive interpretation of the Industrial Revolution that suited its time since he was concerned with the achievements of factories and large-scale technologies which confirmed the contemporary approval of heavy capital investment.[5]

The different economic climate of the 1980s raised new questions focused on the concern of world recession, the causes and features of unemployment, the social and economic impact of new technology and new patterns of work organisation. And it called for new studies. Sidney Pollard was one among many scholars who adopted a fresh approach to this well-worked field by asking new questions and presenting new analysis about the wider role of the Industrial Revolution in human history.[6] A closer examination of the process of industrialisation in Britain has revealed that it was by no means a single, uninterrupted and unitary nationwide process. Different industries developed very differently at various periods; there were distinct phases of transformation. Far from being spread across the country, the changes were highly concentrated geographically and created spatial differentials at any one time. Pollard argued that the interplay of time, industry and region provided an important clue to the understanding of actual historical events in Britain and the way in which industrialisation spread to the rest of Europe.

Already in 1976, Carlo Cipolla was arguing that the Industrial Revolution was only the final phase, the coherent outcome of a historical development which took place in Europe over the first seven centuries of the last millennium.[7] At the same time the new concept of 'proto-industrialisation' caused a good deal of controversy. The theory was developed in the early 1970s by the American economic historian Franklin Mendels and was further elaborated by three social historians in Göttingen.[8] The essence of the theory is the existence of an extensive industrial network based on the countryside of Western Europe since the 16th century. Geographically it was concentrated on certain areas and based on hand-working technologies. In contrast to the village and farm crafts, textile, metal, wood and other goods were produced for distant markets.

By underlining the importance of proto-industrialisation the issue of 'revolution' was replaced by a new concept focused on continuity and discontinuity, traditionalism and technological change. In her book *The Age of Manufactures*, Maxine Berg comes to the conclusion that the period was a complex web of improvement and decline, of large- and small-scale production, of machine and hand processes.[9] Themes of slow growth and continuity are contrasted with regional change, new technologies and women's work. Maxine Berg has clearly shown that industrial growth took place over the whole of the 18th century and not just in the last quarter of it. There was substantial growth in a whole range of traditional industries as well as in the most obviously exciting cases of cotton and iron. Furthermore, technical change started early and spread extensively throughout industry. Innovation was not necessarily mechanisation but also the development of hand and intermediate techniques, the wider use of cheap labour and the division of work. Above all it was a conjuncture of old and new processes, and that conjuncture affected performance and work experience.[10]

Activities within the field of industrial archaeology during the 1970s followed similar lines to those discussed among economic historians at the time. The focus was on buildings and objects, the results of the glorious Industrial Revolution in Britain or the early days of industrialisation elsewhere in Europe and other parts of the world. Since the 1970s marked the beginnings of industrial archaeology in many countries, it is little wonder that the pioneering works of industrialisation did attract so much attention. Additionally, buildings and equipment from the early industrial period were fairly uncomplicated to restore and adapt for new purposes, whether the intention was to convert them to museums or to make use of them for other functions.

This particular concept of conservation, however, changed during the 1980s and '90s from the conservation of industrial monuments and landmarks to consideration of the means of preserving large technological systems or complex industrial landscapes. We have moved away from the concept of unique landmarks to a consideration of the environment of daily work and life, including aspects of social class as well as gender. We no longer limit the consideration of industrial activity to just the period of mechanisation but have extended it to include a much broader concept of industry with roots back in ancient times as far as our present period of structural change.

The concept of Industrial Revolution has once again become an issue of debate with the advent of communication and information technologies as the fundamental instruments of the new organisational logic transforming the world today. In his magisterial three-volume work, *The Information Age. Economy, Society and Culture*, Manuel Castells describes how we live in the midst of a fundamental technological informational revolution which is the backbone (although not the determinant) of all other major structural transformations.[11]

It seems appropriate to remind the TICCIH2000 Congress of the issues of 'The Industrial Revolution' even if it is not the place here to argue about the challenges that such questions influence our future work on industrial heritage and the scope of its conservation. The new questions raised in the 1980s and '90s about the 18th-century Industrial Revolution are important. How does the interplay of time, industry and region provide an important clue to the actual historical events in Britain, and of the way in which industrialisation spread to the rest of Europe? How were new technologies introduced, and how did industries and individuals react to them? How was industry organised and what were the day-to-day structures? Did all European nations seek for the same technological solutions which were introduced by the pioneering country of Britain or can one talk about a conscious choice of technology that determined the paths of industrial development in certain nations for the following centuries? And finally: to what extent should national and regional patterns of technological development influence our national conservation work in a European or global context?

The Swedish Challenge

It seems important to discuss the technological and industrial development of other countries with regard to the industrial break-through in Britain. A few examples from Sweden may cast some light upon the questions that were raised above. They should also be linked with another question: how and to what extent could a small nation like Sweden respond to the challenge of the British Industrial Revolution in the 18th century? Let me discuss this by dwelling upon some examples from one single branch of industry, iron- and steel-making, dating from the latter part of the 18th century to the end of the 19th century. Other branches such as the textile industry could also have been discussed but time does not allow a more extensive account.

From the mid-17th to the latter part of the 18th centuries Sweden was in the front rank of countries exporting iron to the world market. Her chief client was Britain but here, during the 18th century, the Russian iron industry was making its presence progressively felt, and even ousted Sweden from first to second place. But since Sweden was exporting iron to a wider range of countries she could, on the whole, keep her leading position alongside Russia. That is to say, even if Sweden was on the way to losing her long-standing monopoly in Britain, she remained a prime factor in international trade. It has been claimed that she produced upwards of 30% of all the iron made in Europe, but this is only an assumption since no special statistics exist for Europe's overall output during the 18th century. Nor has it been possible to establish them retrospectively — we simply do not know how much iron Europe produced neither can we determine Sweden's share of it. Yet the fact remains: the role of Swedish iron in the European markets was an important one.[12]

Thus Russia had become Sweden's major rival on the British market. But other events, too, gave Swedish iron-masters cause for concern for their hold on British clients. In 1709, as is well known, Abraham Darby had succeeded in smelting pig iron, using coke for fuel at Coalbrookdale. However, it was the puddling process, introduced in 1784, which opened the way to the expansion of Britain's domestic iron industry.

British iron, being softer than Swedish, was at first a rival to the Russian kind, which was similar and therefore the first to suffer. Around the turn of the 19th century Russian imports into Britain fell off heavily, while the Swedish iron-masters still enjoyed growing demand and good prices. Walloon iron, in particular, was still regarded as irreplaceable for making British steel. It was shipped to Hull and then transported to Sheffield. There it had a reputation for being unsurpassed and was described by the steel-makers for having extraordinary qualities such as being 'strong', 'sound' and having a 'body'.[13]

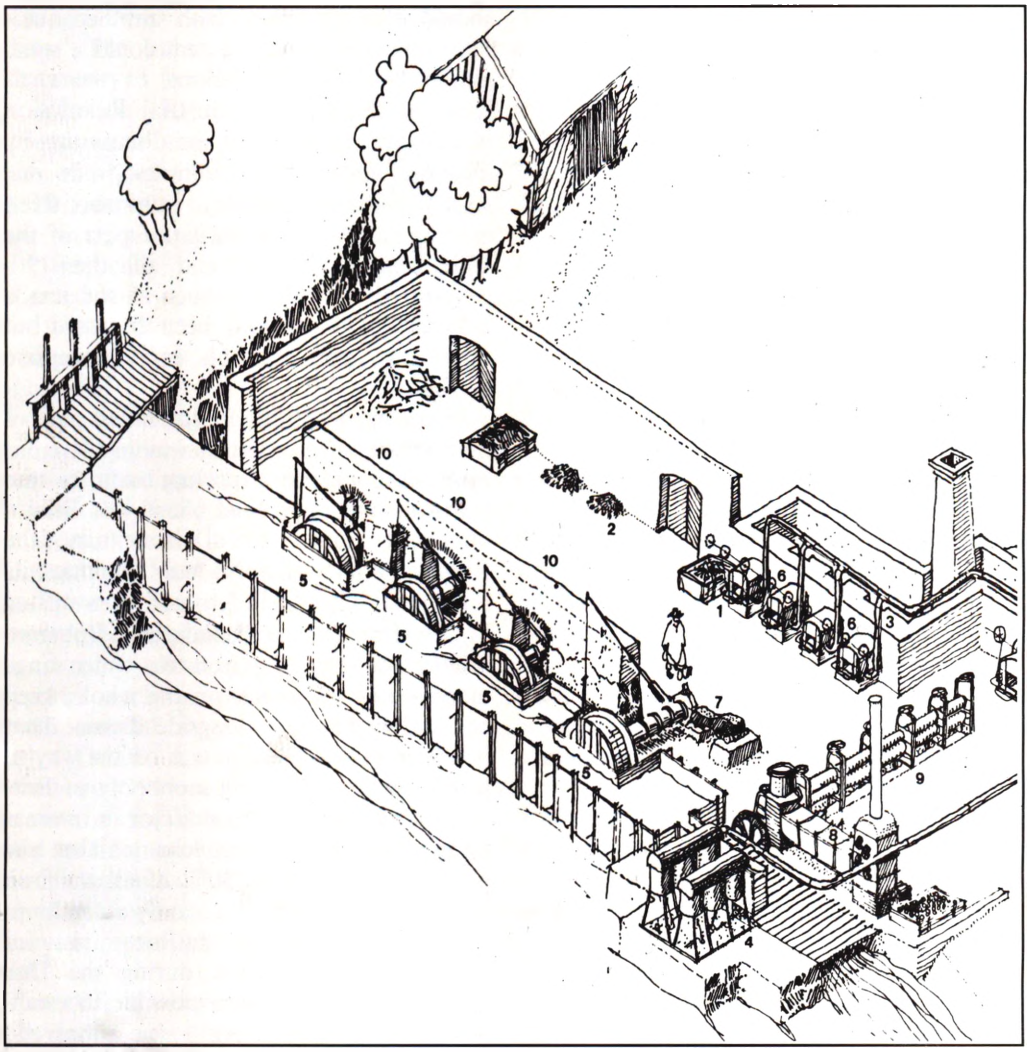

Figure 1. Drawing of the Lancashire forge at Karmansbo which has been preserved with all its equipment. It was closed down in 1958. (1 & 6) Lancashire hearths of different types, (4) two blowing engines of Bagge's invention, (5) water-wheels, (7) hammer, (8) welding furnace of Ekman's invention, (9) rolling mill and (10) straining hammers used for forging bars. Drawing by Torbjörn Almqvist from Attman, A., Svenskt järn och stål 1800–1914 *(1986).*

As long as the market mainly wanted good quality wrought iron, Swedish iron was superior. Yet it could not compete economically with purpose-rolled thin slabs or rods. The so-called 'German-forged iron' was found technically inferior for constructional purposes. So when competition became keener the Swedes began to work hard at improving the iron's quality.

Jernkontoret, the Swedish Ironmasters Association founded in 1747, had financially supported many young metallurgists to make study tours abroad and a fair number of them went to visit Britain.[14] This was one way to gather information and knowledge and could be classed as industrial espionage. In 1800 the Board of Jernkontoret decided to give a supervisor of blast furnaces, Erik Thomas Svedenstierna, full financial support for his travels to Britain, Russia, Germany and France in order to gather information on production and markets. The Ironmasters were deeply concerned about the new competition on the iron market and wanted to have more information from one of their experts.[15]

In November 1802 Svedenstierna arrived in Britain and he stayed there for more than a year. First of all he spent about four months at various institutions in London before he started to travel around the country. He had a social network within the British iron industry, which allowed him to visit a great number of ironworks. His travel report was published in 1804 and is a vivid description of his impressions both as a cultural tourist and as an expert on iron-making.[16] He came to the conclusion that the quality of British pig iron produced with coke as fuel was as good as if not better than pig iron based on charcoal as fuel. Forged iron, on the other hand, was not as good as Swedish wrought iron and this was also a well-known fact to British iron-producers and customers. Hence, British iron-producers had concentrated their efforts on developing skills in casting and manufacturing iron and in this field they had achieved great skill. Svedenstierna was very impressed by what he saw of that production.

In his recommendations to Jernkontoret he seemed to be convinced that Sweden should not try to copy the puddling process. He felt that Swedish iron-makers ought to stick to the natural prerequisites and to the

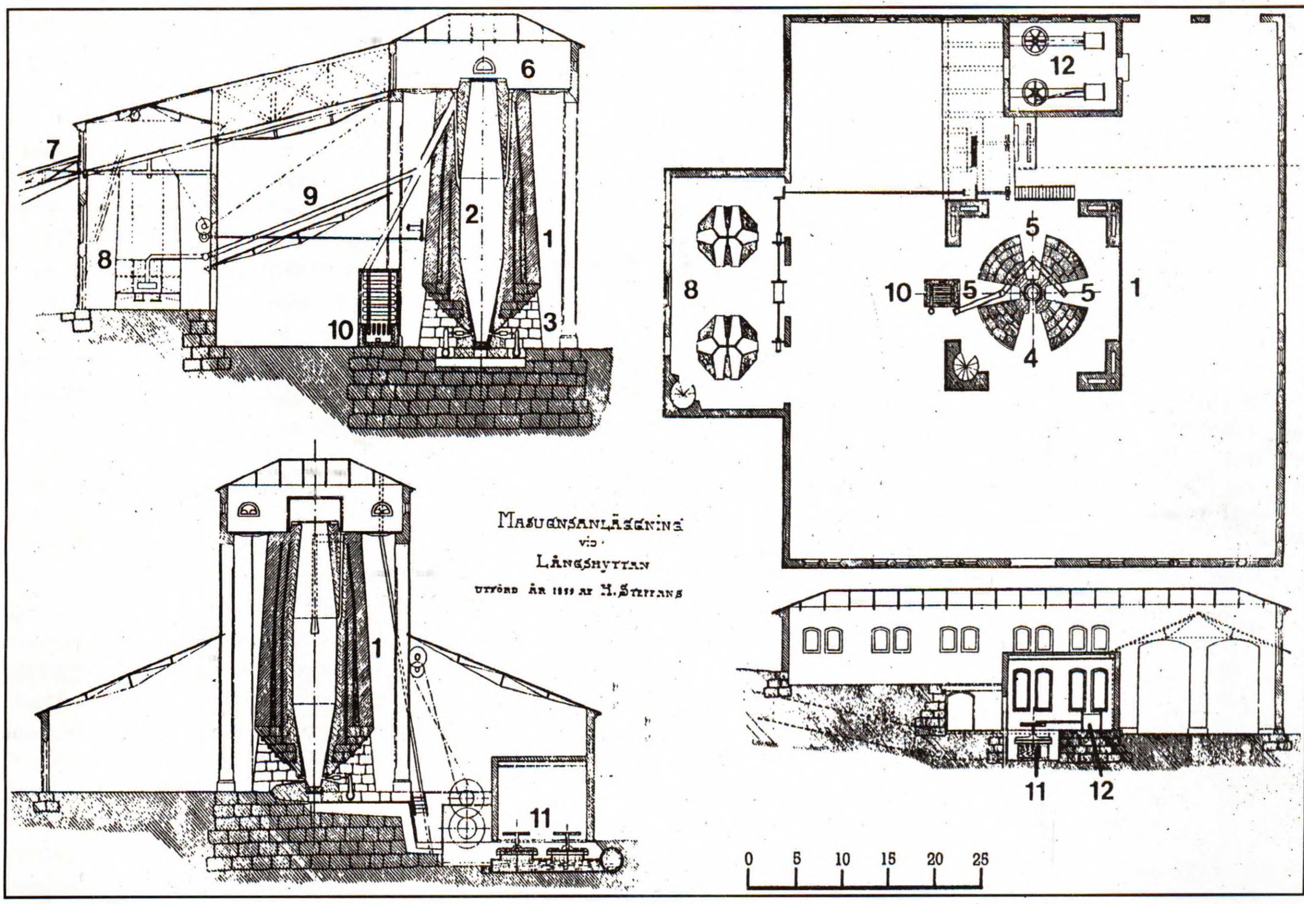

Figure 2.
The 'modern' charcoal blast furnace of Långshyttan built in 1859. Drawings from Jernkontorets Annaler *(1804).*

methods they had developed along the centuries, which were also best fitted to the Swedish conditions of iron production. Sweden had abundant resources of wood but only one fairly small coal deposit in the southern part of the country. However, he also felt that the technique of rolling iron which the British had developed so skilfully should be transferred and adapted to be used alongside Swedish refining methods. If this could be accomplished, the Swedish iron-makers would be able to produce the current dimensions of iron that were in demand by the market.

In Svedenstierna's view, Swedish wrought iron should be able to retain a large enough market as a high-grade product. But he also recommended that the industry should go on improving such production methods as were based on the country's raw materials and accorded with market requirements. And this was the path opted for. It was a question of a conscious technological choice adopted by experts, iron-masters and institutions. Traditional production methods were further developed, so that they could go on meeting demand far into the 20th century. Sweden was a recipient nation in terms of technology transfer but also managed to go its own way. The path that was followed led Sweden in the direction of quality and special steel-making and this is still today the dominating product, enabling the country to uphold its reputation for making good quality steel for export. And this was Sweden's answer to the challenges of the Industrial Revolution in Britain in the 18th century.

The first half of the 19th century became a period of intensive development work for the Swedish iron-masters. For instance, while traditional methods, still using charcoal, continued at the ironworks, metallurgists paid close attention to foreign advances in blast furnace construction, and they were quick to adapt the new techniques to Swedish conditions. The Scotsman James B. Neilson had patented a method to preheat the blast-furnace gas in 1828 and this method was tried in 1833–4 at a number of ironworks in Sweden. The hot blast stoves had to be placed between the blowing machine and the tuyère with the result that the old bellows could no longer be used. Efforts to develop a blowing engine were in progress. In 1835 the Swedish metallurgist J.S. Bagge developed one with three cylinders, which was introduced into most of the country's blast furnaces and forges during the latter part of the 19th century (Figure 1). It was of similar construction to those that could be found in other European countries during the 19th century. At the same time more efficient methods were tried out of roasting ore in wood-heated, later gas-heated, kilns. These

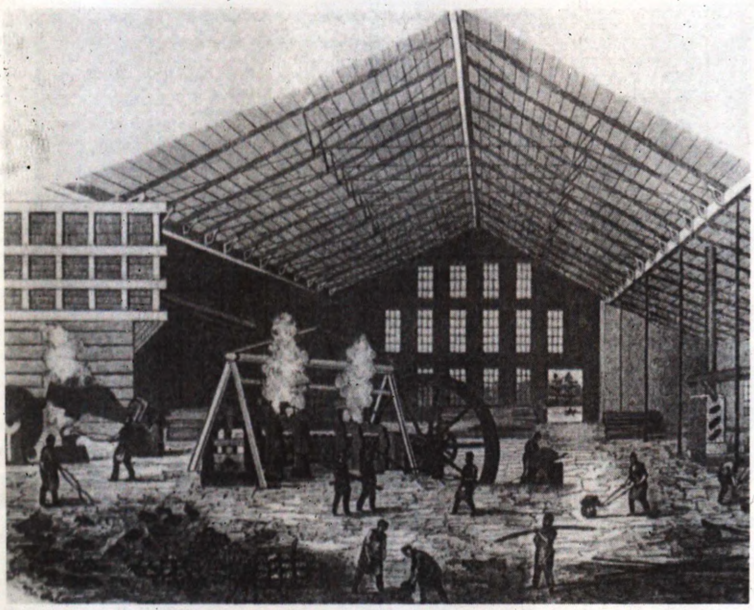

Figure 3. Interior of the rolling mill and Lancashire forge at Axmar in 1864. To the right: three furnaces, in the middle of the picture the rolling mill and to the left the steam driven hammer. Wood-cut engraving by V. Bernström, drawing by C. B-m in Svenska Arbetaren.

reforms led to a massive increase in the ironworks' daily output, but also to reduced charcoal consumption.

In 1859 the installation of a new-type blast furnace at Långshyttan, Dalarna, marked the Swedish breakthrough of modern blast furnace construction (Figure 2). Once again, the initiative had come from Britain. From now on furnace stacks would be taller, with thinner pipe walls and more tuyères. Improvements in blast furnace operation led to a considerable degree of rationalisation of pig iron production. Even though between 1861 and 1885, 47 out of 226 blast furnaces were shut down, production rose during that period from 170,000 to 465,000 tons.[17] At the same time charcoal consumption fell by upwards of 4.5 hectolitres per ton of pig iron compared with the old blast furnace design. This meant a big saving in production costs. Up to the mid-19th century all pig iron had been consumed domestically and its export forbidden. When this ban was lifted in 1856, technical developments and market expansion joined hands.[18]

In hearth refining too, the first half of the century had seen a fair amount of pioneer work. And once again the inspiration for a new type of furnace together with a more rational hearth refining method came from Britain. Gustaf Ekman, who was the supervisor of forging at one of the ironworks in the western part of Sweden, Lesjöfors, set out to Lancashire in 1828 to study a still prevailing method of iron-forging which had some similarities with the Walloon method in Sweden, where pig iron refining and iron forging were carried out in two separate hearths.[19] The Lancashire process, as it came to be called in Sweden, diminished charcoal consumption considerably by its use of a single hearth with heated blast yet greatly improved production. The final product was iron of high quality, which obtained good prices on the market. This was the process that Gustaf Ekman decided to transfer and adopt for Swedish circumstances. However, problems of welding billets were only satisfactorily solved after he had developed his welding furnace in 1845. The source of heat for the Ekman furnace was a charcoal-fed gas generator, raising temperatures to a point to allow welding, without the billets having to come into contact with the source of heat. Such efficient welding, as it turned out, produced unusually dense forged iron. High-grade iron, too, could now be produced more cheaply.

Introduction of the welding furnace solved another major problem: namely, the shape of the billets. Heated in these furnaces to such temperatures, it became possible to roll them into bars, instead of forging them, thus still further reducing costs and facilitating the production of iron to exact dimensions. It was the solution of these problems that laid the foundation for truly industrial-scale output. The 1850s saw ever more rolling mills being built to produce Lancashire billets where integrated plants both refined the iron and rolled it into bars (Figure 3). These new workplaces were much larger than the older Walloon or German forges. Compared with British units they were still small, but whilst the old forges had eight or twelve forgemen, there were more than 50, sometimes as many as 100, skilled workers and apprentices in the Lancashire works.[20]

The 1860s were the age when the Lancashire method celebrated its complete breakthrough in the field of hearth refining. After about a quarter of a century it had virtually supplanted all older methods, except Walloon forging, which still retained its status in Northern Uppland. Hearth refined iron climaxed in 1887, a year in which bar iron, most of it produced by the Lancashire method, reached a peak figure of 221,000 tons. Even several decades later, this iron would still be in demand for many uses on account of its solidity, great toughness, welding properties and electrical and magnetic qualities.

The Lancashire process was one component in the scaling-up of production contributing to Sweden's take-off period. It was one of the answers to the challenge of the industrial revolution in Britain, adaptive and innovative at the same time and it survived until the 1960s. It was a conscious choice of technological development that fitted the circumstances.

The Bessemer process is one more example of a mutual exchange of experience, knowledge and technology transfer between

Britain and Sweden. It allowed the two countries to enter the era of mass-production of steel, in the Swedish case still retaining charcoal as the fuel component. This example does not, of course, belong to the first industrial revolution of the 18th century but more to the second Industrial Revolution.

In 1856 Henry Bessemer developed a new method of producing steel by forcing air through molten pig iron. However, Bessemer's own experiments were not immediately successful in the years following and in Sweden, consul Göran Fredrik Göransson was the first to blow Bessemer steel at the Edsken blast furnace, in Gästrikland in July 1858 (Figure 4). His experiments were carried out with subsidies from Jernkontoret and assistance from a number of metallurgists. Göransson utilised manganese-rich ores and a fixed Bessemer furnace, whose tuyère area he had increased to raise the air supply, so that the whole process was accelerated. This process yielded a product of a completely different quality than hitherto. Later, slip converters were introduced.

Göransson had shown that the Bessemer process was capable of being used to manufacture both structural and high-grade steels. Its definitive breakthrough was at the London Exhibition of 1862, where steel from Henry Bessemer's Sheffield works was on display. The process was soon a success all over Europe and in the United States. The prices of steel could be lowered and there was a rapidly expanding array of new uses. Above all Bessemer steel came to be used for merchant steel, eg for railway rails. This made it necessary to subject inputs of the process to quantitative chemical analysis. The quality of its output was highly sensitive to minute variations in the composition. It has been pointed out that the modern science of metallurgy had its origins in the need to solve practical problems that were associated with the emergence of the modern steel industry. Metallurgy was a sector in which the technologist was the first to develop powerful technologies in advance of systematised guidance by science. Science in its turn was influenced by technology.[21]

The Bessemer process, like many other technical innovations, also provided the framework for a number of subsequent innovations all of that were dependent upon, or complementary to, the original one. Some Swedish steelworks had already installed Bessemer converters in the 1860s, but it was in the following decade that the method really had its breakthrough in Sweden. Between 1870 and 1885 output of Bessemer ingots rose from 7,700 tons to 52,000 tons.[22] Swedish Bessemer steel was regarded as singularly phosphorus- and sulphur-free, but also free of dangerous slag inclusions. It also welded easily, and thus came to be used for case-hardening carbon steels suitable for tool-making. The Bessemer process started a new era of steel-making which was rapidly taken up by the adaptable nation of Sweden. But again it was a question of the inter-relationship of all the developments, not any single one that determined the whole, not only the technological achievement in itself but also the human dimension, the networks, and the workmen. Even if this paper has been focused upon technology transfer, adoption and development, it would be equally important to study social networks, work organisation and the institutional framework as part of a more holistic approach aiming at a deeper understanding of the context.

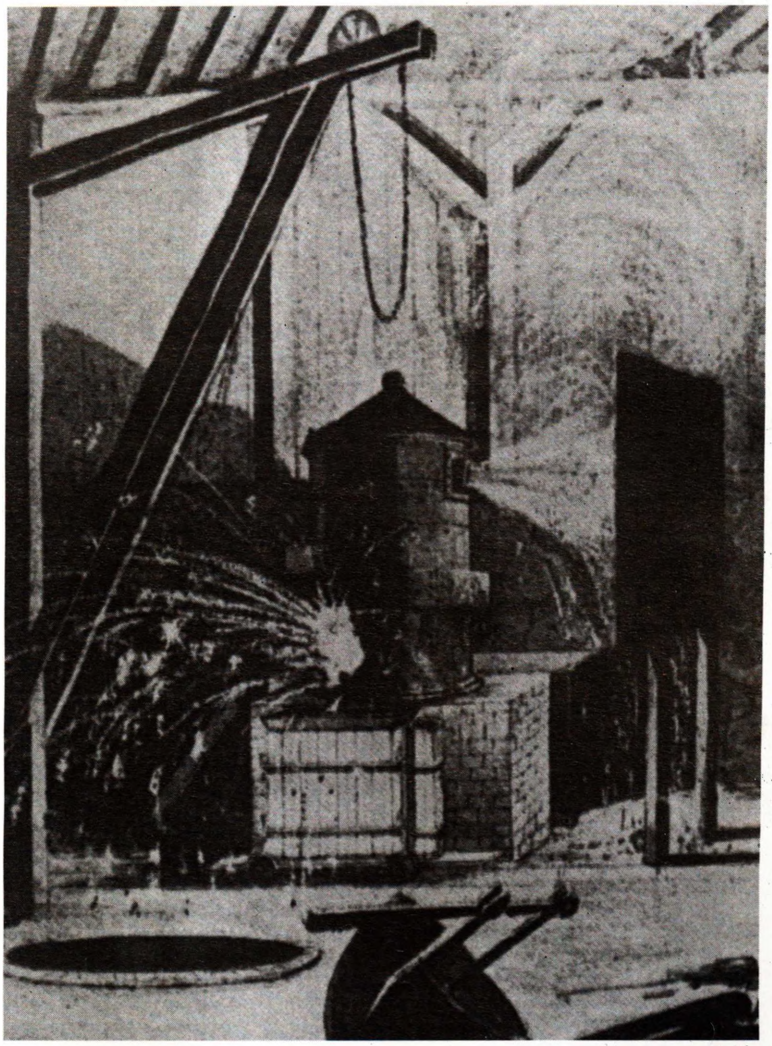

Figure 4. The first and fixed Bessemer furnace at Edsken where the Bessemer process was successfully tested. Watercolour by C.F.A. Cantzler. Photo: Jernkontorets bruksbildkatalog.

Long-Lasting Processes

Sweden struggled hard to find its own way to compete on the iron and steel market. It had been forced to do so as a result of new innovations in Britain during the 18th century. By adapting new techniques to suit its own conditions, Sweden managed to stick to the path that had been outlined in the early 19th century: to produce high quality steel. Many of the old processes survived well into the 20th century. Walloon forging went on until the 1940s; the last charcoal blast furnace closed down in 1968. The Ramnäs Lancashire plant remained the last of its kind in Sweden, and its final closure in 1964 marked the end of this process anywhere in the country. Not long before, in 1961, Sweden's last acid Bessemer converter, at Fagersta, too, had had to cease operations. Neither Lancashire nor Bessemer steel was any longer competitive.

OUR INDUSTRIAL HERITAGE

The long survival of the old iron- and steel-making methods has left Sweden with a great number of well-preserved charcoal blast furnaces, forges, rolling mills, Bessemer and Siemens Martin acid open-hearth plants as well as many beautiful industrial villages from the old days. Today they are important landmarks in Sweden's industrial history, but they are also invaluable sources if we want to discuss some of the questions raised earlier in this paper such as how new technology was introduced, how industry was organised and which were the day-to-day working methods. They also enable us to gain a better understanding of the process of industrialisation and transformation that started in Britain in the 18th century and then spread to other industrialising parts of the world.

It seems important that we gain knowledge about all the facts that add up to a preserved site. By doing so we may also find new arguments for its future conservation. Whether it is an old forge, a blast furnace or a site from another branch of industry, it may have a value that goes far beyond the local, regional or national context. This is the case of a number of well-preserved Swedish Lancashire forges and charcoal blast furnaces. They form part of an industrial history in a much wider context, closely connected with the British Industrial Revolution in the 18th century. But they also tell about Swedish metallurgists and ironworkers who adopted a new technology to fit their own circumstances and managed to uphold iron production and steel-making. Even today this allows the country to have a competitive production for the international market.

ACKNOWLEDGEMENTS

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A major industry before the Industrial Revolution: Great Britain's Royal Dockyards

Jonathan Coad

Industrial archaeologists looking at the origins and growth of industry in 18th-century Britain mostly ignore the dockyards of the Royal Navy. Yet these were extraordinarily complex manufacturing centres well before the dawn of the Industrial Revolution. Permanent naval dockyards were firmly established in England from the late 15th century onwards and by 1711 nearly 6,500 people were employed in them, with an unknown number outside reliant on government contracts. By the 1760s, the 430 or so warships making up the fleet were the highly visible end of what then could reasonably claim to be the greatest and most complex industrial organisation in the western world. By 1814 more than 900 warships were supported by shore establishments employing nearly 17,500 people, of whom some 2,000 were employed at eleven overseas yards.

This paper looks at the component parts of 18th-century dockyards, and pays particular attention to surviving buildings and engineering works in the home and overseas yards. The Royal Navy pioneered the introduction of stepped stone dry-docks at the end of the 17th century, and a hundred years later was the first organisation to use machine tools for mass production. Prefabrication of dockyard buildings for overseas bases was introduced in the 1720s. Later, the royal dockyards were to be in the forefront of using cast and wrought iron for building construction, as well as experimenting with fire-proof buildings. Particular attention will be paid in this paper to Chatham Dockyard, an extraordinarily complete survival of a Georgian dockyard.

Une grande industrie d'avant la Révolution Industrielle: Les Chantiers Navals de la Marine Royale en Grande-Bretagne

Les archéologues industriels qui s'intéressent aux origines et au développement de l'industrie en Grande-Bretagne au XVIII^e siècle ont souvent négligé les chantiers navals de la Marine royale. Mais, bien avant l'avènement de la Révolution industrielle, ces chantiers représentaient des sites manufacturiers d'une très grande complexité. Les premiers chantiers navals permanents existaient en Angleterre à partir de la fin du XV^e siècle. En 1711, ils faisaient travailler 6,500 ouvriers, tandis que les contrats du gouvernement donnaient des emplois indirects à un nombre incalculable d'ouvriers en dehors des chantiers. Au cours des années 1760, les quelque 430 navires de guerre qui constituaient la flotte anglaise étaient le produit fini, spectaculaire, de ce qui était très vraisemblablement l'organisation industrielle la plus considérable et la plus complexe du monde occidental. En 1814, plus de 900 navires de guerre étaient entretenus par des établissements comptant près de 17,500 effectifs, dont 2,000 dans onze centres établis hors de l'Angleterre.

Notre contribution analyse les parties constituantes des chantiers navals du XVIII^e siècle, avec une attention particulière portée aux bâtiments et aux ateliers de construction qui subsistent aujourd'hui dans les chantiers en Angleterre ou dans d'autres pays. A la fin du XVII^e siècle, la Marine anglaise était pionnière dans l'introduction de cales sèches maçonnées en escalier; cent ans plus tard, elle était la première organisation à utiliser des machines-outils conçues pour des fabrications en grande série. Dès les années 1720, la construction des chantiers à l'étranger faisait appel à des techniques de pièces préfabriquées. Plus tard, ces chantiers royaux furent également à l'avant-garde dans l'utilisation du fer forgé et de la fonte pour la construction de bâtiments et l'expérimentation des systèmes 'fire-proof', garantis contre l'incendie. Nous examinerons en particulier l'exemple du chantier naval de Chatham, un survivant remarquablement intact de l'époque georgienne, au tournant des XVIII^e et XIX^e siècles.

Introduction

On 23 September 1689 Edmund Dummer, Surveyor to the Navy, received instructions to 'go to Dartmouth and Plymouth, and taking notice of all the parts thereunto, to represent what was found most suitable to the design and building one single dry-dock'.[1] The result of Dummer's investigations led to the creation of a new dockyard, initially named Plymouth Dock but now known as Devonport. The construction of this westerly dockyard was a tangible recognition of the shift of British maritime power from the confines of the North Sea and English Channel to the Mediterranean, Atlantic and ultimately global influence. By 1700, the new dockyard was largely complete, joining established sister dockyards on the Thames, the Medway and at Portsmouth. As Plymouth Dock was located in a rural area, a new town grew up alongside to house the labour force. All in all, the new dockyard represented a very substantial government investment, the creation of a major industrial community on, in today's parlance, a 'green field site'.[2]

Traditionally, 1750 is still a convenient coat-hook for many on which to hang the start of the industrialisation of Great Britain, although as the *Encyclopaedia Britannica* wisely remarks: 'the term Industrial Revolution, like similar historical concepts, is more convenient than precise'.[3] Yet strangely ignored in most surveys of the rise of Britain as an industrial power is the contribution made by the Royal Navy and indirectly by its paymaster, the British government. This is surprising, for the royal dockyards and the associated naval towns can reasonably claim to be the industrial centres of Britain long before that enshrined date of 1750. Throughout history, warships have been among the most expensive and technologically complex of all building projects undertaken by the human race. Although the construction of a wooden warship required little in the way of investment in shore facilities, the same was not true of its subsequent maintenance and repair. Although a number of medieval English monarchs, notably Henry V, built up royal fleets, they never established permanent shore facilities so the life-spans of their warships remained limited and the royal navies transient. It was one of the great achievements of the Tudor monarchs to establish a permanent fleet and, most importantly, to put in place the financial mechanism and the requisite shore facilities to sustain it. The modern Royal Navy can trace an unbroken descent from the reign of Henry VII.[4]

It is no coincidence that the origins of modern British naval bases likewise date back to 1495 when Henry VII ordered the construction of a dry-dock at Portsmouth. For long, dry-docks remained the single most expensive piece of capital equipment, and upon their location depended all else — the term 'dockyard' literally relates to the working yards centred on the dry-docks. Portsmouth was followed in the 16th century by dockyards at Deptford, Woolwich and Chatham, with outlying yards later established at Sheerness and Harwich. Plymouth Dock, as we have seen, followed in the 1690s. By 1711, nearly 6,500 people were directly employed in the royal dockyards, with an unknown number outside reliant on government contracts for warship-building and the supply of raw materials and finished items of equipment. By the 1760s, the 430 or so warships forming the fleet were the highly visible end of what by then could reasonably claim to be the greatest and most complex industrial organisation in the western world. By 1814, the number of warships had risen to over 900, supported by shore establishments employing nearly 17,500 people. The great majority of the latter worked in the home dockyards, but nearly 2,000 were employed at ten overseas bases stretching from Jamaica to Madras in India. These figures again take no account of the private warship-building yards. Although such figures need to be treated with some care, it is apparent that throughout the 18th century the army and navy absorbed a fairly consistent 50% of net government expenditure, with the navy taking the slightly larger share.[5]

This paper concentrates exclusively on the royal dockyards, which were the responsibility of the Navy Board; it is, however, important to remember that sister boards also ran substantial shore establishments equally vital for the operation of the fleet. The Victualling Board operated large victualling yards, the Ordnance Board supplied weapons and ammunition from ordnance yards, and, from the mid-19th century onwards, the Sick and Hurt Board established and directly ran major naval hospitals at Gosport, Stonehouse, Great Yarmouth and later at Chatham. It was the dockyards, though, that formed the heart of this great naval-industrial complex.

By the end of the 17th century, the role of the royal dockyards was well-established. They maintained and repaired the fleet, as well as constructed the larger ships-of-the-line, while the merchant yards supplied most of the Royal Navy's smaller warships. A very wide variety of trades and skills were to be found in the royal yards, most of which had developed a substantial manufacturing capacity centred on the four main component materials of a sailing warship: timber for the hull and the masts, iron, and later copper, for the various fittings and the hull sheathing, canvas for sails, and hemp for the production of cordage. This paper can do no more than look at a very few of the more notable industrial and engineering developments within the dockyards from *c.* 1690 to the end of the sailing navy.

The Rise of the South Coast Dockyards

For most of the 17th century, strategic reasons had dictated that Chatham was the country's premier dockyard, but the westward shift of naval operations in the 18th century was to lead to the rise and predominance of both Portsmouth and Plymouth. Although Chatham diminished in importance, this was only relative compared to the two south coast yards and all three remained central to the Royal Navy's operations up to the closure of Chatham in 1984. What set apart these three from the smaller dockyards, which were predominantly ship-building yards, was their role as the homes of the fleet. All three had good anchorages and space for laying-up ships in ordinary. As fleet bases, they became the focus for associated ordnance yards and victualling yards. The middle of the 18th century saw the first provision here of naval hospitals and towards the end of the 19th century the beginning of purpose-built naval barracks.

The immense growth in the size of the fleet in the 18th century had a direct impact on the dockyards. A greater number of warships led to a demand for more storehouses and more maintenance facilities. Individual warships were also increasing in size — in the 1690s a 90-gun first-rate displaced around 1,400 tons; a century later a 74-gun third-rate displaced almost 2,000 tons. As a consequence, dry- and wet-docks, building slips, mast houses, sail lofts, roperies and smitheries all needed to be made larger to cope. In 1761, the Navy Board introduced an extraordinarily far-sighted and far-reaching expansion and modernisation programmes for Portsmouth and Plymouth Dock and, as funds became available later, for a more piecemeal and partial modernisation of Chatham. These works, modified as circumstances changed, were spread over more than 40 years, and ensured that by the outbreak of the wars with Revolutionary and Napoleonic France, the Royal Navy was supported by some of the most modern dockyards in Europe.

Many of the buildings and the engineering works of this huge modernisation scheme remain today, in some cases juxtaposed alongside buildings from the earlier part of the century. At Devonport, as Plymouth Dock was renamed in 1823, wartime bombing destroyed a great deal, but much still survives here and at Portsmouth. Chatham, which largely escaped air raids and post-war modernisation, stands today a virtually intact dockyard from the great age of sail.

Dry-Docks

By the end of the 17th century, one of the most important determining factors for the location of a dockyard was its suitability for a dry-dock. These were generally the most expensive of all individual dockyard structures. Although their prime function had always been for hull repairs, they had increasingly and wastefully become used for actual ship-building as it was found easier to float a new warship out of a dock than launch her down a slip; it was only in 1764 the Admiralty ordered an end to this practice. In the days before efficient mechanical pumping, a good rise and fall of tide was crucial, along with deep water close to the shore and firm land in which to excavate the dry-dock. The attraction of the new site at Plymouth was that all three conditions could be met. The displacement of contemporary warships enabled this new dry-dock to drain entirely by gravity. This though was only one of its advantages, for Dummer's work here and at Portsmouth marked a revolutionary advance in design. Until then, dry-docks had been timber-lined with steep sides. Dummer substituted stone at Plymouth and brick and stone at Portsmouth and introduced the systematic use of altars along the sides, with steps for access and chutes enabling material to be slid down to the shipwrights. The introduction of regularly-spaced altars reduced the length of timbers needed to secure a warship in dock, reduced the surplus volume of the dock and hence the amount of water to be removed, and enabled shipwrights to approach the outside of the hull with less elaborate staging. The altars also provided a measure of buttressing against the surrounding ground. In addition, Dummer replaced the cumbersome triple-leafed gates with twin gates, apparently reducing the number of people needed to operate them from 70 to four. To reduce tidal pressure on the dry-dock, Dummer constructed a substantial wet-dock in front of it.

At Portsmouth, Dummer was undertaking a similar scheme almost in parallel to that at Plymouth. At the Hampshire yard he was likewise constructing a new dry-dock opening into a nearly square wet-dock, known as the Great Basin. This was flanked on its northern side by a second wet-dock approached by a channel from the harbour and known as the Upper Wet Dock. At Portsmouth, Dummer had to contend with building on reclaimed land, something that was to give him and his successors considerable trouble. He also had to incorporate pumps as the fall of tide was insufficient to empty the dry-dock purely by gravity. In place of the manually-operated chain pumps then in use, he introduced horse-pumps and had the satisfaction of being able to report to the Navy Board that these had removed six feet of water in one night. In the Dummer drawings in the British Library is an ingenious plan allowing for either horse or water power to work these pumps. A large waterwheel is shown, working on the tide mill principle. Culverts from the two basins formed a head race, with a culvert linking the wheel to the harbour forming the tail race. As with all tide mills, operation would only have been possible at low tide. There is some doubt as to whether or not this system was ever operated here, and the Navy Board may have preferred the certainty of horse-pumps.

At Plymouth, Dummer's pioneer works have been substantially altered by later generations. Although this has also happened at Portsmouth, the evolution and extension of the dry-docks at this Hampshire yard has given us a remarkable group, encapsulating dry-dock engineering developments over the next century and remaining a powerful witness to the levels of government spending enjoyed by the Georgian Navy Board. Dummer himself carried out the first modification in 1699 when he added a pair of dock gates at the west end of the channel to the Upper Wet Dock, thus creating a second dry-dock, although without stepped sides. In 1737 this was extensively rebuilt and is now known as No. 6 Dock. Dummer's original dry-dock, known for long as the Great Stone Dock, was extensively rebuilt in 1769 and is now known as No. 5 Dock. By this date, the great dockyard expansion at Portsmouth was well under way. Between 1764 and 1796 at least nine different plans were drawn up for extending and modifying the dry- and wet-dock system, in part a reflection of the problems of dockyard planning at a time of continuous changes in the size of warships. In 1764 work began on a new dry-dock adjacent to the south side of Dummer's Great Stone Dock; this is now know as No. 4 Dock. The following year a contract was let to extend the Great Basin southwards, in part to allow it to accommodate more ships, in part to allow more dry-docks to open into it. Other priorities ensured that these were not proceeded with for some time. Then, in 1789, a decision was taken to fill the old Double Dock to the south of the Great Basin and replace it with a large single dock. This, the largest so far built at Portsmouth, was completed in 1795 and is now known as No. 1 Dock. Ten years later, by which time Samuel Bentham was in post as the first Inspector General of Naval Works, construction began on two further dry-docks. The South Basin Dock, now known as No. 3 Dock and the home of the *Mary Rose*, was the first to be constructed on the inverted arch principle pioneered by Bentham. A few months later, work began on the South East Basin Dock, now No. 2 Dock and home of HMS *Victory*. Appropriately, this was completed in 1805, marking the completion of this remarkable complex. Save for some alterations to the head and sills of some of the docks, and the replacement of a number of gates by caissons, this is a largely unaltered group, its earliest parts dating back over 300 years.

Equally remarkable, if largely unseen, are the drainage arrangements that date from the modernisations under way in the 1770s. At that stage, the old North Basin was deepened and converted into a huge reservoir or sump. Culverts ultimately linked all save No. 1 Dock to this, allowing the dry-docks to drain by gravity; water could be pumped from the reservoir at leisure. At first, this was done by horse-gins, but in 1799 the navy's first steam engine was installed here. Today, the same system operates using electric pumps.

Such an elaborate group of dry-docks was far in excess of the requirements of any commercial operator, as well as being beyond their financial reach: in 1789, it was estimated that No. 1 Dock cost over £81,000 to construct. No. 1 Basin and its surrounding dry-docks are paralleled in Europe only by the slightly younger Five Finger Docks at Karlskrona Naval Base in Sweden, but Portsmouth is unique in the elaborate system of emptying the dry-docks, which ultimately involved sharing power with Brunel's Blockmills.[6]

BUILDING SLIPS

Surviving ship-building slips from this period are far fewer. The typical building slip, both in the royal dockyards and with commercial ship-builders until late in the 18th century, was a simple timber floor supported on interlacing timbers. As such, they were comparatively ephemeral and easy to sweep away when their usefulness had ended. A number survive as archaeological sites, as at Buckler's Hard in the New Forest and at Chatham Dockyard. Between 1700 and 1830, the number of building slips at Chatham, Portsmouth and Plymouth increased fivefold to a total of 16; increasingly, these were made of stone or brick. Pembroke Dockyard, laid out specifically as a ship-building yard early in the 19th century, had no fewer than ten slips and today has the best group of such structures. Only one 18th-century slip remains intact. This is No. 1 Slip at Devonport, constructed in stone in 1774/5.[7]

A more significant engineering milestone came with the construction of roofs over these slips. These roofs were not designed so much for the convenience of the shipwrights as for the protection of the hull of the vessel under construction from rainwater and the consequent spread of wet and dry rot. In 1807, Bentham visited Karlskrona where a covered slip had been in use for some 50 years, but not until 1812 do the dockyard records show that consideration was being given to roofing slips in the British royal dockyards. From then on, until the introduction of metal hulls in the 1860s made the roofs redundant, there was a sustained building programme to roof both slips and docks. Today, only three of these graceful composite roofs remain. Two survive at Devonport, and one of the last timber ones to be built stands at Chatham. Slip No. 3 at Chatham dates from 1838 and joined to its northern side are slips Nos 4, 5 and 6, each covered with all-metal roofs in 1847. This remarkable group is completed at its northern end by No. 7 Slip, constructed between 1852 and 1855. It is worth noting that in their employment of iron columns and arched iron trusses to support wide-span roofs, Nos 4–6 slips predate the great station roofs at Paddington and Newcastle that are usually cited as the earliest examples of this form of construction. All five of these slip roofs have recently undergone a very extensive programme of restoration, returning them to something of their former glory.[8]

SOME SURVIVING BUILDINGS ASSOCIATED WITH WARSHIP BUILDING

A number of 18th-century buildings associated with the construction and equipping of warships remain in all three dockyards; mention can be made of only a very few of the most important. At Chatham in 1753 work began on the construction of new timber-framed mast houses as workshops for the mast-makers. Compared to the more substantial brick buildings constructed in this yard up to the 1730s, the use of timber reflects the declining importance of Chatham at this stage. The building had been completed as far as the wall-plates when the Navy Board agreed to the addition of a new and much larger mould loft at first floor level. Here, the principal requirement was for a very large uninterrupted floor space where the master shipwright and his assistants could draw out at full scale the cross-sections of a warship for the mould-makers. The new floor at Chatham, completed by the end of 1755, is vast — 119ft long by 55ft wide (36.2m by 16.7m), indicative of the increasing size of warships. The building has one particular claim to fame in that it was almost certainly used to draw out the lines of HMS *Victory* when she was ordered in 1759 and it is very probable that the warship's first set of masts and spars was constructed on the floor below.[9]

To the south-east of the mould loft stands the very substantial Sail Loft, home of the sail- and flag-makers. Sail-making seems to have become an established trade in the royal dockyards at some time in the 17th century, supplementing or perhaps at times replacing sail-making contractors. Canvas was bought in bulk by the Navy Board and cut and sewn into sails in the individual dockyards. Piecing together the largest sails — the huge courses, topgallants and studding sails — required very large and unencumbered floor spaces on which the sail-makers could work. In the cramped conditions in most 17th-century dockyards, this space could most easily be provided above the level of the working yard on the top floor of a building where internal pillars could be omitted to give the necessary clear areas. Floors below were used for the storage of canvas and completed sails. In 1723, the existing sail loft at Chatham was described as being about 100 years old. The present sail loft which replaced it is the only remaining purpose-built sail loft to survive in a royal dockyard. This three storey brick structure, rendered in the 19th century, was originally designed to have two wings, but these were never built. Construction is conventional, with the ground and first floors strengthened by a central row of pillars. These are omitted on the second floor where the sail-makers worked. The dockyard officers informed the Navy Board they would lessen building costs by re-using old bricks and tiles. Proof of their economy is still evident on the ground floor where a number of the timber pillars are formed from the ribs of a 17th-century warship, presumably being taken apart in the dockyard at the time. Sail-making here probably ceased in the 1870s, although canvas almost certainly continued to be worked here for awnings and covers for ships' boats well into the 20th century. In the years before closure in 1984, the sail floor found a new use as a location for constructing inflatable life-rafts. Here, and at other dockyards, flag-makers tended to work in the same building. Flag-making is still carried on here, a private firm having taken over the Ministry of Defence operation in 1984. It is quite possible that flag-making here has been unbroken since the completion of the building in the mid-1720s.[10]

Iron-working trades formed an important element in every dockyard labour force and by the 18th century were becoming divided into two groups — anchor-smiths who specialised in the heavier metalworking associated with the iron parts of anchors — and black-smiths who produced the innumerable metal items required in the building and fitting out of warships. The demands of an expanding navy meant that every single dockyard enlarged or rebuilt its smitheries between 1700 and 1806. Their central locations made them vulnerable to later redevelopment when their role was largely replaced by the great mid-Victorian machine shops and foundries. Despite this later attrition, all the southern dockyards still possess smithery buildings, although in only one example does any of the equipment remain. At Devonport, as part of the mid-century modernisation programme, a new smithery was begun in 1776. The shell of this survives incorporated in a mid-19th-century extension. Metal-working trades continued to use this building into the 1970s, but it has since been totally cleared internally and its future is in some doubt. At Portsmouth a new smithery was constructed at the then northern end of the dockyard in the early 1790s. This had a comparatively short life and for many years has been used as offices. Traces of its original internal layout survive in the structure, while below the existing ground floor recent refurbishment work revealed very substantial remains of the bases for heavy machinery and forges. Between 1806 and 1808 Chatham was provided with a new and larger smithery designed by Edward Holl, architect to the Navy Board. This is a very substantial brick building of three ranges round a central courtyard approached from the west past two small attached lodge buildings. In the course of the 19th century, the smithery was extended to the north and the courtyard was roofed over. In the 1870s a second smithery was built to the west and both remained in use until 1974. A great deal of machinery and equipment, some of it dating back to the 19th century, remained in both buildings. Much of this was salvaged in the mid-1970s by the former Inspectorate of Ancient Monuments and stored in Holl's smithery before the later smithery was demolished. Both the building and its contents — the latter largely without parallel — are now in the care of the Chatham Historic Dockyard Trust and await conservation.[11]

Rope-Making

If dry- and wet-docks largely dictated the location of the heart of a dockyard, no single set of buildings has had a greater impact on the actual planning and layout than the naval roperies. Government manufacture of cordage in the dockyards began early in the 17th century and initially seems to have been done in open-air ropewalks. The need for regular and uninterrupted production, combined with the infinitely greater resources available to a government department compared to a commercial rope manufacturer, enabled the Navy Board to replace the open-air rope-walks with buildings well before the end of the 17th century. The actual roperies were structures over 1,000ft (304m) in length. The cordage production cycle began with the arrival of bales of hemp which were stored in hemp houses. From there, the hemp was taken to the hatchelling house adjacent to the ropery where the fibres were straightened, combed and disentangled before being passed to the spinners. If it was a 'double ropery' the spinners worked on the upper floors of the ropehouse, with the forming of the ropes and the laying of the great cables taking place on the ground floor.

At Devonport, there were separate spinning and laying houses; this was also the pattern at Chatham until the rebuilding of the 1780s. The yarns spun by the spinners were gathered into hauls and taken to white yarn houses before being fed through a tar kettle in an adjacent tarring house. The black yarns were then hung to dry in a black yarn house before being taken to the main floor of the ropery, wound onto bobbins and then spun into ropes and cables by forming and laying machines. Apart from horse gins introduced in the 18th century to power the capstans in the tarring houses, the whole process relied entirely on human muscles and was highly labour-intensive: in 1808 Chatham ropeyard employed around 300 people. When laying the great 24in. cables, 59 men were needed on the winches that dragged the laying machines along the ropery floor and a further 220 men were employed in 'closing' the three strands into the final cable. The very real fear of fire in this highly flammable process meant that it was to be the 1830s before steam power started to be introduced in naval roperies. Usually in close association with the roperies were fitted rigging houses. Here, the completed ropes and cables were cut to the appropriate lengths for each class of warship, their ends were bound and dead-eyes inserted where needed.[12]

Partly on account of the cost of the buildings, partly due to the space they needed, roperies were limited to four sites: Woolwich, Chatham, Portsmouth and Devonport. All these roperies were to be rebuilt and enlarged in the 18th century, but the need for cordage declined steeply with the introduction of steam warships. Woolwich and Portsmouth ceased production in the middle of the 19th century. Devonport remained in production until bombed in 1941. Chatham remained the sole naval ropeyard until 1982. However, Chatham ropery remains very much in production, still using its Georgian and Victorian machinery. The age of the buildings and much of the plant, combined with its production methods, makes this ropery of international significance. For these reasons, this article concentrates on Chatham and seeks to give a brief outline of this remarkable complex.

A sailing navy required prodigious quantities of cordage. For standing and running rigging and anchor cables, a 74-gun third-rate *c.*1800 required 28 different circumferences of cordage from $\frac{3}{4}$in. up to 18½in. (19 to 470mm), in lengths varying from 72ft (22m) of 14in. (356mm) cable to 26,718ft (8,145m) of 3½in. (89mm) rope. Together with sails, cordage was highly vulnerable to the elements as well as to normal wear and tear. By the mid-18th century, all the naval ropeyards needed to be modernised and expanded. Provision for this was included in the great redevelopment proposals drawn up in the 1760s; in the late 1780s work began at Chatham.

Chatham ropery has been established in its present location since 1618. Although the hemp houses had been rebuilt in brick in the first half of the 18th century, the remainder of the buildings were largely of timber. By the 1780s, the fire risks these presented were considered unacceptable and they were nearing the end of their economic lives. Between 1786 and 1791 the whole complex was rebuilt, with the exception of the earlier hemp houses, which still stand. The double ropehouse was modelled on that recently completed at Portsmouth. It is a three-storey brick building with twin lofts running its full length of 1,140ft (347.5m); at its northern end are barrel-vaulted cellars used for storing tar barrels. The ground floor was for the heavy forming and laying machinery while the upper floors were used by the spinners. The twin lofts — known as cock-lofts — were for apprentice spinners or the very experienced line spinners producing fishing line. This building was constructed by a London contractor, Nicholson and Son, Baker and Martyr. The remainder of the new buildings were the responsibility of the dockyard bricklayers and carpenters.

Although modern machinery has recently been installed in the former hemp house, the earlier machinery remains in use. The largest are the great laying machines built in the dockyard in 1854 and used for closing the biggest ropes and cables. Even more remarkable is a set of smaller forming machines constructed by Henry Maudslay and installed here in 1811. All are powered by ropes running the length of the laying floor which take their power from capstans at the northern end of the building. These capstans are now driven by electric motors, but they date from the late 1830s when they were connected to a beam engine; part of the frame of the latter still survives in its engine house.[13]

ORGANISATION

Until the end of the 18th century, the Surveyor of the Navy exercised overall control of the general layout and content of each dockyard, but left the actual design of individual buildings to the dockyard officers. Save for a very few major buildings, this meant that most were designed by the senior dockyard officers — the Master Shipwright or Master House Carpenter, no doubt assisted by the resident Commissioners. In 1795, prompted by growing disquiet about the cost and efficiency of the dockyards, and concern as to whether they were keeping abreast of technological developments taking place elsewhere in Britain, the Admiralty created the new post of Inspector General of Naval Works. The first and only holder was Brigadier-General Sir Samuel Bentham. His general remit was to modernise and mechanise the dockyards. His own remarkable career and interest in designing woodworking machinery to speed ship-building fitted him well for the post. More importantly, the small department he created included a chemist, an engineer and the first salaried architects to be employed in naval service. From these small beginnings ultimately grew the huge Admiralty departments responsible for the Victorian and later dockyards. In 1799 Bentham was instrumental in installing the navy's first steam engine at Portsmouth Dockyard. This was a table engine, designed by his chemist, James Sadler, several years ahead of Maudslay who has been generally credited with the design. It formed part of a major redevelopment of the reservoir next to the dry-docks, replacing the horse-pumps then in use here. The reservoir itself was vaulted over and two buildings were erected to contain Bentham's woodworking machinery. Sadler's engine was sited in the south range, pumping the reservoir dry at night and powering the woodworking machinery by day. By all accounts, this woodworking machinery was not particularly successful, but its reputation may have been subsumed in the greater fame that soon accrued to this building and the single storey link constructed between the two original ranges. It was Bentham's great strength that he realised the potential of Marc Brunel's proposals for steam-powered machinery for making ships' blocks. The remarkable collaboration between the two men and with Henry Maudslay was to result in the first instance in the world of the use of machine tools for mass-production. This was the real beginning of the modern factory system. By 1808 the forty five machines here could produce 130,000 blocks for the navy each year, ten unskilled men replacing 110 block-makers. The blockmills still stand, with sets of their machinery in the Science Museum and at Portsmouth. Brunel and Bentham were to collaborate a few years later at Chatham where Brunel's sawmill also remains. With pumping, sawing and block-making, all simple repetitive tasks, Bentham had more or less reached the limit where steam-driven mechanisation could effect major economies. Blowing engines, tilt-hammers, rolling mills and steam-powered roperies were to follow, but at a slower pace and largely after Bentham's period of office.[14]

If the dockyards may have been slow to embrace the advantages of steam power, their officials were fully alive to the introduction elsewhere in the country of cast and wrought iron for building construction. For the navy this offered two major possibilities. The first was the prefabrication of buildings for overseas yards where materials were in short supply, as at Bermuda, or where the climate was inimical to the longevity of timber construction, as in the West Indies' yards. The second was the possibility of fire-proof buildings. Given the serious fires in Portsmouth in the 1770s, and the fear of arson, this was a powerful incentive for innovative thinking.

The first attempt at fire-proofing, apart from smaller buildings such as pitch houses which had brick vaults, occurred in 1781/2. Then, David Hartley approached the Navy Board with a scheme for nailing thin iron plates to the undersides of joists and floors. His scheme was tried at Portsmouth on what are now 9 and 10 Stores, where traces of the plates still remain. However, there must have been justifiable doubts as to the efficacy of these for they were not used again in a royal dockyard. Cast iron as a structural material makes its first appearance at Holl's dockyard chapel at Chatham, built between 1806 and 1810. Here, thin cast-iron columns support the first-floor gallery. The first attempt to use cast iron as part of a fully fire-proofed structure was around 1808 at Portsmouth with the construction of the main pay office. Here, the first floor was carried on a series of brick vaults supported on curious fluted iron columns. Only the ground floor of this building survived wartime bombing, but the vaults and columns remain intact.

In June 1812, the 1,200ft (365m) spinning house at Devonport was gutted by fire. Over the next three years, its interior was rebuilt to a design by Edward Holl, using cast-iron columns and joists for the new stone floors and with cast- and wrought-iron members for the roof. Window frames, doors and shutters were also made of this material. Although documentary links have yet to be found, it is clear that Holl was well aware of developments of structural ironwork elsewhere, as was to be shown again at Chatham in 1817 where he designed the still-extant fire-proof Lead and Paint Mills.[15]

In the space available, this paper has been able to do no more than sketch a very brief outline of the royal dockyards and to highlight some of the more remarkable buildings and engineering works than in many cases still remain in them. The intention has been to show that by 1700, they were very much the industrial centres of England, the combination of crafts and skills then probably without parallel in their diversity. As industrialisation gathered pace elsewhere in the country, the relative size of the dockyards as industrial centres in relation to new industries started to alter, but they remained immensely powerful industrial complexes in their own right, generating economic activity far beyond their own boundaries. As late as the end of the 19th century, almost 2.25% of men in work in Great Britain were employed directly or indirectly on naval orders.[16] The men who ran the Georgian dockyards were fully aware of new technologies — in the Portsmouth Block Mills they had a 'world first' in terms of mass-production using machine tools — but there were limits, both in the flexibility of the new technology and its application to processes that continued to depend heavily on craft skills. In the use of iron for buildings, the dockyards were clearly well aware of developments elsewhere. Many of these innovations were introduced while the country was at war, and it should not be forgotten that the successful prosecution of the naval wars against Napoleonic France would have been impossible without the backing of the royal dockyards.

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Paris, Capital of the Industrial Revolution

Jean-François Belhoste

Paris, the political, financial and cultural capital of France, was also its industrial capital, although this important dimension of the city's history is rarely acknowledged. By the middle of the 19th century, however, it has been estimated that 60% of its population of about one million inhabitants made their living from industrial activities. The river Seine played an essential role in bringing raw materials, coal in particular, used from the 1750s for example in the glass furnaces created for bottle-making at Bas-Meudon. At the end of the 18th century, Paris was also one of the first French cities to have a Watt steam engine, used for pumping water. Chemical plants and mechanical engineering works — several of the latter run by British entrepreneurs — developed during the early years of the 19th century, stimulated by the city's textile industry. From the 1820s, the industrialisation of Paris was modified by the modernisation of its transport networks: the canal system (Ourcq, Saint-Denis and Saint-Martin), completed in 1825, and then the railways, from the 1840s. Large-scale modern factories such as the engineering works of François Cavé, Etienne Calla or Antoine Pauwels, employing as many as 800 workers, co-existed with more traditional establishments, such as the huge state tobacco manufactory in the Gros-Caillou neighbourhood to the west, and a host of smaller workshops, often producing high-quality articles for a fashion-conscious market. To the east of the Bastille, the faubourg Saint-Antoine, which specialised in furniture production, may be seen as characteristic of this aspect of the capital's industry.

All these activities, however, leave few material remains today. Small backyard workshops disappeared or were transformed into accommodation whilst the progressive de-industrialisation of the centre of Paris from the Second Empire replaced the larger industrial sites by bourgeois apartment buildings. Industrial archaeology in Paris, then, relies heavily on the analysis of street layout and land occupation patterns, often the only discernible traces on the ground, sending the researcher back to iconographical records, plans and notarial descriptions. The ways in which factories, workshops and workers' housing helped shape urban growth during the period of the first Industrial revolution have still to make their contribution to the image that Paris projects today.

Paris, Capitale de la Révolution industrielle

Paris, capitale politique, financière et culturelle de la France, était également sa capitale industrielle, mais cette dimension importante de l'histoire de la ville n'est que rarement reconnue. Vers le milieu du XIX^e^ siècle pourtant, on a estimé à 60% la proportion de sa population (d'un million de personnes) qui vivait d'activités industrielles. La Seine jouait un rôle de première importance dans l'approvisionnement en matières premières, la houille, par exemple, utilisée dès les années 1750 pour les fours verriers de l'usine à bouteilles établie au Bas-Meudon. A la fin du XVIII^e^ siècle, la ville s'enorgueillit de l'une des premières machines à vapeur de Watt, utilisée pour pomper l'eau de la Seine à Chaillot. Stimulées par une importante industrie textile, des usines chimiques et des ateliers de construction mécanique (certains de ces derniers créés par des entrepreneurs britanniques) se développèrent au cours des premières décennies du XIX^e^ siècle. Dès les années 1820, la géographie industrielle de la ville fut modifiée par la modernisation des réseaux de transports: les canaux (Ourcq, Saint-Denis et Saint-Martin), achevés en 1825, et, à partir des années 1840, les chemins de fer. De vastes établissements modernes, telles les usines de construction mécanique de François Cavé, Etienne Calla ou Antoine Pauwels, salariant jusqu'à huit cents ouvriers, coexistaient avec de grandes manufactures plus traditionnelles, telle l'usine à tabacs du Gros-Caillou, et avec une multitude de petits ateliers, souvent consacrés à la production d'articles de luxe pour un marché haut de gamme. A l'est, le faubourg Saint-Antoine, spécialisé dans le meuble, est caractéristique de cet aspect de l'industrie parisienne.

Ces différentes activités de production laissent peu de traces matérielles. Les petits ateliers de fond de cour ont souvent disparu, tout comme les grandes emprises usinières du centre, remplacées, en particulier sous le Second Empire, par des logements bourgeois. L'archéologue industriel s'attache donc à retrouver les traces du Paris industriel dans l'occupation du sol, les plans parcellaires et les réseaux viaires. Le terrain renvoie à des sources iconographiques, cartographiques et notariales. Le rôle de l'industrie dans la formation de la ville à l'époque de

la Révolution industrielle — l'habitat réalisé pour les ouvriers aussi bien que les lieux de production — attend encore sa pleine reconnaissance dans l'image que la ville donne aujourd'hui d'elle-même.

Cette communication a un titre volontairement provocateur. D'abord parce que pour certains, il n'est pas de Révolution industrielle hors de Grande-Bretagne. Mais plus sérieusement parce qu'il n'est pas évident que Paris, siège en France du pouvoir politique, financier et culturel, puisse avoir été — à condition de considérer l'ensemble de son agglomération — la principale ville industrielle de France. Or, elle a bien été la capitale française de la Révolution industrielle: entre la fin du XVIII^e^ siècle et le milieu du XIX^e^, son industrie a connu une forte poussée, mesurable en terme de production et de nombre d'ouvriers employés, ainsi qu'une transformation profonde, marquée par une mécanisation croissante et par l'apparition de nouveaux secteurs; elle a abrité, de façon plus générale, des entrepreneurs, capitalistes, techniciens et savants qui ont joué un rôle majeur d'entraînement dans le développement de toute l'industrie française de l'époque. Les données en sont plus ou moins bien connues des historiens. On estime ainsi qu'ayant doublé entre 1800 et 1860, sa population de plus d'un million d'habitants à cette dernière date vivait dans une proportion de 60%, de façon plus ou moins directe, du travail industriel. Dans un secteur aussi emblématique de la Révolution industrielle que la filature du coton, Paris comptait 44 établissements en 1813, il est vrai de petite taille et disparus pour la plupart dès les années 1820.

Les raisons pour venir parler d'un tel sujet dans un colloque d'archéologie industrielle sont que la discipline permet de prendre mieux conscience de ces faits oubliés. Non pas que les vestiges soient nombreux; ils ont été au contraire le plus souvent gommés par l'effort déployé pour nier ce caractère industriel qui ne 'colle' pas avec l'image que la capitale veut donner aujourd'hui d'elle-même. Mais il y a une manière de lire le paysage urbain qui permet de comprendre l'importance que l'emprise industrielle — celle des ateliers, mais aussi des habitations qui leur étaient liées — a eu sur le développement de la ville. Cette démarche de terrain fait d'abord ressortir des traces matérielles beaucoup plus nombreuses qu'on le soupçonnait, reconnaissant des voies — rues et canaux — dont le tracé ne s'explique que par leurs anciennes fonctions industrielles. Le parcellaire peut également révéler un mode de formation de la ville conditionné par la présence initiale de grosses emprises usinières. L'attention portée à ces vestiges, aussi ténus soient-ils, et se résumant souvent à ces contours et à ces espaces rebâtis, a encore la vertu d'inciter à rechercher et analyser l'iconographie disponible, et même les descriptions écrites les plus concrètes, qui, considérées seules, paraîtraient souvent incompréhensibles.

Il n'est pas question, bien entendu, de rendre compte ici de la diversité d'activités industrielles et artisanales qui comptaient plusieurs dizaines de milliers d'établissements. Nous voudrions simplement en évoquer les traits les plus saillants, à partir de cette approche qui privilégie la recherche de vestiges. Un premier point concerne l'ancienneté de l'implantation industrielle à Paris, tenant simplement au fait qu'en tant que capitale elle avait toujours à disposition un marché, des capitaux et des compétences. Paris a été, en particulier, une grande ville lainière dès le Moyen Âge. Aux XV^e^ et XVI^e^ siècles fonctionnaient le long de la Bièvre, affluent de la Seine dont le cours urbain a été recouvert en 1906, de très grands ateliers qui teignaient des draps fabriqués surtout dans la région de Rouen, que des marchands parisiens vendaient ensuite dans toute la France et même en Espagne ou en Italie. Quelques édifices subsistent, en particulier un grand bâtiment édifié en 1536 par les Gobelins, teinturiers venus d'Italie, longtemps considéré comme une ancienne résidence aristocratique, ce qui lui a valu l'appellation d'Hôtel de la Reine Blanche. Le quartier de la Bièvre continua, jusqu'à la fin du XIX^e^ siècle, d'être un quartier de teinturerie: une grande fabrique de draps y fonctionna aussi au XVIII^e^ siècle, à côté de tanneries et de brasseries. La manufacture de tapisserie des Gobelins y fut implantée au début du XVII^e^ siècle; elle est encore en activité.

A l'est de la ville, en des zones qui pouvaient être facilement approvisionnées par la Seine en matières diverses — bois, charbons, fers — l'industrie trouva aussi sa place, notamment dans le faubourg Saint-Antoine, encore récemment réputé pour son industrie du meuble. C'est là, à proximité de la Bastille, que furent installées quelques-unes des plus grosses entreprises de la capitale. La manufacture des glaces de Saint-Gobain y établit, vers 1680, ses ateliers de polissage des miroirs, qui employèrent jusqu'à 600 ouvriers à la fin du XVIII^e^ siècle. La fabrique de papier peint qu'exploitait Reveillon occupait dans ce même

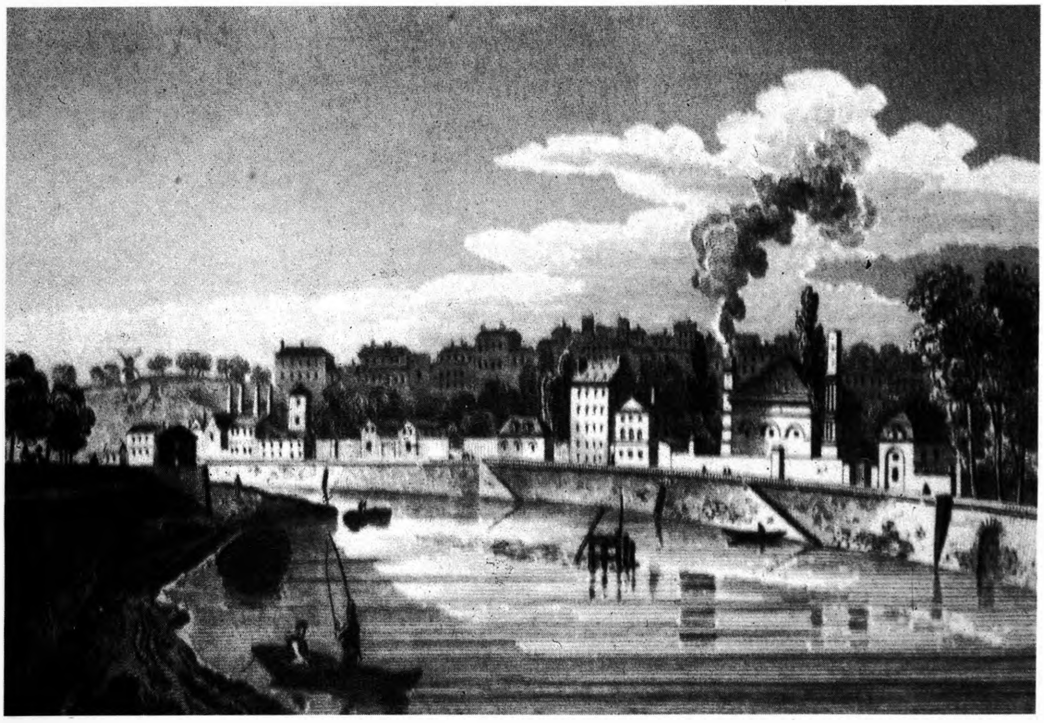

Figure 1.
Vue de la Seine vers 1819. À droite, la pompe à feu de Chaillot (Dessin de Goblain, gravure de Baugean, Extrait de Nouveau voyage pittoresque de France*). Photo © Photothèque des musées de la Ville de Paris.*

faubourg un hôtel construit à la fin du XVII[e], célèbre pour avoir été incendié en juillet 1789 par les révolutionnaires. C'est encore dans ce quartier que fut construite en 1732 la première usine de laminage de plomb, mue par un grand manège à chevaux, qui, compte tenu de la nouveauté de ses mécanismes, se trouva illustrée par plusieurs planches de l'*Encyclopédie*. Elle avait l'exclusivité de la couverture des propriétés royales. La plupart de ces grands établissements cessèrent leur activité au début du XIX[e] siècle. Leurs locaux furent néanmoins souvent réemployés par un artisanat qui continua d'être actif jusqu'au milieu du XX[e] siècle. Il permit la sauvegarde d'éléments épars plus ou moins anciens que seule une étude détaillée permet d'identifier et d'expliquer.

Dès le XVIII[e] siècle, furent également créés des établissements davantage liés aux changements habituellement attribués à la Révolution industrielle, en particulier l'utilisation du charbon et la mise en œuvre de machines à vapeur. La Seine, encore, joua un rôle décisif en permettant l'acheminement à coût acceptable, grâce au canal de Briare, de charbons extraits des exploitations minières profondes nouvellement installées en Bourbonnais et en Forez, dont l'usage s'accrut alors largement à Paris, aussi bien dans les ateliers de serrurerie et ferronnerie que dans les teintureries, les brasseries et même les fabriques de chapeau. C'est dans l'industrie verrière, celle de la fabrication des bouteilles noires servant à faire vieillir les vins de Bourgogne et de Bordeaux dans les caves, que cet usage nouveau fut toutefois le plus significatif. Des fours venus d'Angleterre, employant exclusivement le charbon, ont commencé à être employés dès les années 1720 dans les ports de Nantes, Bordeaux et Dunkerque. En 1750, cependant, c'est à l'ouest de Paris, au Bas-Meudon, toujours le long de la Seine (là où s'établirent, au début du XX[e] siècle, les usines automobiles de Louis Renault) que fut créée la verrerie à bouteilles qui allait devenir la plus importante de France. Ses fours servirent également à illustrer l'*Encyclopédie*. Une autre verrerie à bouteilles fut établie en 1792, cette fois en amont de Paris à Ivry, dans le quartier du Quai de la Gare qui prit ce nom parce qu'une gare fluviale y avait été aménagée quelques années auparavant. C'est dans cette zone que s'élevèrent à partir de 1918 les Grands Moulins de Paris, dont les bâtiments sont destinés aujourd'hui à accueillir des locaux universitaires.

L'installation de machines à vapeur de Watt est encore plus emblématique de la Révolution industrielle, et c'est Paris encore qui voit les premières réalisations. En 1781, les frères Périer établirent une machine à vapeur, ou 'pompe à feu', à Chaillot, pour élever l'eau de la Seine au profit de leur nouvelle Compagnie des Eaux (Figure 1). On sait moins que les Périer y créèrent en même temps une fonderie et une fabrique de machines à vapeur. Celles-ci équipèrent très vite de grandes entreprises comme les houillères d'Anzin dans le Nord et l'usine de laminage de plomb installé en 1784 à Saint-Denis, au nord de Paris. Elle se consacra aussi, dès 1789, à la confection de mécaniques à filer et carder. L'usine de construction mécanique de Chaillot n'a fait l'objet d'aucune représentation, alors que la pompe à feu voisine s'est trouvée très souvent illustrée, du fait de la qualité architecturale de son bâtiment (œuvre, d'ailleurs, d'un architecte connu, François-Joseph Belanger) ainsi que de sa situation remarquable en bord de Seine.

Dans la suite de ces installations pionnières, furent créées, dès les premières décennies du XIXe siècle, un grand nombre d'entreprises appartenant à deux secteurs emblématiques de la Révolution industrielle, à savoir la construction mécanique et l'industrie chimique, qui l'une et l'autre doivent leur essor initial à celui des industries textiles. Les premiers ateliers de construction mécanique, créés dans les années 1790–1810, petits établissements pour la plupart, fabriquaient surtout des métiers à filer et à tisser pour l'industrie cotonnière et lainière. Beaucoup, du reste, étaient aux mains de techniciens anglais. C'est le cas de l'usine créée en 1804 pour fabriquer du matériel destiné à l'industrie lainière par William Douglas, sur l'île des Cygnes, à quelques centaines de mètres de la deuxième pompe à feu des frères Périer. L'évolution ultérieure en a fait disparaître toutes traces, lorsque cette île a été rattachée à la rive gauche.

Un certain nombre de ces établissements utilisèrent d'ailleurs d'anciens bâtiments monastiques ou d'anciennes résidences aristocratiques. C'est notamment le cas de l'Hôtel de Mortagne, utilisé dès 1750 par Vaucanson pour abriter un atelier de construction servant à fabriquer des machines-outils et des 'modèles d'art mécanique', qui servirent en 1794 à constituer la collection du Conservatoire des Arts et Métiers. L'Hôtel de Mortagne, toujours existant, abrita aussi en 1801 les ateliers du constructeur anglais John Milne.

En 1820, cependant, c'est une usine entièrement nouvelle qu'élevèrent les Anglais Aaron Manby et Daniel Wilson en amont de Paris à Charenton, laquelle réunissait une forge à l'anglaise avec fours à puddler et laminoirs, une fonderie et une usine de construction mécanique pour fabriquer non seulement des machines à vapeur, mais aussi des équipements industriels, tels que laminoirs et moulins à broyer le tabac. Là non plus, il ne subsiste aucun vestige. On ne dispose même pas de vue pour nous montrer en élévation cette grande usine qui couvrait environ un hectare. Seuls sont disponibles quelques plans au sol, faisant voir la disposition générale des ateliers, et une série de beaux dessins de machines, appartenant au portefeuille du Conservatoire des Arts et Métiers.

Autre grand secteur industriel où Paris s'illustra, la chimie prit naissance après les découvertes qui permirent de fabriquer 'artificiellement' l'acide sulfurique, la soude et le chlore. Deux grandes usines au moins virent le jour avant 1820. D'abord celle de Javel, créée toujours en bord de Seine, dès 1777, qui compta parmi ses associés deux grands chimistes, Claude-Louis Berthollet, puis Anselme Payen. Ensuite celle que le comte J.-A. Chaptal et ses associés installèrent en 1806, aux Ternes, au nord-ouest de Paris, pour fabriquer à la chambre à plomb l'acide sulfurique, à laquelle fut adjointe une autre usine servant à produire la soude, établie à Nanterre. À cette industrie chimique, on peut légitimement adjoindre les nouvelles raffineries de sucre, non seulement parce qu'elles comportaient d'importants équipements de distillation, mais aussi parce qu'elles nécessitaient la production parallèle de noir animal, par la calcination d'os de bovins. Benjamin Delessert, l'un des pionniers de cette industrie, créa dès 1804 une grande raffinerie à Passy, en aval de Chaillot, et une fabrique de noir animal au sud de Paris, à Montrouge.

La Seine, on le voit, joua un rôle considérable dans les choix d'implantation de ces nouvelles usines. Il est certes difficile d'en suivre la logique sur le terrain, tant ont été nombreux les réaménagements ultérieurs, qui ont eu pour effet, en particulier, d'effacer les liens qui existaient originellement entre la ville et le fleuve. Il reste évident, cependant, que l'expansion de Paris à l'Est comme à l'Ouest a été commandée en partie par ce développement usinier. A l'Ouest, l'installation de la plus grande entreprise du début du siècle, la manufacture de tabac du Gros Caillou, avec ses 1 300 employés en 1811, est venue en quelque sorte amorcer le mouvement d'extension qui, au-delà des Invalides, permit de rejoindre, par l'urbanisation de la plaine de Grenelle, l'ancienne usine de Javel (emplacement ultérieurement occupé par le constructeur d'automobiles André Citroën).

À partir des années 1820, cependant, un nouveau mode d'implantation s'imposa consécutif à la refonte progressive du système de transports, marqué d'abord par le creusement des canaux de Saint-Denis (Figure 2), de l'Ourcq et de Saint-Martin, achevés en 1825, puis par la construction, à partir des années 1840, des premières lignes de chemin de fer. Les grandes usines se positionnèrent désormais par rapport à ces nouveaux axes.

Un exemple particulièrement intéressant est celui de l'usine de construction mécanique que François Cavé installa à partir de 1830 à l'extrême nord de Paris, en haut du faubourg Saint-Denis. Exemplaire d'une génération de mécaniciens qui prirent le relais des mécaniciens anglais du début du siècle, Cavé, qui avait en fait une formation

Figure 2.
Canal Saint-Denis à Paris. Entrepôts édifiés à partir du milieu du XIX^e siècle et transformés aujourd'hui en locaux d'activités. Photo © Philippe Fortin, Inventaire général, 2000, ADAGP.

de menuisier et ne passa du travail du bois à celui du métal que vers 1820, fut un inventeur extrêmement fécond. Il mit au point la machine à vapeur oscillante vers 1825, puis construisit les premiers bateaux à vapeur français. L'un d'eux, le *Courrier de Calais*, était considéré en 1828 comme le plus rapide de son temps. Il entreprit en 1838 la construction de locomotives destinées à la ligne du Paris-Saint-Germain et avait conçu, dès 1836, un système de marteau mu par le vapeur qui annonçait le marteau pilon; il mit encore au point l'une des toutes premières riveuses mécaniques. L'usine qu'il installa aux portes nord de Paris couvrit progressivement 2,5 hectares. Elle reçut vers 1840 deux grandes halles de fonderie et de montage faisant chacune 36m de long. La vente de l'entreprise en 1853 fut suivie quelques années plus tard par sa démolition totale pour permettre la construction d'immeubles résidentiels qui ont effacé, au temps du préfet Haussmann, toute référence à cette grande activité industrielle, dont, une fois de plus, il ne reste aucun vestige, pas même une image.

L'étude de ce quartier a révélé en fait que Cavé n'y était pas le seul constructeur, quoique le plus important, et qu'à côté se trouvaient d'autres mécaniciens et fondeurs tels Etienne Calla, installé dès 1806 rue du Faubourg-Poissonnière, et Antoine Pauwels qui, après avoir établi l'une des premières usines à gaz parisiennes, dès 1820, dans cette même rue, vint élever en 1836 une usine de fabrication de machines à vapeur pour bateaux, puis de locomotives, à La Chapelle-Saint-Denis, au nord de Paris. La construction de matériel de chemin de fer dans une zone qui vit s'établir trois gares au cours des années 1840, constitua évidemment un stimulant majeur (Figure 3). Mais il faut noter que ces établissements commencèrent souvent par fabriquer du matériel pour bateaux à vapeur et pour usines à gaz, c'est-à-dire déjà de grosses pièces de fonderie et de chaudronnerie.

Le développement de ces grandes usines de construction mécanique au nord et nord-est de la capitale, dans l'environnement des nouveaux canaux, au moment du reste où le long de ces mêmes canaux s'installaient huit raffineries de sucre, ne doit pas occulter un autre phénomène, sur lequel nous finirons notre présentation. Il se prête d'ailleurs à un autre type d'approche sur le terrain, dans la mesure où il correspond moins à la constitution de nouveaux ensembles qu'à la réutilisation de bâtiments existants et à la densification de parcelles qui n'ont pas modifié radicalement l'ancien tissu urbain.

C'est selon ce mode que ce sont industrialisées un certain nombre d'activités traditionnelles axées sur la production de biens de consommation, qui tout en restant dans le cadre des fabrications de qualité, voire de haute gamme — les 'articles de Paris' — ont connu une certaine mécanisation, en recourant éventuellement à de petites machines à vapeur et en introduisant la production en série. A cette catégorie appartenaient des secteurs aussi divers que la confection d'habits, le travail des métaux — fontes et bronzes notamment — l'imprimerie, la parfumerie...

Un secteur particulièrement intéressant est celui de la fabrication d'instruments scientifiques et de modèles de machines dont

Figure 3. Vue de Paris en 1855 (détail). Quartier des gares du Nord et de l'Est. L'une des cheminées est sans doute celle de l'usine Cavé. Dessin de J. Arnout, gravure par Outhwaite. Photo © Département des estampes et de la photographie, Bibliothèque nationale de France.

Paris s'est fait une spécialité. Elle traduit bien le rôle majeur que la ville a pu joué dans l'innovation. Une soixantaine de modèles fabriqués par Eugène Philippe, qui avait établi en 1831 ses ateliers au nord de Paris rue du Chateau-Landon, figurent dans les collections du Conservatoire des Arts et Métiers. On y remarque un atelier complet pour la fabrication de roues, avec machines réduites à percer, scier et araser. Autre secteur clef, la fabrication de meubles existait depuis le XVII^{e} siècle dans le faubourg Saint-Antoine (Figure 4). Le rassemblement au sein d'unités locatives d'ouvriers travaillant dans la succession de métiers complémentaires qu'exigeait la confection d'un meuble de qualité, donna naissance à des immeubles particuliers à quatre ou cinq étages, largement éclairés. Un inventaire systématique en a recensé une centaine. La prise en compte de cette petite industrie est assurément essentielle. En terme de nombre d'ouvriers employés et de chiffre d'affaires, elle restait majoritaire. Mais pour finir, il convient aussi de dire que cette présence a permis à la grande industrie de se développer à Paris avec des spécificités propres. Parlant de l'entreprise Cail — au départ fabricant de matériel pour sucrerie, devenu au milieu du XIX^{e} siècle la première entreprise de constructions mécanique et métallique de la capitale — Turgan, dans le tome IV des *Grandes Usines,* écrivait en 1869: 'Aux premiers pas que l'on fait dans la cour, on sent qu'on est dans une usine parisienne ... L'artisan est entouré de luxe et d'élégance dont il prend malgré lui l'exemple...'.

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Figure 4. Cour d'ateliers, 37 bis rue de Montreuil (Paris XI^{e}) dans le faubourg Saint-Antoine. Emplacement de l'ancienne fabrique de papiers peints Reveillon. En 1853, ce site fit l'objet d'un programme d'ateliers et de logements ouvriers, financé, en partie, par l'industriel anglais Robert William Kennar. Photo © Philippe Fortin, Inventaire général 2000, ADAGP.

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'Ignorant of all science': Technology transfer and peripheral culture, the case of Gwynedd, 1750–1850

David Rhys Gwyn

At the beginning of the 18th century, Gwynedd (north-west Wales) was one of the least industrialised, and least mechanised, areas of western Europe. Its mineral reserves were unexploited, and industrial technologies were unknown. In the course of the following century, although a lack of coal and textiles prevented Gwynedd achieving more than a modest position amongst the regions of the British Isles, its slate quarries, and its mines of lead and copper came to sustain an economy that was partially industrialised. At the same time, the Telford road and Stephenson's railway to Holyhead, and the bridges by which they crossed the Menai Straits, demonstrated engineering on a new scale. Although the population of the area became increasingly literate in this period, it remained loyal to the Welsh language, sustained by the traditions of Protestant dissent. The following paper therefore examines technology transfer to a recipient culture, by studying the outlook of the regional élite, the movement of experts, particularly of experienced miners from Cornwall, and the means by which technical knowledge was passed on. As such, it offers a regionally-based and sector-based approach to the problem of industrial 'take off'.

'Dans l'Ignorance de toute science': Transfert technologique et culture périphérique, le cas de Gwynedd, 1750–1850

Au début du XVIII^e siècle, le comté de Gwynedd dans le nord-ouest du Pays de Galles était l'une des régions les moins industrialisées et les moins mécanisées de toute l'Europe occidentale. Ignorant les nouvelles technologies industrielles, le Gwynedd n'exploitait pas ses ressources minérales. Sans charbon et sans industrie textile, la région n'est jamais devenue un grand centre industriel, mais, au XIX^e siècle, les carrières d'ardoise et les mines de cuivre et de plomb ont néanmoins soutenu une économie en partie industrialisée. La route nationale de Thomas Telford et le chemin de fer jusqu'à Holyhead, de Robert Stephenson, ont fourni, dans leurs ponts respectifs à travers le Menai, des exemples retentissants des technologies modernes de génie civil. Pendant la même période, l'analphabétisme était en retrait, même si le peuple, nourri par de fortes traditions protestantes, parlait surtout gallois. La communication analysera donc l'acquisition de technologies industrielles par un pays non-initiateur, en considérant la mentalité des élites régionales, la venue d'une main d'œuvre spécialisée, notamment les mineurs de Cornouailles, et comment les savoir-faire techniques se sont diffusés. Elle tient ainsi à apporter une contribution sectorielle et régionale au problème du 'take-off' industriel.

Introduction

In the summer of 1823, after Lord Newborough of Glynllifon had given instructions that his slate quarry in Ffestiniog was to be opened again, his London surveyor, Samuel Smith of Lincoln's Inn Fields, made his way along the quarry road to check up on progress. He was not impressed. John Hughes (1766/7–1845), the manager was, he suggested:

> ... A clever man in his Business but quite illiterate and ignorant of all Science who was brought up a Blacksmith & spent more than 30 Years at his Trade working at his anvil ... I therefore take the liberty of suggesting that the Advice and Opinion of some skilful and scientific Engineers be obtained and also that of the most experienced practical men. Lord P[enrhyn] had the advice of several eminent men.[1]

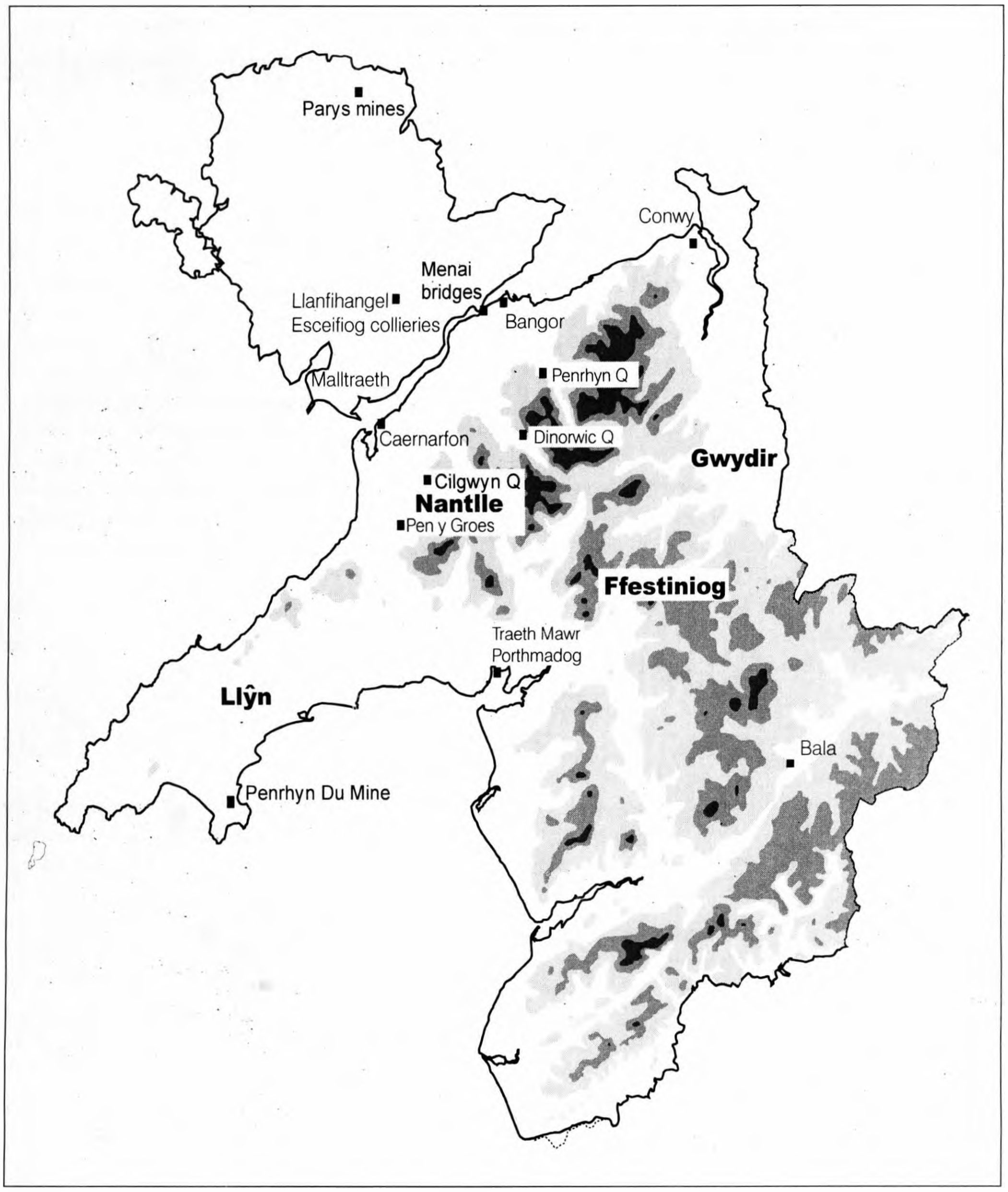
The lawyer William Glynne Griffith, Newborough's agent, wrote back:

> John Hughes is a man possessed of great strength of Mind and Judgement and by no means wanting in experience, and where any difficulties occur or are to be encountered in any of the principal slate works in this County his Opinion and Skill is appealed to. The fact is that Mr Smith has been unfortunate in the source from which he has derived his information ... The late Lord Penrhyn was guided in his works by the Opinion of the experienced Quarry men of the Country ... I am convinced that no practical advantage or good could be gained from the opinion or Judgement of an Experimental Engineer *un*acquainted with the essential qualities and Constitution of this particular fossil.[2]

Many of the management and technical priorities of the early industrial revolution in Gwynedd (the historic counties of Anglesey, Caernarvonshire and Merioneth in north-west Wales)[3] are implicit here — the lordly owners of the quarries (as well as of much land elsewhere), the lawyers and consultants who administered their estates, the practical men who managed the quarries, little removed from the workmen, wise in their craft. The purpose of this paper is to examine the role of all these social groupings in the development and transfer of technology within this area in the period 1750 to 1850.

Background

Nowadays this area forms part of the periphery of the United Kingdom economy, and so it did in the mid-



18th century, but in the intervening period its reserves of slate, lead and copper brought it into the mainstream British economy. Yet it remained largely untouched by industrialisation in the 'leading sectors' of coal and textiles, and never developed the networks of mechanics' or scientific institutes that appeared in many places in England. Still less was there any institution that could offer an academic education in Natural Philosophy such as was available at Glasgow and Edinburgh Universities, nor the formal engineering training represented in France by the École des Ponts et Chaussées, in Prussia by the Department of Mines and Ironworks and the Freiberg Mining Academy.

In the early years of the 18th century, Gwynedd remained a rural area, largely untouched by even the modest industrial developments which were already transforming other parts of Wales. A limited amount of mineral extraction took place — slate-quarrying on the Cilgwyn wastes south of Caernarfon, lead-mining on the Llŷn peninsula and in the Conwy valley, mining for coal on Anglesey, and some stone quarrying here and there — but the overall picture is of a backward, sleepy society of bucolic squires and conservative, tight-fisted farmers. Knowledge of English was very rare indeed, though the Society for the Promotion of Christian Knowledge and the circulating schools were beginning to make an impact on illiteracy in the Welsh language. In terms of its technical culture, it lagged far behind its neighbouring counties. Machines of any sort were practically unknown, other than corn-mills, powered variously by wind, tide or river, and water-driven fulling mills. Clock-making had barely established itself.[4] Even wheeled carts were a rarity; it was to be several decades before they penetrated some of the upland parishes.[5] Ship-wrighting was all but unknown.[6]

Within a hundred years, the picture was to change completely. By 1850 Anglesey was already reverting to its agricultural base, having for a few heady years dominated the world market in copper from the mines on Parys Mountain. Caernarvonshire and Merionethshire had long assumed the leading role in the production of roofing-slates over a world market. Ocean-going ships were being fabricated in shallow creeks the length and breadth of the coast.[7] Thomas Telford's revolutionary suspension bridge had crossed the Menai Straits, and now barely a mile away there stood Robert Stephenson's tubular railway bridge, through which, on 5 March that year, the first train ran. Even the tramways on which horses pulled slate wagons to the sea would, before long, find a new lease of life as passenger-carriers with locomotive haulage, providing a cut-price method of railway-building which brought engineers from all over the world to marvel and imitate.[8]

The social transformation was no less complete. The position of the Welsh language, far from weakening, had strengthened immeasurably, mainly through the encouragement given to education by the dissenting congregations, which over the preceding hundred years had come to claim the allegiance of the great majority of the population. Higher education, however, was for prospective ordinands only — Oxford, Cambridge, or Trinity Dublin for the churchmen, the lesser glories of Bala Theological College (founded 1837) for the nonconformists.

This remarkable change begs a number of questions. How, within a linguistic minority culture, and away from the leading sectors, was technology transfer possible? Was there a regional technical culture which, however initially modest, proved sufficiently adaptable to meet the needs of this industrialising area? Or were technical developments wrought by immigration from established industrial centres outside Gwynedd, or indeed by the arrival of heroic figures like Telford and Stephenson?

The career of these last two men as it was played out within Gwynedd has entered history. The building of the Conwy and Menai bridges represented a technical response to broader political and economic issues, above all the need to create reliable transport links between the capitals of England and Ireland, and the lessons learnt in building them form part of the world-wide diffusion of engineering knowledge.[9] In their study of the Britannia bridge, Professors Rosenberg and Vincenti emphasise the need to:

> ... look at technological change in particular rather than in general, as the outcome of some specific set of concrete human actions and learning experiences rather than as some vague machina ex deo from which material blessings have been made to flow.[10]

The value of such an approach is not only that it can be applied to humbler levels of achievement, but can also suggest ways in which these might have been affected by whatever major engineering projects were going on in their midst. Above all, it emphasises the human dimension to technical change. This is not to fall back on 'heroic' explanations. As well as the personal qualities — doggedness, courage, insight — which a generation raised on Samuel Smiles learnt to associate with the engineer, the social relationships which exist between individuals, as well as the economy and the broader intellectual milieu within which they functioned, all dictate the pace and scale of innovation. It is with this in mind that the following analysis takes as its starting point the different functions by which individuals affected technical change — the patricians who funded industrialisation, those who administered the process, and those who rolled up their shirtsleeves to build and maintain machines.

Patricians

In Gwynedd, land was concentrated in the hands of a few individuals. Though some, like Lord Newborough, were descended from the Welsh noble tribes, they were increasingly apt to marry beyond the borders of Wales, forgetting their Welsh and acquiring in the process a social polish and a tendency to rebuild their houses every so often.[11] Sir Nicholas Bayly of Plas Newydd (1707–82) was another such; his son became Earl of Uxbridge and his grandson Marquis of Anglesey. This family owned the moiety of the copper-ore beds on Parys mountain, and of the old lead mine at Penrhyn Du on the Llŷn peninsula, as well as much of Anglesey's tiny coal-field, and extensive collieries in Staffordshire. A complete *arriviste* was Richard Pennant (1737–1808), first Lord Penrhyn, who, by marriage and by purchase, acquired the old Penrhyn estate in the Ogwen valley, and its slate quarries, which soon reaped the benefit of the enormous wealth Pennant had accumulated from his Jamaican sugar plantations. Pennant was a classic 'improver', with close links to the commercial world of Liverpool. His neighbour, Thomas Assheton Smith III (1776–1858), squire of Vaynol, survives in memory as a hard-riding Tory of the old school, with a violent temper and ready fists. Even so, his passion for all things steam not only led to improvements in his own slate quarry, but also prompted him to dabble in ship design. The wave theory that John Scott Russell (1808–82) confirmed scientifically, Tom Smith considered himself to have established by trial and error — which in his case meant building a succession of extremely large yachts. Though his physics had been imbibed at Eton, and he had picked up some mathematics from a local postmistress, he was as much a 'rule of thumb' man as any rural artificer, deriving his theories of hull design from watching ducks land on the Menai Straits.[12]

These men and their kind had abundant wealth to reinvest in industrial developments. Less successful was William Alexander Madocks (1773–1828), a Foxite M.P. and fellow of All Souls', who ruined himself building an embankment to enclose the mouth of Traeth Mawr, though not before he had set out the model village of Tremadoc and laid the basis of the area's Victorian prosperity.[13]

Agents and Managers

Whilst the gentry undoubtedly financed and patronised the process of industrialisation, it was their immediate clientele that actually managed affairs, either directly on their patrons' behalf or as their tenants. Significantly, there were, by the end of the 18th century, plenty of social organisations where they could mingle with their aristocratic patrons — the Menai Pitt Club, the Militia, the hunt clubs, the Druids and doubtless Freemasonry — as well as county honours such as the High Shrievalty to which they could aspire.

Inevitably, local attorneys are well represented in this category. Many acted on behalf of several estates and individuals, and in the process developed business interests of their own. By far the most successful of them was Thomas Williams, *Twm Chwarae Teg* ('Tom Fair Play' — 1737–1802), whose management of the Parys copper mines made him an astonishingly wealthy man, and whose commercial empire dominated world production.[14] Others were Owen Poole of Llangefni (1779–1841), Henry Rumsey Williams (1774–1841) of Caernarfon and John Evans (1766–1827), also of Caernarfon. Evans best embodies the attributes of this new class, not only in his ruthlessness but also in the coterie of like-minded minor gentry and businessmen he attached to himself. When he took a lease on the crown slate quarries at Cilgwyn in 1800, his partners included a Bangor gentleman who was fond of writing low-church tracts,[15] the then manager of the Earl of Uxbridge's Parys copper mine, and a local banker who was also a prominent Baptist.[16] This last individual was already leasing the Hafodlas slate quarry in nearby Nantlle, at that time the most technically advanced in Wales, and, as Evans pointed out, understood how to construct water-wheels, pumps, horse-whims 'and other machines that are necessary for working a Quarry'.[17] Evans, though a Church-and-State man himself, was not bothered by religious affiliation, and it is possible that the appearance of bilingual dissenters in business circles kept open the lines of communication with the more articulate and skilled craftsmen and quarrymen.[18]

The most prominent dissenting businessman in the area, however, was the English Unitarian Samuel Holland, who in 1821, at the age of eighteen, arrived in Blaenau Ffestiniog from Liverpool clutching a carpet-bag, to take charge of the slate quarry his father leased from the Oakeley estate, and to manage a workforce who could not understand a word he spoke.[19] Holland was unusual in that his background lay specifically in commerce, rather than in estate management.

Other members of this élite had first come to notice as upper servants — men with considerable experience of management, some investment capital and a wide range of contacts. George Bettiss, erstwhile house-steward to Lord Newborough of Glynllifon, not only became a quarry tenant in his own right, but also moved into the lucrative hotel business, hosting Pitt Club meetings and marrying into the family of the county's leading Tory attorney. Edward Pearson, butler to the Nannau family, and John Mann, butler to Lord Penrhyn, also invested in slate quarrying and shipping respectively.[20] William Madocks appointed John Williams, the Marquess of Anglesey's gardener, as site manager and executive engineer of his sea-wall at Traeth Mawr. Williams had no knowledge of civil engineering but had the experience and vision to carry through a large project – he had worked with Humphry Repton on the Plas Newydd gardens and had managed a labour force.[21]

These changes reflect the more hard-nosed attitude that landowners began to take towards their property from the late 18th century onwards, and the conviction that they could be best developed by individuals who spoke — literally — their language, rather than by local quarry partnerships. Assheton Smith leased the Vaynol estate's Dinorwic Quarry to English adventurers from 1787, the crown leased out Cilgwyn to John Evans and his partners in 1800, and at Ffestiniog the same year, an experienced group of Lake District slate-quarrymen managed to buy Diffwys quarry from the Wynne family before the established Welsh workforce could raise the purchase price. Where Welshmen held their own, such as in the Nantlle slate district, which was never dominated by one landlord, they also appointed in their own image; at Dorothea Quarry in 1849, the overseer was chosen by ballot of the shareholders, in the true Methodist fashion.[22]

Lord Penrhyn, however, chose to work his slate quarries directly, at the suggestion of William Williams (1738–1817) a former saddler who, being able to read and write, and having a talent for map-making, found himself secretary to Richard Hughes, overseer of the Penrhyn estate and of its scattered diggings. 'He, in the year 1782, was the humble means of inducing ... Lord Penrhyn to "form the wise and benevolent resolutions [*sic*] of opening a spacious slate quarry" at Cae Braich y Cafn.'[23] Yet the same tendency to appoint from outside became apparent here also. Ironically, as output expanded under Williams, the quarry came to need roads, a harbour, then an iron railway and a slab manufactory, which called for engineering skills which Penrhyn did not believe him to possess. In 1786 the architect Benjamin Wyatt from Staffordshire was appointed estate agent over Williams's head and immediately initiated a vigorous programme of estate improvement. Other individuals in the same mould followed — a Sussex surveyor-engineer, James Greenfield, assumed responsibility for the quarry in 1802, and married Wyatt's daughter. Williams's name never appeared on the Pitt Club rolls (despite his impeccable Toryism) nor was he appointed to the County Agricultural Committee, the magistrate's bench or the Turnpike Trust.[24]

If Williams was unable, or was not permitted, to try his hand at major engineering projects, his son Robert (1779–?) fared better. Like his father, he learnt the land surveyor's task of recording an existing landscape. This led to his becoming an enclosure commissioner and estate manager. Somewhere on the way he acquired the skills of the engineering surveyor, who decides how best to fit a project into an existing landscape, producing plans for the Dinorwic Quarry Railway of 1825 and Caernarfon's water supply.[25] James Spooner (1790–1856) made the same progression, beginning as a surveyor in his native Worcestershire, and joining the Ordnance Corps as a civilian, with whom he arrived in Wales in 1816. In 1823 he produced an able survey for an unbuilt railway on Moelwyn mountain, and in 1830 the masterly survey of the Ffestiniog Railway, opened in 1836, of which he became the manager, adding the responsibilities of engineer in 1847 and secretary in 1853.[26] Other surveyors doubled up as, for instance, architects, but in their readiness to learn new skills they were typical of their profession throughout Wales at that time; first and last, they figure in the lists of the managerial class.[27] They were not only trained to observe the economic potential of the estates they surveyed but were also well placed to make contacts amongst the gentry and to advise on business partnerships.[28]

Practical Men

Though mines, quarries and engineering works might be under the authority of the landowners and the general direction of their immediate clientele, they required the day-to-day supervision of practical men.[29] This might be an experienced and trusted workman, a manager of men, or else an expert in building and maintaining machines, who might or might not be acknowledged as an 'engineer', and who might or might not be a Welshman.

Substantial civil engineering works initially required the technical skills of outsiders, even if work-force management could be entrusted to a local man. Experts from the Bedford Level were brought in to carry out sea-defence works — James Golbourne at Malltraeth Marsh from 1788,[30] and James Creassy at Traeth Mawr from 1800 to 1813, assisting the sometime gardener John Williams.[31] The construction of the post road across Gwynedd from 1815 to 1830, and of the Menai Bridge, depended on Telford's own coterie of engineers and craftsmen, but undoubtedly affected the technical culture of the area through which it ran. His assistant Provis found time to accept other contracts in Gwynedd, and even attempted to gain his own foothold in the burgeoning slate industry.[32] Individuals who had worked in subaltern positions on the post road acquired the confidence to accept responsibilities at which they would formerly have balked. William Owen, an Anglesey farmer who constructed the bed of the Nantlle Railway in 1826–8, may have been a foreman on the road.[33] So, probably, was Thomas Prichard (*c.*1799–1866), 'a very good & competent man', who assisted Spooner first in building the Ffestiniog Railway, despite a quarrelsome and parsimonious Managing Director and inexperienced contractors, then in running it.[34] It is unlikely to be a coincidence that foundries appeared at Bangor and Menai Bridge in the 1820s.

The building of the Britannia Bridge and of the Chester and Holyhead Railway between 1845 and 1850 had less direct impact on the area. Unlike the railways built through mid-Wales from the 1850s onwards, which transformed some rural craftsmen into business moguls,[35] the Chester and Holyhead made use of English contractors, even if they in turn employed Welsh labour, the rural poor who afterwards filled the jobs of porter and platelayer on the completed railway.[36] Some items were supplied locally; Robert Stephenson was sufficiently impressed with Owen Thomas's Union Iron and Brass Works in Caernarfon to order components for the Britannia Bridge from him. A contract to supply girders for Barry's Houses of Parliament followed in 1852.[37]

It was a different story in the mines and quarries of Gwynedd, with their need for smaller-scale technology. The Plas Newydd estate mined lead at Penrhyn Du, copper on Parys mountain and coal at Llanfihangel Esceifiog; personnel, even individual machines, moved from site to site. It is in the coal-pits that we first hear of horse whims in Gwynedd, in 1742,[38] though the English origins of the windlass and the whim is demonstrated by their Welsh names — *tyntri* ('turntree') and *chwimsi*. Such machines were erected in the open, and could be seen from footpaths and turnpikes — easy things to copy. It is here also that we first hear of a railway proposal, in 1757, when a prospective tenant attempted to interest Sir Nicholas Bayly in the idea of building a canal or a 'frame road' to the sea.[39] Bayly's Penrhyn Du mine, on the other hand, was so near the coast that 'they may cast the ore into the ship' — handy for the smelters of north-east or of south Wales, if only the problems of flooding could be sorted out. Local millwrights and consultant engineers from London were variously sounded out about water- and horse-driven pump engines, until in 1768 the then lessees resolved on a water-wheel and flat-rods, stipulating, significantly, that 'a proper Engineer be employed To View the ground'. When Roe and Company of Macclesfield took over, a water-wheel and pumps of recent erection, which had cost no less than £600, were dismantled and moved without permission to the Parys copper mine by Jonathan Roose, their agent[40] — the same Jonathan Roose who, on 2 March 1768, by sinking a shaft at the Golden venture, confirmed the mineral wealth of Parys and 'First drew its minerals blushing from the ground'.[41] In 1779 a Boulton and Watt pump engine, the first steam engine in Gwynedd, was installed at Penrhyn Du under the supervision of Jabez Hornblower, recently sacked from his position with the Soho Foundry.[42] Parys followed suit in 1790, with the erection of a rotative engine.[43]

At much the same time, the copper mines on Assheton Smith's Vaynol estate were undergoing a revival. Experienced miners from Cornwall were making their way to his Drws y Coed mine in the Nantlle valley, where they constructed the first known stamp-mill in Gwynedd, in 1769–70.[44] This venture was short-lived, but from them the local slate quarrymen learnt the use of gunpowder and possibly of the horse-whim. The decline of Drws y Coed from the 1770s onwards coincided with the rise of the Nantlle slate industry, and the Cornish community which had worked in the one migrated to the other.[45] It was the same story at Vaynol's Llanberis copper mine, where the immigrant managers, the Closses and the Wheldons, married into the families which were running the estate's slate quarries, and founded the dynasties from which the estate drew its managerial staff into the following century.[46]

Quarrying for slate, that 'most Welsh of Welsh industries', had been under way here since at least 1700, and for very much longer in the Ogwen valley and Nantlle, but until the late 18th century had been untouched by technical developments elsewhere. Partnerships, often based around family units,[47] quarried the rock, hand-split and dressed the blocks to produce roofing slates, transported them to the coast, and even kept an eye on marketing in London.[48] Here the picture that emerges is of a vigorous and expanding economy, generating profits which were reinvested elsewhere in Gwynedd. Methusalem Jones (1731–1810) not only quarried and shipped Cilgwyn slate, he also farmed, built houses for the Parys miners, and kept a pub in Caernarfon, where he became a burgess. It was he who, following supernatural revelation, set out across the mountains to establish slate quarrying in Ffestiniog.[49]

Men such as Methusalem Jones were skilled craftworkers and canny salesmen, but they lived in a world which had little need of technology or machines.

Nevertheless, though he and his kind lost out to an English or Anglicised business class, they effectively re-emerged as the quarry stewards and engineers of the early 19th century. By this time the bilingual minority were in a strong position — men such as William Rowlands, who had learnt English (and, as it happens, French) in the army, and became Samuel Holland's trusted agent. Less to be envied was the Ffestiniog quarryman who had picked up some English as a valet, and who was deputed by his work-mates to negotiate with Lord Palmerston over their unpaid wages.[50] For those entrusted with building machines, as well as the technology bequeathed by the Cornishmen, there were other sources of inspiration — for instance, the Black Countrymen coal-masters at Tal y Sarn quarry in Nantlle in the 1820s who brought with them 'wonderful engines', water-balances and rope-haulage mechanisms.[51] Under these circumstances, local artisans learnt to construct the mills, prime movers, cableways and railways that the quarries required. John Hughes, who as manager of Lord Quarry prompted Samuel Smith's patronising comments, was indeed a blacksmith by calling, but as well as constructing machines, he could turn his hand to land-surveying, and to house-, road- and bridge-building. Illiterate until well into adulthood, he learnt to write both Welsh and English. His neighbour John Edwards Pen y Groes (1782–1834) trained as a wheelwright (itself a craft of no long standing), but his forte was the construction and installation of water-power systems for operating slate saw-mills or for pumping. His best-remembered machine was a three-stage water-engine at Hafodlas Quarry, consisting of three water-wheels, one above the other, driven by the same stream and meshing with each other by rim-gears — a system which requires exceptionally fine workmanship if it is to operate successfully.[52]

To anyone living in any of the industrialising communities of Gwynedd at this time, there were new marvels to see day by day, as turnpikes and railways were carved out of the hill-slopes, and carpenters and masons struggled to erect machines on the edges of ever-deepening quarry pits. One who beheld and wondered was the young Griffith Williams (1824–81), whose pleasure it was to build miniature versions of the water-courses and machines in the quarry at Ffestiniog where his father worked. Initially these were play-things, but by the time he grew into his teens he had convinced himself of the possibility of turning them into a machine of perpetual motion, whereby a pump or perhaps a hydraulic ram, fed from the tailrace of a water-wheel, pumped the water back to the wheel. Friends and neighbours crowded into his workshop to see the prototype, and money was offered to help bring it into being. Inevitably, it failed to work, and Williams derived some consolation from tinkering with the machines in the quarry, where he had more success, before finding his true vocation as a Congregationalist minister.[53] If he and his circle appear to have inhabited a different universe from Telford and Stephenson, it is worth reflecting that in a culture ignorant of the first law of thermodynamics but conscious of innovation and novelty, all things might seem possible. It was in this vein that the wheelwright-poet Matthew Owen recalled his youth many years later:

> I remember Aber Cegin before any ship could come near it, and when all the slate was carried down on the backs of mules, in baskets. Then I saw a hundred and twenty teams on the road carrying slates in carts; and now four hundred and fifty wagons bring the slate down on the railway. In the course of my life the post road from Holyhead was built through Nant y Benglog and through Llanllechid, Holyhead harbour was built, and the lighthouse at Ynys y Blawd, Malltraeth and the Traeth Mawr were enclosed, Menai bridge and Conwy bridge were built, and I was the first to sing a song of praise to the Menai bridge.[54]

The arrival of new technologies, which for Owen mirrored religious and moral improvement, appealed strongly to nonconformist craftsmen increasingly convinced that they might remake their world in their own image. Even so, the godly ordinance of Methodism could not suspend the laws of nature, nor reverse the doom of man. The traveller Edmund Hyde Hall came across another enthusiast for perpetual motion around 1810:

> While visiting at Gelliwig I heard of an attempt made or making to discover the perpetual motion by a poor man resident in a wretched hovel wretchedly situated. The ambition of making this discovery is not uncommon, I understand, in this part of the world, and more than one adventurer is engaged in the enterprise. I was eager to examine the machinery and to learn the process, though my faith in its success, as may easily be supposed, was not very abundant. We accordingly explored the spot, found the house, and rapping at the door found that the man was in the agonies of death. Oh ambition![55]

Conclusions

The technologies introduced to Gwynedd in the latter half of the 18th century and the earlier half of the 19th were for the most part simple and purposive, called forth by the requirements of extractive industries and civil engineering projects. Technology transfer took place not through formal scientific education but through personal contact, observation and emulation amongst individuals who were in that sense 'ignorant of all science'. Linguistic and other cultural barriers obstructed, but did not entirely impede, this process. Study of this area in this period serves as a reminder that the early phases of the industrial revolution can only be understood if the human agents of technical change are also studied, in their familial, social, even devotional milieu. It also emphasises the need for further study of industrialisation by sector and by region.

Notes and References

1 Caernarfon Record Office (CRO), XD2/15699.

2 CRO, XD2/15357.

3 Gwynedd is both the pre-Conquest kingdom of north-west Wales, and a county, created in 1972. Boundary changes in 1996 lopped off Anglesey and part of the eastern area shown on the map. For convenience's sake, these changes are ignored.

4 From 1745, at Llanrwst, as an enclave of the clock-making industry of Lancashire and Cheshire — Brown, C. & M., *The Clockmakers of Llanrwst* (Wrexham: Bridge Books, 1993), 217–8, 262–3.

5 Owen, Trefor, M., 'Y Drol Gyntaf', *Medel*, 3 (1986), 21–6.

6 Thomas, D., *Hen Longau Sir Gaernarfon* (Caernarfon: Caernarvonshire Historical Society, 1952).

[7] Space precludes any treatment of the development of ship-wrighting in this period, which has been expertly covered by Aled Eames.

[8] Ransom, P.J.G., *Narrow Gauge Steam: Its origins and world-wide development* (Yeovil: Oxford Publishing, 1996).

[9] Paxton, R.A., 'Menai Bridge (1818–1826) and its Influence on Suspension Bridge Development' *Transactions of the Newcomen Society*, 49 (1977–8), 87–110; Rosenberg, N. & Vincenti, W.G., *The Britannia Bridge: The Generation and Diffusion of Technical Knowledge* (Cambridge: Massachusetts Institute of Technology Press, 1978).

[10] Rosenberg & Vincenti, ref. 9, 2.

[11] For the fusion of the élites of Wales with those of England and Ireland, see Colley, L., *Britons* (New Haven and London: Yale University Press, 1992), 155–64.

[12] See Eardley-Wilmot, J., *Reminiscences of the Late Thomas Assheton Smith* (John Murray, 1860), 16, 81–122, 165, and Emerson, G., *John Scott Russell, A Great Victorian Engineer and Naval Architect* (John Murray, 1977), 25.

[13] Beazley, E., *Madocks and the Wonder of Wales* (Aberystwyth: P&Q, 1985).

[14] Harris, J.R., *The Copper King* (Liverpool: Liverpool University Press, 1964).

[15] University of Wales, Bangor (UWB), Bangor ms, 3592 (105 and 106).

[16] James, J.S., *Hanes y Bedyddwyr yng Nghymru* 3 (Caerfyrddin: W. Morgan Evans, 1903), 283–5, 358–9; 4 (Caerfyrddin: W. Morgan Evans, 1907), 280 and UWB, Porth yr Aur 27826.

[17] Public Record Office (PRO), CRES, 2/1579–1582, letter of 2 November 1799 from John Evans to William Harrison.

[18] Gwyn, D. Rh., 'From Blacksmith to Engineer: Artisan Technology in the North Wales Slate Industry', *Llafur* 7, 3 & 4 (1998–9), 54.

[19] *The Memoirs of Samuel Holland. One of the Pioneers of the North Wales Slate Industry* (Dolgellau: Merioneth Historical and Record Society Extra Publications, 1954), series 1/1. 4.

[20] Jones, D.G., *Un o Wŷr y Medra* (Dinbych: Gwasg Gee, 1999), 63.

[21] Cadw/ICOMOS UK, *Conwy Gwynedd & The Isle of Anglesey: Register of Landscapes, Parks and Gardens of Special Historic Interest in Wales: Part 1, Parks and Gardens* (Cardiff: Cadw, 1998) 34–42; Beazley, ref. 13, 78, 192–7. Some of Madock's appointments *were* odd — he took on a stone-mason because he was a good harpist, promoted his pig-boy because he refused to defend Madock's honour in a duel, and for a while relied on the assistance of the teenage Percy Bysshe Shelley, newly sent down from Oxford.

[22] Sylwedydd, *Hanes Chwarelau Dyffryn Nantlle a Chymdogaeth Moel Tryfan* (Caernarfon: Cylchwyl Lenyddol Rhostryfan, 1889), 32.

[23] Jones, ref. 20, 44.

[24] Jones, ref. 20, *passim*.

[25] Porth yr Aur mss 20310, 20312, 20318, 209328, 30850; Bangor ms 8702, 101r; Chapman, J., *A Guide to Parliamentary Enclosures in Wales* (Cardiff: University of Wales Press, 1992), 109–110: CRO, X/Plans/GW/21.

[26] Lewis, M.J.T., 'Archery and Spoonerisms: The Creators of the Festiniog Railway', *Journal of the Merionethshire Historical and Record Society*, 13, part 3 (1996), 263–76.

[27] Lewis Morris (1701–1765), the earliest and in many ways the most remarkable of this group of land surveyors, lies outside the scope of the present survey. Though born and trained in Anglesey, it was in the lead mines of Cardiganshire, in mid-Wales, that he made a name as an engineer and manager. See *Dictionary of Welsh Biography* (Hon. Society of Cymmrodorion, 1951).

[28] Thomas, C., 'Land Surveyors in Wales, 1750–1850: the Matthews Family', *Bulletin of the Board of Celtic Studies* 32 (1985), 216 32.

[29] I use the gendered term with reluctance. Apart from the semi-mythical Margaret ferch Ifan of Penllyn (1696–1801), whom no-one excelled at blacksmithing and boat-building (nor at hunting, wrestling, shooting, fiddling, rowing and harp-stringing), there is precious little evidence for female involvement with technology in Gwynedd in this period. Thomas Pennant, *A Tour in Wales* 2 (Wrexham: Bridge Books reprint of 1783 ed., 1991) 166–7.

[30] CRO, X Poole 1729, 1766.

[31] Beazley, ref. 13, 57, 137.

[32] Williams, G.H., 'Lord Newborough and Mr Madocks' "Very Fortunate Circumstances" ', *Industrial Gwynedd*, 3 (1997), 26–33.

[33] Porth yr Aur, 30845, 2219/Add. — 2220/Add.

[34] Lewis, ref. 26, 263–76.

[35] Thomas, I., *Top Sawyer* (Carmarthen: Golden Grove, 1988), *passim*.

[36] Jones, D., *The Coming of the Railways and Language Change in North Wales 1850–1900* (Aberystwyth: University of Wales Centre for Advanced Welsh and Celtic Studies, 1995), 5–15.

[37] Lloyd, Lewis, *DeWinton's of Caernarfon 1854–1892* (privately published, 1994), 11.

38UWB, Plas Newydd IV, 8484.

[39] UWB, Plas Newydd VII, 3132.

[40] UWB, Mona Mine 3534, 42

[41] Tombstone in Amlwch churchyard.

[42] Birmingham Public Library, Boulton and Watt Agreements box, 27/4; Dickenson, H.W., and Jenkins, Rh., *James Watt and the Steam Engine* (Encore Editions, 1981), 306–7.

[43] By 1850 probably around thirty steam engines had been erected in Gwynedd. Gwyn, D.Rh., 'An Early High Pressure Steam Engine', *Industrial Gwynedd*, 5 (2000), in preparation.

[44] CRO, Vaynol 5047, 8, 10, 20.

[45] Sylwedydd, ref. 22, 27.

[46] Bangor ms 8277; Crew, P., 'The Copper Mines of Llanberis and Clogwyn Goch', *Transactions of the Caernarvonshire Historical Society*, 37 (1976), 58–79.

[47] NLW, Glynllifon 84, 55–57ᵛ, 69ᵛ.

[48] UWB, Penrhyn 1967.

[49] Williams, M.C. & Lewis, M.J.T., *Pioneers of Ffestiniog Slate* (Penrhyndeudraeth: Snowdonia National Park, 1987), 6–9.

[50] Williams, G.J., *Hanes Plwyf Ffestiniog o'r Cyfnod Boreauf* (Wrexham: Hughes and Son, 1882), 89, 91.

[51] Sylwedydd, ref. 22, 21; Fereday, R.P., 'The Career of Richard Smith 1783–1868', M.A. thesis, Keele University, 1966.

[52] Gwyn, ref. 18, *passim*.

[53] Owen, R., *Cofiant a Phregethau y Parch. Griffith Williams, Talsarnau* (Bala: Davies ac Evans, 1886), 16–7.

[54] Jones, ref. 20, 119.

[55] Hyde Hall, E., *A Description of Caernarvonshire* (Caernarfon: Caernarvonshire Historical Society, 1952), 300.

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The social archaeology of the textile industry

Marilyn Palmer & Peter Neaverson

Although considerable work has been carried out on the functional and technological significance of textile mills, far less attention has been paid to their cultural context. Yet a study of the housing of textile workers may reveal the social consequences of the changes brought about by the slow, and far from uniform, transition to factory production between 1750 and 1850. This paper considers ways in which the styles of housing and the spatial layout of communities reflect the changing nature of the workforce and the attitudes of entrepreneurs, and also how far the dwellings indicate the continuity of domestic workshop production alongside powered factories. Research in Britain suggested a four phase model of the development of textile housing which was then tested and modified following fieldwork in Belgium, northern France and western Germany. While there are parallels for the first two phases of domestic production and the transfer of much of the industry from an urban to a rural setting following the introduction of water-powered processes, there is far less evidence in Europe than in Britain for the third phase of continuity of domestic alongside factory production. Finally, the extensive development of integrated mill complexes in towns and cities generally resulted in the provision of housing by speculative developers or the municipalities. Of particular interest are the 'beluiks' of Gent in Belgium, and similar court housing in Roubaix in France, many of which have been restored.

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Les filatures ont suscité de très nombreuses études quant à leur fonctionnement et à leur technologie, mais, jusqu'à présent, on s'est moins intéressé à leur contexte culturel. Pourtant, l'étude des logements des ouvriers du textile peut nous donner des éclaircissements sur les conséquences sociales de l'évolution vers la production usinière entre 1750 et 1850, une évolution qui était à la fois lente et peu uniforme. Cette communication s'attache donc à la forme des logements ouvriers du textile et à l'aménagement spatial des communautés. Comment ce regard peut-il nous renseigner sur l'évolution de la main d'œuvre, sur les attitudes des industriels et jusqu'à quel point se perpétue la production à domicile à côté des usines nouvelles?

Pour ce qui est des industries textiles, des recherches entreprises en Grande-Bretagne ont donné lieu à un modèle de développement du logement ouvrier en quatre phases distinctes. Des recherches complémentaires effectuées sur le terrain en Belgique, dans le nord de la France et dans l'ouest de l'Allemagne ont permis ensuite de tester et d'infléchir ce modèle. On constate ainsi des parallèles pour les deux premières phases, celle de la production domestique puis celle du transfert de cette production des milieux urbains vers des milieux ruraux, à la suite de l'introduction de procédés basés sur l'énergie hydraulique. Pour la troisième phase, toutefois, celle d'une continuité du travail à domicile à côté des grandes usines, il y aurait apparemment moins de cas en Europe qu'en Grande Bretagne. La quatrième phase est caractérisée en Grande Bretagne et dans les régions européennes étudiées par l'apparition de grandes usines intégrées, situées en milieu urbain, et par la construction de logements par des entrepreneurs spéculatifs ou par des municipalités. A cet égard, les 'beluiks' à Gand, en Belgique, ou encore les courées de Roubaix (dont certaines ont été réhabilitées), sont particulièrement intéressants.

Introduction

Industrial archaeologists have been so concerned with identifying and classifying industrial structures to ensure their survival that they have frequently failed to utilise their evidence in a normal archaeological manner, i.e. treating the physical remains as evidence for social change and development. Yet the majority of sites in the industrial period provide structural evidence for the dramatic social upheaval and redefinition of the class system which accompanied the process of industrialisation, and this is nowhere more marked than in the textile industries. The development of a settlement around an isolated mill site may indicate benevolence on the part of the mill owner: it also indicates the demands of the shift system of working, the mill owner wishing to recoup the capital costs of construction and equipment by exploiting the new power source to the maximum, using relays of people who therefore needed housing close to the workplace. The provision of housing was in itself a means of control, since occupation was dependent on continued employment of whole families in many cases.

The power source removed the need for human strength, if not skill, from the tasks to be performed and allowed the exploitation of female and child labour on a scale not seen before outside the home. At a time of rising population, the potential under-employment of men posed serious problems, resulting in a lengthy period of readjustment on the part of both employers and employees. The changing built environment of the textile industry from the late 18th century onwards is indicative both of new patterns of working and of new systems of discipline among the workforce. This paper will argue that we must go beyond our normal functional approach and look for the cultural meaning of our landscapes, sites and structures. What can they tell us about the social cost of industrialisation in human terms?

Our intention has been to investigate the ways in which the styles of housing and the spatial layout of communities reflect the nature of the workforce and the attitudes of entrepreneurs in different countries, and at the same time to observe how far the dwellings indicate the continuity of domestic alongside factory production. At this stage of our research, we cannot hope to provide the whole picture of the interaction between the workforce and the buildings in which they operated: we can only indicate some of the ways in which the buildings we have looked at indicate certain trends. The work we have so far carried out in Britain and parts of western Europe and Massachusetts has enabled us to develop a four phase model of the development of textile housing, as follows:

Phase 1. Home-based spinning and weaving of woollen cloth organised by capitalist clothiers, often occupying urban properties with workshops attached. Small settlements grew up around rural fulling mills, while some clothiers grouped their hand spinners and weavers in a proto-factory. This phase in England is 18th century and earlier, but appears to have continued for longer in mainland Europe.

Phase 2. The development of water-powered processes transferred much of the industry from an urban to a rural setting. Technological innovations were adopted more quickly in the rapidly expanding cotton industry than in the traditional woollen industry. The mechanisation of carding and spinning enabled the employment of women and children, resulting in the construction of communal living quarters in some locations. Other mills made use of family labour, leading to the creation of the first factory housing colonies in Britain, Europe and America.

Phase 3. The continuity of various processes including hand-loom weaving, framework knitting and some preparation and finishing operations in a domestic or workshop setting alongside powered spinning. This phase lasted from the 1780s until the latter part of the 19th century in Britain, and is relatively easily identified in the surviving buildings, but is less obvious in Europe and the USA.

Phase 4. The construction of large integrated textile production complexes, usually steam-powered but continuing to make use of water power where this was sufficient. This phase often led to the creation of further factory colonies, frequently urban, in which housing was provided for the workforce and financed both by textile entrepreneurs and speculative developers.

The timing of these phases varies greatly both between different branches of the industry and different countries of manufacture.

PHASE 1: DOMESTIC INDUSTRY

The early woollen industry was revolutionised by the mechanisation of the fulling process, with use of new rural water power sites as well as the conversion of many corn mills leading to the creation of fulling hamlets, often as adjuncts to existing cloth making centres. To take one British example, the clothiers of Trowbridge and Bradford-on-Avon occupied elegant town houses, often with workshops attached where cloth was finished.[1] Many of them made use of fulling mills in the surrounding countryside, as at Stowford and Tellisford where clothiers' houses and workshops were added to the fulling mills in the 16th century.[2]

Spinning and weaving were largely carried out on a domestic basis but, as is well known, attempts were made by some clothiers to group their workforce together in what may be described as a proto-factory, probably both to prevent embezzlement of the yarn and to undertake a degree of quality control.[3] The town of Verviers, in Belgium, has many similarities to the textile production centres in south-west England. The first fulling mill here dates from the early 17th century, and masters' houses incorporating workshops to the rear still survive although much altered.[4] The so-called Maison Closset, constructed in the late 17th century for the Peltzner family, is evidence for collective hand-powered production in a heavily fenestrated building which was converted into housing in 1924.

The extensive woollen manufacture in Monschau, an ancient village in the winding gorge of the river Rur in the Eifel massif in Germany, was centred upon fulling mills from the 16th century. Around 1760, the Rotes Haus was built for the Schleibler family, members of whom later built textile mills in both Prussia and Poland.[5] The Rotes Haus was a clothier's house incorporating both warehouse and workshops, the two separate entrances for the master and workforce identified by the Golden Helmet on the residential side and the Pelican on the commercial entrance. The interior staircase on the master's side is noted for its superb carved .panels depicting textile processes. As in parts of the Stroud valley in Gloucestershire, the surrounding hillsides were terraced for tenter racks. Water-powered carding and spinning machinery was added to existing fulling mills as late as the 1820s.

The distinctive buildings from this first phase of the industry are, then, the clothing hamlets and even small towns in Europe associated with fulling mills and the few surviving examples we have found so far of collective production before the mechanisation of the spinning process. Of course, such buildings continued to be erected for hand-powered processes such as hand-loom weaving and framework knitting well into the 19th century, their occupants making use of machine-spun yarn.

Phase 2: Technological Innovation

The development of water-powered carding and spinning in Britain in the second half of the 18th century resulted in an increased use of female and child labour in the textile industries as well as the need to attract labour to isolated mills built in rural water-power sites. One solution adopted in Britain was the use of pauper apprentices, who were placed in purpose-built accommodation. Samuel Greg, at Styal in Cheshire, housed 100 apprentices, working in shifts, in a building still used by the National Trust for educational purposes. Pauper apprentices were housed in dormitories in the New Lanark mills in Scotland, where 800 boys and girls were employed in the 1790s. Many of these lived with their families, since parents could get accommodation if they had three children fit to work who could be contracted for four years.[6] Equally, Richard Arkwright advertised for weavers with families for his tied housing in Cromford. The apprentice system died out in Britain following legislation in the early 19th century, leading to the use of family labour.

The early British factory colonies such as those in the Derwent Valley, Styal and New Lanark and Stanley Mills in Scotland are too well known to be detailed here.[7] We were interested to see if this model could apply to Europe and America, and whether the layout and styles of housing provided for the workforce differed from those of Britain. At Cromford, near Ratingen, in Germany, Brugelmann imitated Arkwright by establishing mainland Europe's first water-powered cotton spinning mill in 1783–4. This was followed by the five-storey High Mill about 1800, now part of the Rheinisches Industriemuseum. As in England, the majority of the workforce in the 1790s were children, mostly between 8 and 11, and housed in their family homes. Some housing was provided but was occupied mainly by foreign skilled workers and their families and others essential to the daily management of the mill.[8] Brugelmann's mansion of 1790, much closer to the mill than Arkwright's Willesley castle in the English Cromford, now houses galleries and the museum administration. In the nearby Wupper valley six water-powered iron forge sites changed over to woollen manufacture between 1815 and 1830. Wülfing at Radewormwald-Dahlerau imported English machinery and provided housing for his workers, consisting of tall blocks along the narrow valley, possibly with top-shops for weaving. Similar blocks may be found at the nearby Vogelsmühle where there is also an elegant mill-owner's mansion.

The activities of William Cockerill and his two sons in the mechanisation of the European textile industry has been well-documented and we will not enlarge upon it here.[9] The established woollen clothier families in Verviers competed with each other to construct new mills to house Cockerill's machinery. In 1801, Ywan Simonis purchased a fulling mill (formerly a corn mill called 'Au Chat') and dye works and constructed a cloth factory alongside them.[10] The complex was considerably extended in the 19th and 20th centuries along the river Vesdre. To accommodate their growing workforce, Simonis and Biolley, another clothier, collaborated to finance the construction of two blocks of workers' housing, the *Grandes Rames*, on an area formerly used for tentering cloth. Begun in 1808, these were barrack-type blocks comparable to those of New Lanark and even more overcrowded. Each block comprised ten dwellings with 16 rooms and was capable of holding 80–100 occupants in all, who shared kitchens and cellars, while the attic spaces were probably originally used for weaving.[11] They are among the

Figure 1.
The Grandes Rames in Verviers, Belgium, dating from c.1808. One of the two blocks of workers' housing constructed for Simonis and Biolley, they are now undergoing conversion into flats.

oldest purpose-built workers' housing in Europe and have undergone conversion to flats (Figure 1).

Another clothing family, Dethier, constructed a new woollen mill in the old Hodimont textile quarter of Verviers. An elegant master's house of 1802 fronted the Rue de la Chapelle and the existing mill to the rear was built by the same architect in 1804 and subsequently extended in the same style. This was later used for cotton spinning, but sold to Lambert Bettonville in 1855 and continued to spin wool until the 1970s. Like Simonis, Dethier constructed workers' housing opposite the mill. These were grouped around a courtyard, the *Cour Magnée*, behind two earlier workers' houses and are accessed through an archway beneath these houses. The Dethier housing had much more architectural detailing than the *Grandes Rames* blocks and was designated as a Historical Monument in 1992.

The early textile housing in Verviers, therefore, is of the tenement type and, certainly in the case of the *Grandes Rames*, of a poorer standard than the housing of, say, Cromford or Belper in England, possibly because it was not so necessary to attract workers to this established manufacturing town. Yet, 25 years after the construction of the *Grandes Rames*, Raymond Biolley's *Cité Raymond* was housing of an entirely different type. Built in terrace form, each house had a cellar, a kitchen on the ground floor and a room above as well as a back garden plot. It is probable that the economic conditions of Belgium under French rule in 1808 had prevented the construction of better quality housing which became possible after Belgian independence in 1830.

In North America, as in Europe, the technological innovations that revolutionised English cloth production were first introduced by an English emigrant, Samuel Slater. Apprenticed at Strutt's mill in Belper, Slater left for America in 1789, despite laws forbidding textile workers from emigrating.[12] In partnership with two Americans, Slater established the first water-powered cotton-spinning mill in America at Pawtucket in Rhode Island in the early 1790s.[13] The associated textile community resembled that in Cromford, with large numbers of children working in the mills and weaving done by hand in workers' homes. Dozens of small spinning mills were rapidly established on the rivers of southern New England, the workers remaining in their own homes.

Handloom weaving at first remained on a domestic basis, but both a shortage of labour and few restrictive practices permitted the unopposed introduction of mechanised weaving by the second decade of the 19th century. Boston entrepreneurs exploited the abundant water-power potential of the Charles and Merrimack rivers in Massachusetts to construct the first integrated textile mills. Francis Cabot Lowell pirated designs of power looms he had seen in Manchester in 1810 and with fellow Bostonians established the first mill on the Charles river at Waltham. Instead of relying on traditional family labour, he began the practice of employing young single women from the surrounding countryside and housing them in supervised boarding houses. This system is best seen on the Merrimack river, where a small settlement known as East Chelmsford was transformed into a major textile centre by the Boston Associates in 1821 and renamed Lowell in honour of the machine builder. The population increased one hundred-fold between 1820 and 1840, from 200 to 21,000.[14] This vast expansion was kept under control by a strict policy of corporate paternalism, designed both to protect the morals of the workforce and to maximise production.

The Boston associates controlled the development of the town by leasing water-power rights and selling land for construction. At least eight large mills had been built by 1835, with boarding houses close to them. For the Boott mills, 32 boarding houses for unskilled, unmarried women and 32 tenement blocks for the families of supervisors and skilled labourers were erected.[15] Arranged in eight long blocks, each with four boarding houses and four tenements, the latter included independent living units with their own kitchens. In the strictly supervised boarding houses, each bedroom was shared by 4–8 girls, some 20–40 in each block, but artefacts excavated in the back yards suggest that they managed to avoid control on occasions.[16] Similar boarding houses can be found in other centres such as

Lawrence, also on the Merrimack river. By the middle of the 19th century, the farm girls were less prepared to submit to this kind of discipline and were replaced by immigrants, first from Ireland and then from eastern Europe. Their housing was considerably more ramshackle than that provided for the mill girls and has now been largely destroyed.

The application of water power to the carding and spinning of cotton and wool fibres, dating to the later 18th century in Britain and generally the first half of the 19th century in continental Europe and North America, resulted in the employment of cheap and unskilled female and child labour. The often isolated mills were therefore frequently accompanied by new types of workers' accommodation, notably the apprentice houses found in Britain and the Massachusetts boarding houses. Other mills, usually those near existing centres of population, made use of family labour, controlling their workforce by the provision of tied houses. Whereas in Britain, these generally consisted of terraced rows as in Belper and Cromford, the characteristic early form of workers' housing in Europe was the tenement occupied by several families sharing communal facilities.

Phase 3: Technological Inertia

Edmund Cartwright's power loom, developed in the 1790s, was not taken up with the same enthusiasm as Arkwright's carding and spinning machinery. The reasons were partly technological — the inability at first to produce fine woven cloth — and partly gender-related, the predominantly male workforce resisting the introduction of the power loom in a period of declining economic conditions. The increased production of spun yarn resulting from mechanisation created a period of unprecedented growth in handloom weaving in the first quarter of the 19th century, marked in Britain by the construction of large numbers of houses adapted for domestic weaving. Many of these, usually including attic rooms with plenty of light for the looms, can be found in West Yorkshire, either attached to farms — the so-called weaving folds — or in village locations. In south-west England, weaving took place either in small hamlets just outside the main water-power centres such as Bradford on Avon and Trowbridge in Wiltshire, or in the towns themselves in purpose-built terraced houses. For example, Yerbury Street in Trowbridge was developed in the 1790s by John Ching, a local draper and grocer, who leased Ostler's Close from the Trustees of the Yerbury Charity.[17] Silk-weaving, too, continued in a domestic environment for even longer than wool and cotton, as in Macclesfield where purpose-built terraces such as Paradise Street co-existed with powered throwing mills.[18] The Jacquard loom for figured weaving and fancy ribbons needed additional headroom, and the few surviving ribbon weavers' houses in the Coventry area are notable for their high windows and tall storeys. Garret workshops were notably absent in Lancashire, but the fieldwork of Geoffrey Timmins identified the cellar and ground-floor workshops necessary to provide a damp environment for cotton weaving.[19]

The first moves toward integrated production in Britain are marked by the construction of multi-storey communal loom-shops as part of the mill complex. Many of these were identified by RCHME in their surveys of textile mills and represent a half-way house between domestic and factory production, the hand-loom weavers being under the control of the mill-owners.[20] This was achieved in Coventry by different means, bringing power from a central steam engine to domestic workshops grouped around a courtyard. These cottage factories date from the mid-19th century, the best surviving being those constructed by the Cash Brothers in 1857 (Figure 2).[21]

Another group of textile workers to remain outside the factory system were the framework knitters, who continued to make use of power-spun yarn on the hand-frame developed in the reign of Elizabeth the First. In the East Midlands, cottages incorporating long windows continued to be constructed well into the second half of the 19th century.[22] Wide frames introduced in the mid-19th century were unsuitable for domestic use and so, like many hand looms, were grouped together in large workshops, the best surviving examples having been converted into small museums at Ruddington in Nottinghamshire and Bushloe End in

Figure 2. A row of 'cottage factories' constructed for the Cash Brothers in Coventry in 1857: the large windows imply the use of Jacquard looms. Power was supplied to the upstairs workshops from a central steam engine, whilst living accommodation was on the lower two floors.

Leicestershire. Many of these continued to operate well into the 20th century.

We have not so far been able to identify buildings clearly associated with this phase of development in Europe. However, in the Leie valley in Belgium, flax preparation continued on a domestic basis into the 20th century, resulting in some distinctive buildings. Cleaning and even hand-scutching of flax seems to have taken place in alleys through the houses, marked by half-doors with ventilation above, while the upper floors had loading doors and roof-lights or dormer windows and may have been used for weaving.[23] Further investigation of this phase is needed in the silk-production areas of France and Italy, where hand-loom weaving survived. Equally, we have found no building evidence for domestic production alongside powered spinning in North America, although documentary sources imply that this existed in the early years of the 19th century. Generally, despite its technical problems, the power loom was accepted earlier and with less resistance in both Europe and the USA and our research so far seems to indicate no equivalents of the 19th century purpose-built weavers' terraces that are so characteristic of many of the textile areas of Britain.

However, the apparent independence of these domestic workers was illusory, since they relied on clothiers and merchant hosiers for both the supply of yarn and the marketing of goods. This was but a small step away from the fully mechanised integrated production system of the large powered mill complexes.

PHASE 4: PATERNALISTIC COMMUNITIES & SPECULATIVE HOUSING

The rapid growth of all branches of the textile industry in the course of the 19th century created an immense demand for labour, which was met both by population increase and migration from rural areas. This new labour force still had to be accommodated but mill owners did not need to provide housing to attract workers as many had done in the late 18th century. When they did, their motivation was a mixture of philanthropy, self-aggrandisement and a desire to exercise control over their workforce. New urban colonies, related spatially to the mills, were constructed on the fringes of towns in Britain. However, the majority of the workforce were accommodated in housing provided by speculative developers, much of it of lower quality than that provided by mill owners until building regulations ensured minimum standards.

The addition of weaving sheds to existing mills required the relocation of the handloom weavers from their often remote locations to new houses near the mills. For example, the Ashworths extended their Lancashire cotton enterprise and added over 100 cottages to their existing communities at Bank Top and Egerton by 1844.[24] In West Yorkshire a handful of mill owners, emulating each other, built a number of model suburbs on the outskirts of Bradford and Halifax, including the well-known Copley and Akroydon of Edward Akroyd, Sir Titus Salt's even better known Saltaire, Sir Henry Ripley's Ripleyville and the Crossley's West Hill Park estate. All these date from the two decades between the late 1840s and 1860s.

Edward Akroyd's building activities illustrate the potential conflict between the philanthropy of the mill owner and the expectations of the workforce. As he himself stated, his houses in Copley were 'not merely for the purpose of aggregating a sufficient number of operatives for the supply of labour but also with an eye to the improvement of their social condition by fitting up their houses with every requisite comfort and convenience'.[25] However, many of his workers were unwilling to pay a rent of over £5.00 per year for the privilege of two upstairs bedrooms, and the second group of houses, at £4.00 per year, reverted to a single upstairs bedroom and a fold-up bed in the downstairs living room. In Akroydon, some fifteen years later, he constructed through rather than back-to-back houses like those at Copley, yet many of the workforce were now prepared to finance actual purchase by means of loans from a building society.[26] These two settlements are good illustrations both of paternalism and the changing aspirations of the workforce by the second half of the 19th century.

Sir Titus Salt, a well-established Bradford worsted manufacturer was, like Akroyd, convinced that social harmony could not be established unless the workforce could be persuaded that the new industrial world had something to offer them. In 1850, he purchased 49 acres of land on the outskirts of Bradford and erected a new factory and the model village of Saltaire whose streets were named after members of his family. The first houses were relatively modest and intended for his ordinary workers, who paid a rent of £6.50 per year, while larger houses with parlour, kitchen, three bedrooms and a garden were constructed for the overlookers in the mill. The spatial layout of the village therefore reflected the social hierarchy within the mill. Houses continued to be built until

1868, by which time there were nearly 4,400 inhabitants.[27]

There are fewer examples of such paternalistic enterprise in south-west England, where the textile industry was declining in comparison with Yorkshire. One exception was at Tiverton, in Devon, where John Heathcoat had purchased a disused woollen mill early in the 19th century and continued the lace manufacture that he had begun in the East Midlands. Perhaps influenced by the early growth of mill communities in that region, he greatly expanded the housing provision for his workforce and his successors continued to do so throughout the 19th century. He acquired several houses with the mill purchase, including what became known as Heathcoat Square. These three storey houses with top floor loom-shops were converted to house workers he brought with him. Subsequently, he acquired other houses scattered throughout the town but in the 1840s commenced a programme of new building on land adjacent to the factory. The different building styles of these terraces indicate various periods of construction, the last dating from as late as the 1940s.[28] At Westbury in Wiltshire, the Laverton family financed the construction of 32 houses for their workforce in the 1880s, the income from which supported the maintenance of old and disabled factory operatives and their widows in seven almshouses, all in Prospect Square.

Our research has so far failed to identify similar paternalistic urban model settlements in Europe and this absence of private initiative could be due to the different political and economic situation in continental Europe in the 19th century. One exception is the textile colony on the fringe of Oudenaarde in Belgium, constructed around 1900 by the Geveart family for workers in their cotton mill. The town constructed the new streets and the family financed the terraces which lined them, creating an industrial quarter complete with corner shops and public house. The houses follow Flemish tradition and form a pleasing group (Figure 3).[29]

Further east in Europe, the accepted housing type was the tenement block containing flats rather than the terraces favoured in Britain. In the 'Polish Manchester', otherwise Łódź, decreed as a textile town by government in 1820, private capital was not invested on any scale until the second half of the century, mainly by German entrepreneurs. For example, Karl Schleibler, a descendant of the Monschau family, constructed vast integrated cotton mills in Łódź from 1854 onwards and housed the workforce in tenement blocks

Figure 3. Some of the houses constructed c.1900 for cotton mill workers by the firm of Gevaert in Oudenaarde, Belgium.

built close to them. The first contained one-roomed flats with no services — sheds and toilets being built at the rear — while the second, dating from 1875, consisted of 18 two-storey blocks of eight flats with two rooms each and some attic space. A local entrepreneur, Izrael Poznanski, housed his workforce in four huge blocks containing 1,000 flats. As late as 1916, 67% of housing in Łódź consisted of one-roomed dwellings, a very different situation from the family homes of Britain.[30]

These paternalistic colonies, for all the interest that they attract, in fact represented only a very small proportion of the housing needed for textile workers in the latter part of the 19th century. The majority rented housing, not from their employers, but from speculative developers, often shopkeepers or traders. For example, in the town of Crewkerne in Somerset, a small-scale linen manufacturer and girth web weaver called Henry Holman built cottages on South Street over a period of thirty years. In the late 1820s, he began to acquire land next to his workshops and borrowed money in order to finance the building. By his death in 1858, he had built a row of eighteen cottages which were let to hand-loom weavers of girth web, many of them members of his own family.[31]

On mainland Europe, two good examples of speculative development for textile workers are the cities of Roubaix in northern France and Gent in Belgium. In the former, whose population grew from 12,000 in 1820 to more than 100,000 in 1900, many of the new workers came from Belgium. The most common form of housing was the *courée* or enclosed yard, very similar to the courts of many English towns and erected on small plots of land between existing properties. Nearly 250 of these yards remain in Roubaix, whose entries are concealed within houses fronting the street. A similar pattern, on a much larger scale, can be found in

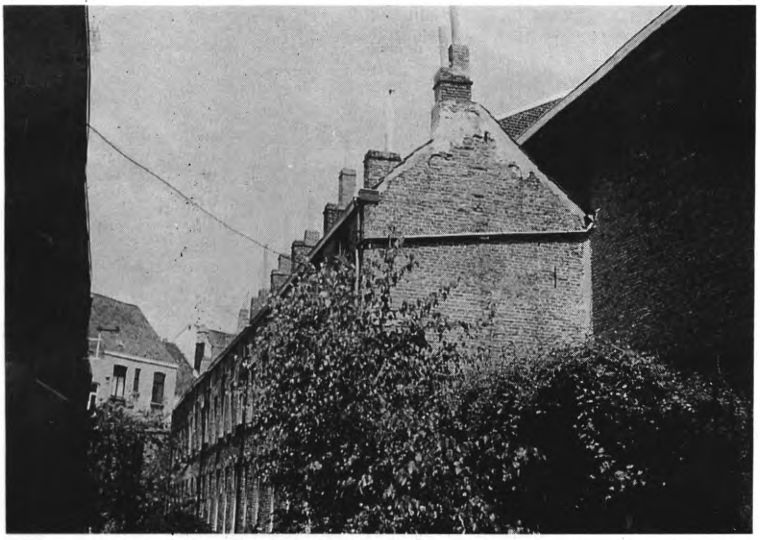

Figure 4. Blind-back housing in the Kartuizerlaan beluik in Gent, Belgium, one of the many beluiks which have been adapted for modern occupation.

Gent, where large steam-powered mills proliferated outside the historic quarter. The workers were housed in *beluiks*: by 1880, 700 of these housed one quarter of the Gent population.[32] Some were rows of single storey cottages squeezed into gaps between larger houses: other rows were two storey plus attic with blind backs laid out at right angles to the main street (Figure 4). It is surprising in both Roubaix and Gent how many of these courts have been retained. In Gent in 1997 there were still 296 *beluiks* having a total of 2,140 houses. Now regarded as desirable residences, locked gates across the entries have turned them into private enclaves whose inhabitants achieve a sense of community which is not found in the high-rise blocks which replaced court housing in Britain.

CONCLUSION

Our model of the four phases of textile housing was developed following work in south-west England in April 1999, for which we are indebted to the NMRC for the use of their database. A grant from the Pasold Foundation enabled us to see if our model applied in Belgium, northern France and western Germany. So far, we have concluded that our model is useful but can only serve as a general guide. The timing of the phases varies greatly both between different branches of the industry and different countries of manufacture. Our research in America has been limited to Massachusetts, where the phases are much more clear-cut. The situation in Europe is far more nebulous, and we would like to understand more of the housing of textile workers in the earlier phases, for example the silk workers in Lyon and northern Italy. We hope that our research will eventually demonstrate the role that industrial archaeology can play in understanding not just the technology but also the social context of past industrial activity.

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Places of proto-industry revisited: architectural remains of the 18th- and early 19th-century woollen and worsted industries in the Eichsfeld region of Germany

MICHAEL MENDE

According to Abraham Rees about 1820 and the Descriptions des arts et métiers *of the 1780s, a 'very fine worsted yarn from the environs of Gottingen' had played a considerable role in both the French and English worsted industries. During the 18th century, however, the environs of this Hanoverian university town and the area south of the Harz, the Eichsfeld in particular with thousands of skilled combers and spinners, did not just supply slivers and yarn, but were sources of the manufacture of fabrics well-known as Gottingen woollens. Calling themselves fabricators since about 1750, the entrepreneurs, originally master dyers or raschel-makers, began to convert the cluster of crafts into manufacturing industry. They began with dyeing, printing and finishing; carding and spinning only became mechanised between 1790 and 1820, whilst the first power looms did not appear before 1850. In this context the introduction of mule spinning in the 1820s would demand new mills and thus the removal from town sites to rural ones with sufficient water power. Though there are almost no remains of the manufacturing equipment or the products, however, at Gottingen, Grossbartloff, and Osterode, a considerable number of buildings have survived which date back to a period between about 1740 and 1830 and illustrate the development from a manual to mechanised industry.*

Les sites de la proto-industrie revus: les témoignages architecturels de l'industrie lainière du XVIII^{e} siècle à Goettingen, Osterode et Grossbartloff dans l'Eichsfeld supérieur

D'après les Descriptions des arts et métiers à la fin du XVIII^{e} siècle aussi bien que l'encyclopédie industrielle d'Abraham Rees au début du XIX^{e}, il y avait un 'fil peigné le très fin des environs de Goettingen' qui avait eu en grande estime dans la lainerie française et plus tard également l'anglaise. Mais en cours du XVIII^{e} siècle il y avait aussi les lainages de Goettingen les bien connus. Pourtant il n'a été que cette ville universitaire où on ait produit ces lainages, et particulièrement il en a été l'Eichsfeld, une enclave du Mayence électoral, qui par ses milliers des peigneurs et des fileurs y a representé le veritable coeur de l'industrie. Nominés les fabricants par ils-mêmes dès le mi-XVIII^{e} siècle, ces entrepreneurs aux origines des maîtres teinturiers ou maîtres lainiers déjà s'en allaient convertir des artisans aux industriels. Ils n'y ont débutés par la mécanisation de la filature, mais à la teinturerie, l'impression ou à tous les procédés d'apprètage. La mécanisation du cardage et du filage n'y a mis en place qu'avant de 1790 et 1820, du tissage ne qu' avant les années 1850s. En ce contexte l'introduction des mull-jennys, des métiers à cylindre, a demandée les filatures hydrauliques et donc le transfert des entreprises aux localitées en dehors de la ville. Malgré qu'il n'y ait guère des installations originales ou des produits contemporains, il y a toutefois une nombre très remarquable des bâtiments permettants prendre une bonne image du déroulement de la lainerie du métier à l'industrie.

'GOTTINGEN YARN' AND 'GOTTINGEN WOOLLENS'

In the late 18th century a 'very fine worsted yarn from ... the environs of Gottingen' was being imported into France as well as later to England. During the early 1780s this hand-spun yarn and that being imported from Saxony altogether made up about 10% of the material used in the worsted weaving of Picardy.[1] However, 'the environs of Gottingen' in the south of the electorate of Hanover and present-day Lower Saxony (Figure 1) were not only well

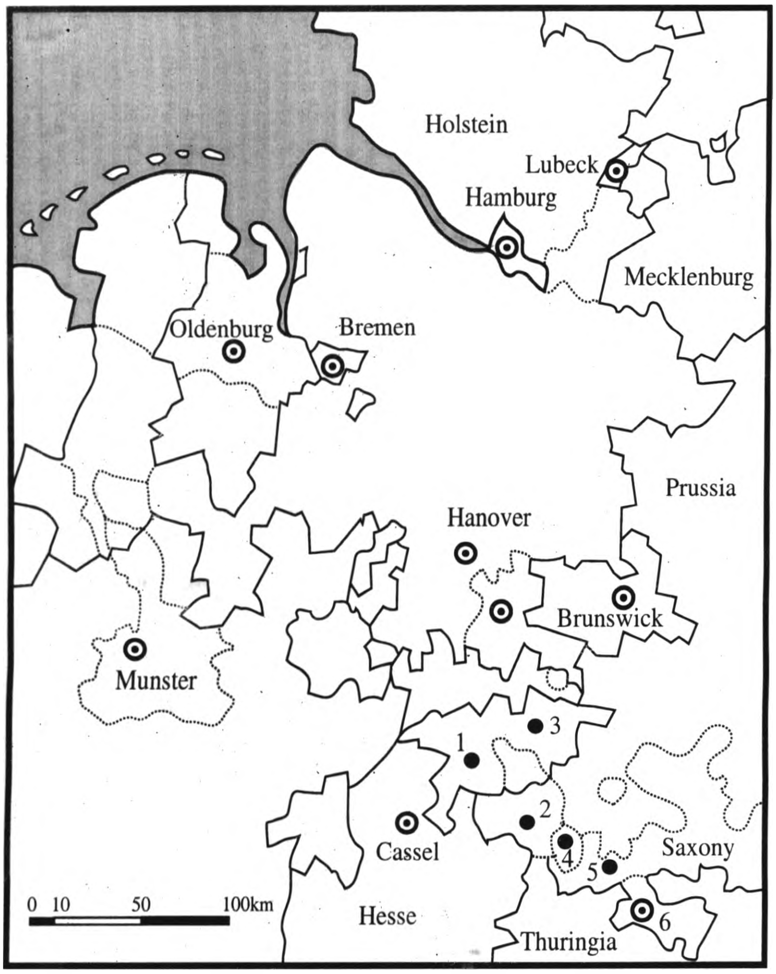

Figure 1. Gottingen, Osterode, and the Eichsfeld within north-west and central Germany, c.1800/15.

Key:
1 - Gottingen,
2 - Grossbartloff,
3 - Osterode,
4 - Muhlhausen,
5 - Langensalza,
6 - Erfurt,
.... *Boundaries 1800*
~ *Boundaries after 1815*

known as suppliers of woollen yarn, but also enjoyed a reputation as a source of fine cloth and worsteds. 'Gottingen woollens', a kind of a non-fulled, but tight and waterproof camlet, both plain and twilled with doubled warps, had since the 1730s been sold at the fair of Frankfurt on the Main, the emporium for southern Germany, Switzerland and eastern France.[2] The fame of those fabrics led to their imitation. At Marburg and Cassel in the landgraviate of Hesse, between Gottingen and Frankfurt, merchants received privileges in the 1730s and 1750s respectively to manufacture 'Gottingen woollens' either to compete with their original on foreign markets or to supply the local courtiers and army officers.[3]

The 'environs of Gottingen' included the town itself, with 11,000 inhabitants at the end of the 18th century and home since 1737 of a university which soon became a centre of the Enlightenment in Germany. Osterode, only 50km north-east on the south-western slopes of the Harz, might also have been identified with the 'environs of Gottingen'. With only 4,000 people, it was much smaller, but because of the number of the worsted 'factories' there it was already called by contemporaries the 'first real industrial town' of all Hanover.[4] However, it was probably the Eichsfeld, located only about 20km to the south-east, that Abraham Rees had meant when he spoke about Gottingen yarn. The Eichsfeld was an area of poor soils but rather densely populated with 100,000 inhabitants. During the 18th and early 19th centuries, the area was both a centre of the German worsted trade[5] and something like the industrial backyard of its more prosperous neighbours. The Upper Eichsfeld was the home of thousands of wool combers and spinners, some of whom, if local wool supplies were insufficient, had to walk for miles to the manufactories at Gottingen and other places every week where they could pick up Spanish merino wool to convert into yarn ready for weaving.[6] Although combing and spinning remained the predominant occupation at various villages, not later than the end of the Seven Years War did the Eichsfeld become one of the main competitors to Prussian woollen and worsted manufacturers, particularly those from Berlin.[7] In 1815, it was divided into Prussian Upper Eichsfeld and Hanoverian Lower Eichsfeld.

THE HEART AND BACKYARD OF THE TRADE

The Eichsfeld did not merely figure as a supplier of worsted or woollen yarn for conversion to finished fabrics solely by her neighbours, but also had several places where all the processes of manufacture were carried out. Abraham Rees and his contemporaries might have spoken even more about the 'environs of the Eichsfeld' than those 'of Gottingen'. The close relationship between the Eichsfeld and the surrounding regions was such that at the same time she could appear as both the heart and the backyard of the trade. This phenomenon was based on a kind of frontier-crossing division of labour which itself originated in an inter-regional network of merchant or artisan families and leading officials of the various territories bordering the Eichsfeld.

Muhlhausen in the south-east, an Imperial Free City of about 8,000 inhabitants when it was occupied by Prussia in 1803, was the main place to absorb the Eichsfeld woollens and worsteds.[8] The merchant family of the Lutteroths dominated the trade. Buying up raw fabrics in the Eichsfeld, this family dyed and finished them before despatch to the Frankfurt fair or one of their entrepots in Danzig, Amsterdam, or London where they also purchased indigo, logwood, and other dyestuffs. On the other hand, at Langensalza located in the Saxon district of Thuringia, bordering both Muhlhausen and the Eichsfeld, the old woad guild remained until 1812 and monopolised both the manufacture and the distribution of this dyestuff for which the town was once one of the five centres in the area.[9] Langensalza had developed as one of the Saxon centres for the manufacture of raschels and other kinds of worsted since the late 17th century. Here the Weiss family had dominated the trade[10] and finally, in 1817, two years after the town had become part of the new Prussian province of Saxony, established Germany's first worsted spinning mill.[11]

Originating from the cloth- and raschel-makers' guild, the Weiss was the most prominent of ten families at Langensalza who had followed almost the same pattern during that period as did the Lutteroths at Muhlhausen or, among others, the Greves at Osterode in Hanover, the neighbour of the Eichsfeld in the north. Less successful, however, were the centres of the woollen and worsted trade in the area of the neighbour in the south-west, the landgraviate and, after 1803, the electorate of Hesse. With the exception of the state enterprises of the French and the Spanish Manufactories, both established in Cassel, most of the cloth-makers at the traditional Hessian centres like Eschwege and Hersfeld focused merely on the yarn business because of the pressure of their competitors in and around the Eichsfeld. They supplied camlet manufactories at Hanau or places outside their homeland, making use of the poor in work-houses to spin inferior qualities and spinners in the Eichsfeld to provide the superior.[12]

Therefore, although the Eichsfeld had become important because of the many highly-skilled workers who made this region a retreat of both manual combing and hand spinning even beyond the mid-19th century, there had also been several places where all stages in woollen and worsted manufacture had been executed since the early 18th century.

The Gradual Change from a Craft to an Industry

Among these places, Grossbartloff, a village of merely some 100 inhabitants, was the first and remained the most important. The manufacture of worsteds began to change gradually from a craft to an industry after 1748, when the governor of Erfurt and the Eichsfeld had asked his superiors in Mainz for support in finding an entrepreneur to take over the 'new factory' there. 'Industry' in this context meant both that at least some parts of the production process would be exempt from the restrictions of the traditional guild system, and that most of the products would be destined for a supra-regional or even international market, represented at the time, for example, by the fairs of Frankfurt-am-Main, Brunswick, or Leipzig. Here the woollens and worsteds from the Eichsfeld or one of her neighbours had to compete with comparable products from Prussia or Aix-la-Chapelle, as well as from the Netherlands, France, or in course of time, also England. The quality of the finished fabric and its smoothness, indicating the evenness and fineness of the yarn, were decisive factors in commercial success as well as the brightness of the colours and the durability of the finish. Price-cutting in this context was only an additional incentive to prospective buyers, and less important than quality in ensuring a profit on all procedures.

Success in foreign markets, however, had to transcend the restrictions of the respective local guild in every sense, politically, economically and technically. In order to move upwards from being a craftsman or artisan to becoming a merchant or the owner of a manufactory or later even a mill, the future entrepreneur had to obtain privileges. As a cloth- or raschel-maker, he had to be licensed to undertake the dyeing, finishing and printing of his fabrics, or at least one of these operations, but above all he had to be permitted to act as a wholesaler of them as well. The transition to industry started with the control of weaving and thus subsequently of all the operations which preceded it. Dyers, printers and finishers would therefore continue in the weaving of woollens and worsteds either as putters-out, employing a considerable number of former guild members who were still independent, or as clothiers who bought up unfinished textiles. While the hand loom usually remained in the ownership and therefore in the tenement of the weaver, the facilities for printing or dyeing as well as those for napping and shearing were the first to be either attached to the entrepreneur's premises or even directly becoming part of his residence. By gradually converting it into a manufactory which in the 1760s was becoming known more and more as a 'factory', the entrepreneur was able to exploit, for example, his dyeing recipes without forfeiting his trade secrets and still retain control over all the operations essential to yield the quality requested by his customers.

The conversion of the woollen and worsted manufacture from a craft into an industry, however, would always depend on the presence of a whole cluster of pre-conditions which both the locality and the actors had to provide. To be chosen as a manufactory or even a mill, the site had to offer a constant flow of pure and also soft water combined with a sufficient fall. The site also had to be favourably situated with regard to the road network for long distance traffic in order to secure both the supply of wool and dyestuffs as well as the distribution of the finished product. However, success would also depend on the political initiative and often even financial support of the respective government officials who sometimes had to heed what influence the local guilds still might have been able to exercise. The experience and skill of both labourers and the prospective entrepreneur would always remain the crucial factor.

In the Eichsfeld, the first worsted manufacturers had been licensed to settle as artisans through individual privileges, given by the local representatives of the archbishop and elector of Mainz. Although he renewed his special regulation concerning a sole worsted- and raschel-makers' guild covering the entire Eichsfeld in 1718, this was already too late to stop the early artisans on their way to a proto-industrial or manufactorial entrepreneurship. From 1780, the policies of mercantilism meant that nobody actually would be obliged to join that guild.

STRUCTURES FOR MANUFACTURE UNDER DIRECT CONTROL

In Grossbartloff, the cradle of worsted manufacture in the Eichsfeld, an array of structures still represents the shift to manufactorial entrepreneurship as well as its peak during the 1770s and 1790s. The former began in the early 1680s when Valentin Degenhardt, born in nearby Frieda in Hesse, who had followed his apprenticeship in Picardy, obtained permission to establish his spinning and weaving shop.[13] After his death in 1748, his son Johann who previously had entered the firm following an apprenticeship at Cassel and Berlin, specialising in tammies, erected a fulling mill, press, dye works and a block printing shop. Only three years after their completion in 1761, he obtained privileges for a further decade.[14] During this period, he engaged finishers from Saxony and dyers from Hesse, but the considerable increase of his production depended largely on the experience of the hundreds of his workers living at Grossbartloff and other villages in its environs. The skills of the Eichsfeld hand spinners had become proverbial and, in spite of many attempts being made by entrepreneurs or authorities in the surrounding states, they could not really be superseded by cheaper domestic labour until spinning finally became mechanised after the 1820s.[15]

After Johann's death in 1772, the enterprise was taken over by his brother-in-law, Johann Martin Fromm. Sales by the firm more than tripled to about 50,000 talers mainly on transactions at the Frankfurt fair and on orders from southern Germany, Italy and the Levant as well as from France. The constant expansion of the business enabled first Degenhardt and later Fromm to erect a remarkable residence in 1763 and further manufacturing structures, a 'factory' to finish plush and camlets in 1770 and a 'copper' or golgas printing shop in 1772. Fromm added an office in 1790 and a multistorey warehouse two years later, but he died in 1797 and the enterprise decayed following the occupation of the Eichsfeld by Prussia in 1802.

Degenhardt's palatial residence, a three-storey timber-framed structure topped by a mansard roof and situated just in front of the church was, in every respect, the centre of his industrial realm. Still displaying the staircase and several rooms with their original stucco ceilings, this building is the most imposing structure which has remained. Since the mid-19th century, it has been used as the village school and today as an office for the local authority, the entrepreneurial residence has undergone minor alterations. However, the former production premises scattered around are either in ruins, like Degenhardt's fulling mill, adapted for habitation or entirely lost. The most regrettable loss happened as recently as 1980, when the great warehouse alongside the residence, a three-storey oak-framed structure which previously had been used as an orphanage, was demolished. Only the area of the car park gives any idea of the original extent of that building, while the previous press-house where once the flannels were lustred has been replaced in the 1970s by a house of the same dimensions but masked with contemporary cladding materials. All the other remaining structures of the 18th century woollen and worsted manufacture at Grossbartloff were converted into dwelling houses after the 1880s, but still give some impression of the extent of that early industry which employed a total of 17,000 people in 1792.[16] These included the former golgas printing house on the opposite bank of the Lutterbach behind Degenhardt's 'palace', Fromm's office and the block printing house, probably not that erected by Degenhardt or Fromm, but by Bernhard Hey from Duderstadt in the Lower Eichsfeld in the late 18th century. Entering the remote village of Grossbartloff, it is immediately obvious that its inhabitants could never have earned their living solely from agriculture but by industrial activity. The many vernacular timber-framed houses of the late 18th century indicate that they lived there in considerable number. It is not therefore surprising to note that in 1802, at the end of the Mainz dominion, no less than 200 raschel-makers were employed by Martin Fromm & Sons.

Searching for Prestige among Scholars and Aristocrats

In acknowledgement of Fromm's importance as by far the most important domestic textile manufacturer in the Eichsfeld, he had been appointed a councillor of commerce and later an electoral chamberlain by the Mainz government. However, the first entrepreneur to be so honoured was, in fact a non-resident, Johann Heinrich Graetzel from Gottingen, in 1748. In the same year, the British king and Hanoverian elector George II visited Gottingen and Graetzel's new palatial residence, and appointed him a superior commissioner of commerce. This title was also bestowed on Graetzel's son in 1793 by George III.[17] At this time, young Graetzel, in addition to the spinners working for him in the Eichsfeld, employed about 300 people. Not less than 37 hand looms on camlets and 25 on drapery were directly operating under his control in four shops, mostly located in the Neustadt, a street just round the corner from the Allee. So in Gottingen, the Graetzel factory outpaced both main competitors, Funcke and Scharff, making about 60% of all cloth leaving the town. Thus the titles bestowed on the Graetzels only mirrored the rather eminent role both played at that time.

To achieve such a position, the elder Graetzel had started very early to extend his social relations well beyond the limits usually associated with his trade and rank. Called an 'entrepreneur in camlets' even in 1723, he soon aimed to become more than just the main supplier to the Hanoverian army or to high-ranking ecclesiastical customers in Mainz and other Roman Catholic territories. Rather, he attempted to establish personal relationships with all those contemporaries who were able to secure for him a constant flow of further orders or, even more, privileges to support the expansion of his manufacture at the expense of his competitors. The once gilded statues of Mercury and Minerva, still gracing the residence erected between 1739 and 1741 on the new avenue Graetzel had lined with trees, might clearly demonstrate his goals. Like his double escutcheon which surmounted the main entrance beneath after 1745, both these more than life-size sculptures flanking the central gable underline the reputation that Graetzel gained as a successful entrepreneur, an experienced artisan and inventor, a distinguished scholar, but not least even a quasi member of the nobility (Figure 2). One of the two blazons represents Graetzel's family while the other indicates that in 1739, not least because his collections, he was admitted to the Imperial Academy of Naturalists, the Leopoldina-Carolina at Halle.[18]

Figure 2. Gottingen: The central pediment of Graetzel's residence topped by statues of Minerva and Mercury, 1741.

The palatial residence at the Allee, soon the favoured address for university professors, is evidence of the advances that the elder Graetzel had made. In 1711, after his apprenticeship as a dyer, he became head of dyeing at the Electoral Factory established earlier in 1704 to meet the demands of the Hanoverian army in coarse drapery, raschels, worsteds, and linings. After 1723, Graetzel established his own manufactory based partly on his capabilities as a dyeing-master and his relevant recipes, but also helped by his close relationship to the responsible officials in the capital. He procured exemption from the traditional bounds of the cloth-makers' guild, which was essential to employ the weavers and finishers he had recruited from Thuringia. As government business increased, Graetzel soon was able to install looms and finishing equipment in own premises.

He erected most of these facilities during the early 1730s on sites close to each other as well as to his residence (Figure 3). In addition to Graetzel's stately apartments, this also contained several offices, lodgings for students or apprentices, and space in both attics to store wool, dyestuffs, and other raw material.[19] His dyeing and fulling mill, however, he had to set up on an extramural site on the Grone,[20] a small tributary of the Leine, located about 3km from his loom and cropping shops. These were sited in the Neustadt, and also in a side street across a bridge over the intramural branch of the Leine. At the corner of this street and the embankment, the timber-framed buildings may still be found where Johann Georg Scharff, originally a dyer from Langensalza, had established both his residence and manufacturing premises in 1750.

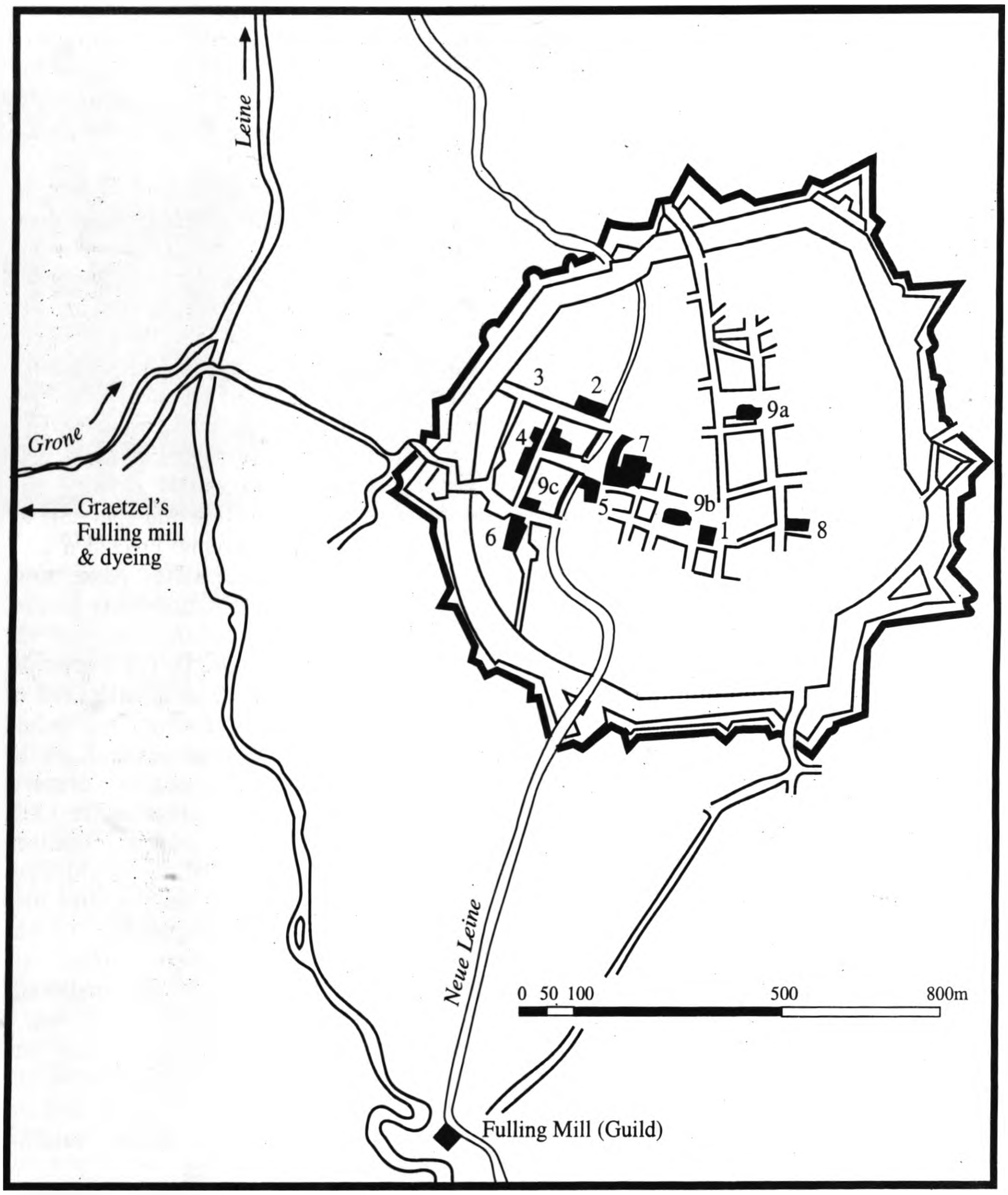

Figure 3. Gottingen: Woollen and worsted manufactories of Graetzel and his contemporaries within the walled town, c.1750/1800.

Key:
Gottingen c.1750
1 *Town Hall*
2 *Graetzel's Residence*
3 *Avenue (Allee)*
4 *Graetzel's Manufacturing Premises*
5 *Scharff's Residence*
6 *Funcke's Factory*
7 *University Library*
8 *Eberwein's Dyeing*
9 *a-c Churches*

INTEGRATED WOOLLEN MILLS LEAVE TOWN CENTRES

Compared with Graetzel's palatial residence, however, the former Scharff factory seems rather modest, as did that erected by Johann Heinrich Funcke after he had come from Essen on the Ruhr in the late 1730s and established himself as an independent manufacturer of fine cloths. In spite of its size, the layout of this factory had followed a general plan, which was a favoured topic in the lectures on technology given by Johann Beckmann at the university of Gottingen.[21] It did not matter whether the factory was founded by a raschel-maker, a dyeing master, or a finisher and draper. In every case, at Grossbartloff, Gottingen, as well as at Osterode, the 18th century woollen or worsted manufacture was centred in the owner's residence. It was the heart of the business, enabling the owner to keep visual control over both the stages of manufacture and the quality of the products. The storage of wool, particularly the precious, imported dyestuffs as well as the finished goods, at the residence was quite usual but as their amount and value increased, enlarged premises or even a warehouse were needed. Whatever the solution, the entrepreneur always exercised his personal control and the storage facility had to be within his sight. An eye-catching attic or warehouse represented his wealth and economic potential, underlining the character of his residence as the heart of the 'factory' and thus serving as a means of publicity.

The woollen or worsted factory therefore evolved step by step as a series of structures. Depending on their size and on local land availability, they almost always were situated in the town or village. However, if there was an insufficient fall of water to power a fulling mill or the threat of pollution interfering with the dyeing process, then the manufacturer had to settle outside the town or village.

As late as the 18th century in Germany, the strength of the guilds meant that there was almost no freedom of trade outside rural areas. A 'factory' on the other hand involved a collection of workers and artisans who, although originally members of a particular guild, were allowed to work together under the direction of an entrepreneur who had usually been granted privileges by the sovereign for that very purpose. The situation changed in 1802 when first the Eichsfeld, then the Free City of Muhlhausen, and finally Hanover were occupied by Prussia. With the intention of annexing these territories, Prussia appointed a High Commission to investigate the state of the woollen trade. Its recommendation was to liberate the trade, but also to protect the livelihoods of the 15,000 combers, spinners and weavers in the Eichsfeld. For this purpose, they proposed the establishment at public expense of a new factory, including warehouses where raw wool could be stored to keep the prices low and finished fabrics delivered for proof and final sale.[22] However, these proposals were not carried out since, in 1807, the whole area was integrated into the new kingdom of Westphalia and immediately general freedom of trade was declared and the guilds abolished. At the end of the Napoleonic wars, Prussia regained control of the Eichsfeld, Muhlhausen, and the former Saxon district of Thuringia, but the conditions of the Eichsfeld textile workers did not improve. From the late 1820s, hand- and also jenny-spun worsted yarns could not be exported any more 'and the Eichsfeld weavers were forced to survive locally on a mere one-seventh of their earlier output'.[23]

The efforts of Christian Peter Beuth, head of the Prussian trade department, to support the Eichsfeld weavers had therefore failed. Neither the investigations he had made in 1826 on his visit to England, particularly Yorkshire, nor the considerable investments he tried to induce after he had returned to Berlin succeeded. Beuth focused his attempts on the improvement of the texture and regularity of the worsted yarn which would enable the weavers in the Eichsfeld to compete with imports from England, France, and Saxony or other parts of Germany. To achieve the quality required to keep pace with trends in fashion, he proposed 'to buy some of England's best long-haired sheep', but even more to purchase 'an impressive set of French machines for spinning fine combed wool' as models to be reproduced at Cockerill's mechanical workshop in Berlin.[24] However, the abundance of skilled workers and the lack of both private capital and sources of energy, both water power and coal to fire the boilers of steam engines, prevented the introduction of spinning mules in the Eichsfeld on a sufficient scale.

In Hanover, restored as a kingdom in 1814, the entrepreneurs faced the same pressures but caused here by the considerable imports of cheap woollens and worsteds from England. The traditional firms at Gottingen suffered more than their competitors at Osterode. For example, Graetzel's grandson, who had entered into a partnership with his father in 1813, tried hard to maintain his business at a time when new competitors were successfully entering the trade. He improved sorting and spinning, as well as weaving and dyeing; erected a new fulling mill in 1825; and started to mechanise carding and spinning in the same year. In the early 1840s, however, despite all his efforts he went bankrupt, a fate that Funcke's firm had already met in 1826, notwithstanding his introduction of new spinning machinery.[25]

Their place was taken by those entrepreneurs who in the course of the 1820s had been able to change over to spinning mules, carding machinery and the gigs, cropping and brushing machines and calendering presses needed in finishing, all using water power. Since there was no space to for this new machinery, nor the water power to drive them within the towns and villages, new factories had to be established on sites outside the town with adequate water power. The first to remove his factory at Gottingen was the master dyer Christian Eberwein in 1823, who had some success in the long run. More remarkable, however, was the growth displayed only a little later by the woollen and worsted manufacturers of Osterode In the early 1830s they had erected a considerable number of new mills on the river Soese just outside the town, but they also expanded elsewhere (Figure 4). Two of them, Greve and Struve, had already established branches in the Eichsfeld and at Cassel respectively during the Napoleonic rule. August Böhme and Hermann Levin moved to Gottingen in 1830 and in 1846 bought out Graetzel's entire equipment, dominating the trade by 1850. Like Eberwein and his associates at Osterode, Levin also introduced the first power looms in the 1850s.

So the municipal council of Osterode were able to report in 1845 that at least 'in the worsted factories everything except weaving would be done on machines'.[26] By 1861, one third of all woollens and worsteds was woven on power looms, but the industry still depended on the skilled hands of the combers

Figure 4. Osterode: Front of the main building of Greve & Uhl's woollen mill (Eulenburg), former carding and spinning floors, 1832; since c.1970 out of operation and temporarily used as office or storage facilities.

from the Eichsfeld. Even after combing became mechanised in the 1860s, many of them remained indispensable as both feeders or supervisors in the new big combing mills which were established from the early 1870s in nearby Hanover, Bremen or Hamburg to process the increasing amounts of raw wool coming into Germany from Australia and the area of the La Plate river.

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[10] Haendly, ref. 8, 178.

[11] Blumberg, ref. 5, 77.

[12] Dascher, ref. 3, 113.

[13] Haendly, ref. 8, 95.

[14] *Ibid.*, 167.

[15] Lower Saxon Main State Record Office Hanover (NHStA) Hann 74, Osterode 593(73), reports of 23 October 1760, 24 February, and 5 March 1763; Hann 84, 420, report of 23 December 1835.

[16] *Chronik von Grossbartloff* (1923), 142.

[17] Haendly, ref. 8, 184; Koch, ref. 2, 171.

[18] Haendly, ref. 8, 105.

[19] *Ibid.*, 121.

[20] *Ibid.*, 108.

[21] Beckmann, ref. 6, 60 & 101.

[22] Haendly, ref. 8, 215.

[23] Brose, Eric Dorn, *The Politics of Technological Change in Prussia. Out of the Shadow of Antiquity, 1809–1848* (Princeton, NJ, 1993), 122.

[24] *Ibid.*, 106.

[25] Koch, ref. 2, 202 & 208.

[26] NHStA, Hann 74, Osterode 592, report of 22 November 1845.

[27] *Ibid.*, Hann 80, Hildesheim I, F 255, 3592; statistical report on trades and industries at Osterode, 1961.

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The centrality of the 'Chemical Revolution' for later industrial change: a challenge for industrial archaeology

COLIN A. RUSSELL

The spectacular growth of the British chemical industry from the later 18th century is shown to have had profound effects for the Industrial Revolution in general. Five important examples are discussed: the gradual replacement of charcoal by coke in the extractive industries; the first appearance in substantial quantities of coal-tar and coal-gas; new ways of making sulphuric acid; efforts to achieve a route to synthetic soda; and the invention of chlorine bleaching. The implications for industrial archaeology are examined, with special reference to the fragility of much chemical plant. Suggestions made for dealing with this problem include analysing materials in and beneath the top-soil, utilising archive photographs and film and using oral evidence.

Le rôle central de la 'Révolution Chimique' dans le développement industriel: un défi pour l'archéologie industrielle

Le développement spectaculaire des industries chimiques en Grande Bretagne à partir de la fin de XVIII^{e} siècle a eu des conséquences énormes pour la Révolution industrielle en général. Cinq exemples importants sont présentés dans cette communication: le remplacement progressif du charbon de bois par le charbon de terre dans les industries métallurgiques; l'apparition de quantités importantes de goudron et de gaz de houille; les nouveaux procédés pour la fabrication d'acide sulfurique; les tentatives explorées pour la fabrication de soude synthétique; et l'invention du blanchiment au chlore. Ces développements sont analysés du point de vue de leur archéologie industrielle. En effet, de par leur grande fragilité, les équipements de l'industrie chimique soulèvent des difficultés particulières. Des réponses à ces difficultés sont suggérées: l'analyse physique des vestiges au sol ou dans le sol, l'utilisation de photographies anciennes ou de films et le recours aux témoignages oraux.

INTRODUCTION

Chemists, and especially historians of chemistry, love to speak of the 'Chemical Revolution'. That is the emergence of a radically new view of chemical elements, the process of combustion and the character of chemical compounds, associated above all with the French chemist Lavoisier (1743–94). However at the same time another series of events, equally revolutionary, was transforming not so much the theory as the large scale practice of chemistry. This is the other 'Chemical Revolution', so-called by Archie and Nan Clow in their memorable book of that name.[1] How far the two revolutions were related cannot be pursued now, though it is a fascinating quest. What is beyond doubt is that by the end of the 18th century the production and use of a fairly small number of key chemicals had vastly increased, and their appearance on the industrial stage had the most profound effects on manufacturing processes that had hitherto had little to do with chemistry. These included the extraction of metals (especially iron), the burgeoning textile industry, the glazing of home and factory windows, and even the production of artificial lighting. Indeed it is no exaggeration to state that without this second 'Chemical Revolution', the Industrial Revolution as we know it could never have happened. Many, though not all, of the major advances in chemical technology took place in Britain, and are recorded in historical accounts of the British chemical industry.[2]

THE GROWTH OF CHEMICAL INDUSTRY IN BRITAIN

Five areas of specially important growth for industrial chemistry by the end of the 18th century will now be discussed.

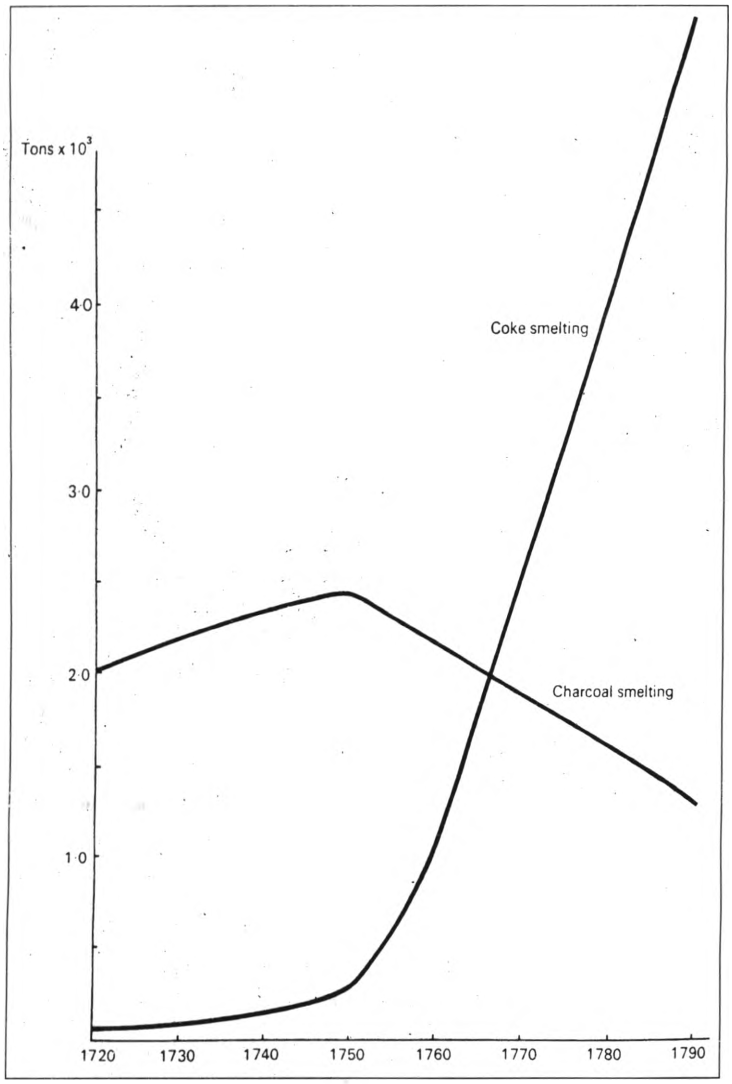

Figure 1. Production of pig iron in Great Britain in the 18th century.

Gradual replacement of charcoal by coke in the extractive industries

Much has been written on this subject, and so the reader is merely reminded here of the enormous extent of deforestation of this island in the endless quest for charcoal to make iron (chiefly for military purposes). Replacement of charcoal by coal was useless on account of the undesirable constituents in that material. The same problem had been encountered in beer-production and from the late 17th century maltsters had first converted the coal into coke which proved to be a quite acceptable fuel. In 1709 the iron-master Abraham Darby (who had once been apprenticed to a maltster) successfully made iron by smelting ore with coke. That of course was at the historic site at Ironbridge. In the north of England the first coke smelter was established before 1745 by Isaac Cookson at Whitehill, near Chester-le-Street; coal was available locally and iron ore was transported from Robin Hood's Bay by sea and river.

Though needing a more powerful air-blast, coke furnaces could be made larger and gradually the new material replaced the old. By 1788 only 24 of Britain's 77 iron furnaces consumed charcoal and by 1806 that number had dwindled to 11. The concomitant increase in iron production met the accelerating demands for machinery, factories and (later) railways. Figure 1 shows the trend until 1790.

To make coke was of course a chemical process, where 1,000kg. of coal yielded about 600kg of coke and supplies seemed inexhaustible. The coal was heated by a variety of methods, but in the relative absence of air, and yielded much volatile matter as well.

The first appearance in substantial quantities of coal-tar and coal-gas

The 9th Earl of Dundonald, Archibald Cochrane (1745–1831)[3] had a remarkable interest in chemistry, and a small estate in Culross, Scotland rich in coal deposits. During a brief career in the Royal Navy Dundonald noticed the ravages of worms on the wooden bottoms of ships and thought of a solution that would avoid the expensive importation of wood-tar or pitch. By 1780 he had found a way to extract coal-tar from the volatile products made during coke manufacture. A patent was duly obtained and by 1782 his British Tar Company was established. It prospered only mildly, largely through a certain lack of business acumen in the noble proprietor. He was, however, quite exceptional (and far ahead of his time) in using tar to preserve timber. In the early 19th century, so much coal-tar was produced that even with some used for timber preservation, the place was awash with the evil-smelling liquid. It was only after 1860 that what was at first an unwanted by-product became the basis of a vast new chemical industry making dyestuffs, explosives and drugs.

It was rather in character that Dundonald failed to exploit a further discovery: not only tar but also a gas was produced. An unexpected fire at one of his tar-kilns produced a light of such intensity that, for amusement only, he would occasionally entertain his friends on the opposite bank of the Forth by passing large quantities of this gas through a gun barrel and igniting it. However others had already become aware of the commercial potential of coal-gas, most notably William Murdoch at his house in Redruth in 1792. He persuaded his employers, Boulton and Watt, to use gas to light their factory at Soho, Birmingham in 1800. Although it belongs to the early 19th century the growth of gas manufacture and distribution transformed not only home life, education, crime prevention

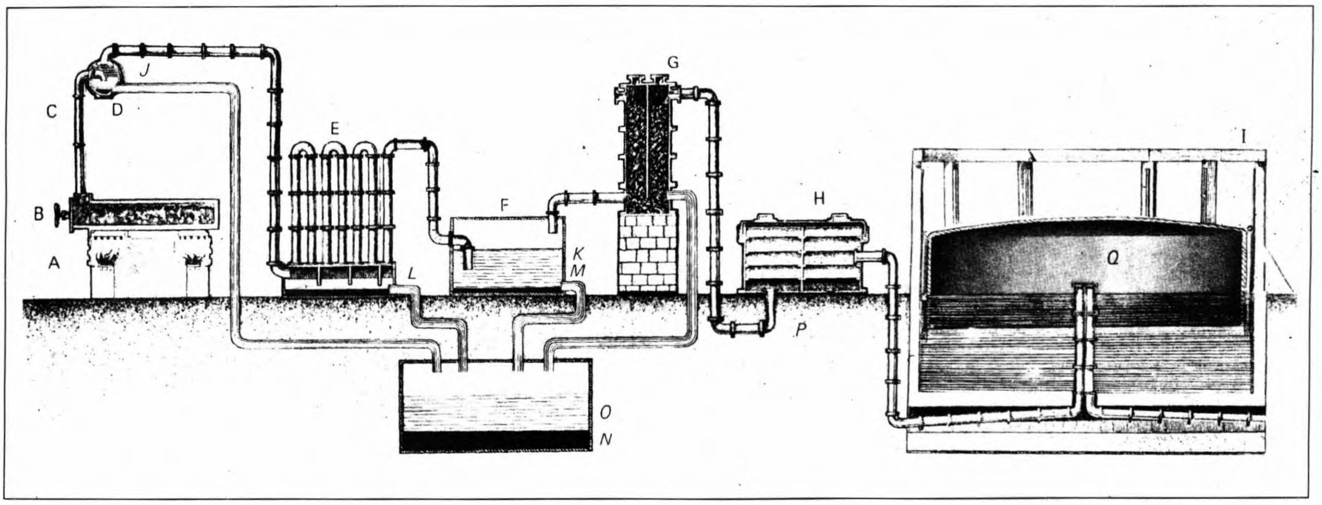

Figure 2.
Coal carbonisation: a typical Victorian gas-works layout.

and even theatrical performances but also working conditions in factories. Certainly by the 1840s delicate work could be performed at any hour of the day (or night). The production of coal-gas was a chemical process of some complexity and continued in the UK until the 1970s, hardly changed in its essentials over 150 years (Figure 2).

New ways of making sulphuric acid

Sulphuric acid, or oil of vitriol,[4] had long been known as a product of heat on 'copperas', or hydrated iron (II) sulphate [$Fe_2SO_4.7H_2O$]. This in its turn was obtained by the weathering of iron pyrites [FeS_2] from at least the 16th century in Britain. By the early 18th century it was being increasingly used for a range of industrial purposes such as 'pickling' metals, bleaching cloth, and making other chemicals such as nitric acid. But demand was rising and supplies of pyrites were becoming short. An alternative method had long been known in which sulphur was burned to form sulphur dioxide which was then oxidised by moist air to form sulphuric acid. Unfortunately the process was extremely slow, and the sulphur had to be imported. However addition of potassium nitrate [nitre] to the sulphur was found to accelerate the desired reaction, and by 1736 Joshua Ward, a quack doctor, had found ways of doing this efficiently using large glass vessels or 'bells'. Later the replacement of glass by lead (which resists attack by the acid) made possible much larger installations and by mid-century Roebuck and Garnett had set up two manufactories, at Birmingham and at Prestonpans. The sulphur needed to make sulphur dioxide was, from about the 1830s, replaced by either iron pyrites or the spent oxide from gas-works (which was rich in combined sulphur). The so-called 'lead chamber' process continued in England until the 1970s. Two hundred years previously the acid had become a vital material for the manufacture of another much-desired product, soda.

Efforts to achieve a route to synthetic soda

It is impossible to overstate the importance of soda for the Industrial Revolution.[5] The substance is alternatively known as sodium carbonate [Na_2CO_3] and was required for the manufacture of two vital commodities: soap and glass. The former was made by heating soda solution with fats, and the latter by fusing the solid with sand and limestone. For a growing textile industry soap was needed for the raw fibres, the finished cloth and (of course) the workers' hands. Animal fibres such as wool are rich in grease and this cannot be removed by water without a detergent — in this case soap. Glass, on the other hand, was required for a multitude of minor purposes, and on a large scale for bottles and windows. It provided many a workforce with both containers for their liquid refreshment and protection from the worst of the weather outside their factories. Together with gas light it made such establishments a much more profitable investment since they could be used for round-the-clock operation.

But for soap and glass to be freely supplied there had to be immense quantities of soda available. The amounts obtained from the traditional burning of certain seashore plants (as seaweed or barilla) were quite inadequate. An alternative to soda was potash [K_2CO_3], but it was not so good for making glass. It was obtained from wood-ashes, and these were usually imported from America until the American War of Independence cut off most supplies. It was just at that time (1775–83) that demand was escalating in the UK. Similarly France, at war with Spain, was unable to import the usual amount of Spanish barilla. An alternative source was desperately needed, and some kind of conversion of the ubiquitous salt [NaCl] into Na_2CO_3 seemed the obvious solution.

To this problem the indefatigable Lord Dundonald turned his attention. He met with some success and set up a works on Tyneside in partnership with John Losh, though even here he received less than he had invested. But for the struggling glass and soap industries help was on the way. In France a physician and amateur chemist Nicholas Leblanc had stumbled on a new process. On paper it is quite simple, but not in practice. There are three stages:

1) Salt is heated with sulphuric acid to yield 'saltcake' (sodium sulphate) and hydrogen chloride:

$$2\ NaCl + H_2SO_4 = Na_2SO_4 + 2\ HCl.$$

2) Saltcake is heated with coal and limestone in a revolving furnace to produce 'black ash' (a mixture of soda and coal residues), together with calcium sulphide and carbon monoxide gas:

$$Na_2SO_4 + 4C + CaCO_3 = Na_2CO_3 + CaS + 4CO.$$

3) The black ash is extracted with water from which soda is allowed to crystallise.

The Leblanc process soon appeared in Britain, on Tyneside, Merseyside and Clydeside. It was a wasteful and dangerous process. At first the environment was polluted by clouds of hydrogen chloride gas emitted from the chimneys, devastating crops and metal equipment for miles round. Later the Alkali Acts ensured that this nuisance was minimised. In addition the tons of calcium sulphide ('galligu') accumulating daily polluted air, water and earth by its very presence, for in damp weather it emitted the noxious hydrogen sulphide. To this day large deposits exist underneath the topsoil on Tyneside. Working conditions were often appalling, as were living conditions near the plant. Eventually the process was replaced by the environmentally friendly Solvay process, though the last Leblanc plant lingered until the 1920s. But industry had its supply of soda.

The invention of chlorine bleaching

By the middle of the 18th century an increased production of textiles led to something of a land crisis. Even after washing with such soap as may have been available the overall appearance of linen cloth (for example) was an unattractive grey. Bleaching was essential. The only bleaching agent available was the sun, but effective solar bleaching required many weeks of exposure. This could be accomplished only by laying out the cloth in the open air, on land designated as bleach-fields. This was possible in Scotland and Ireland, though was usually accomplished in Holland. The process could be accelerated a little by soaking in dilute acid. Sometimes this was butter milk (for which Holland was famed), sometimes the juices of crab apples, and sometimes by sulphuric acid. Even then there was never enough land in the UK and so bleaching came to be a rate-determining process in the manufacture of finished textile products. It is difficult to imagine what might have happened if a Swedish apothecary, C.W. Scheele, had not discovered a new gas in 1774. This was chlorine, and it was soon found that it could bleach cloth not in weeks but in minutes. The toxic character of the gas led to many problems and the use of free chlorine did not continue after the 1830s. But in the meantime Charles Tennant of Glasgow discovered a far more satisfactory agent, made by passing chlorine into slaked lime. This was bleaching powder, made from 1799 at his St Rollox works. With the advent of the Leblanc process, and the availability of vast quantities of hydrogen chloride, it became possible to oxidise the latter to chlorine and thus make bleaching powder from an otherwise wasted by-product. When in the 1860s, esparto grass became used in paper making the demand for bleaching powder soared, and this became more valuable than the soda itself (Figure 3).

INDUSTRIAL ARCHAEOLOGY AND THE CHEMICAL INDUSTRY

At first sight it might appear that the British chemical industry has *no* industrial archaeology. Only a handful of papers in the last twenty years focus on the chemical industry as a producer of chemicals. Two noble exceptions consider, respectively, one establishment with its origins in the 18th century[6] and another of the 20th century.[7] A few other papers refer to the metal smelting industries, coke ovens and gasworks. The chemical industry is conspicuously absent from most books of industrial archaeological interest, and the one book that might be expected to deal with the subject does not in fact do so. That is W.A. Campbell's *The chemical industry*, published as part of the Longman Industrial Archaeology Series.[8] Though one of the best popular accounts in print of the history of industrial chemistry in Britain, its gazetteer is confined to less than five

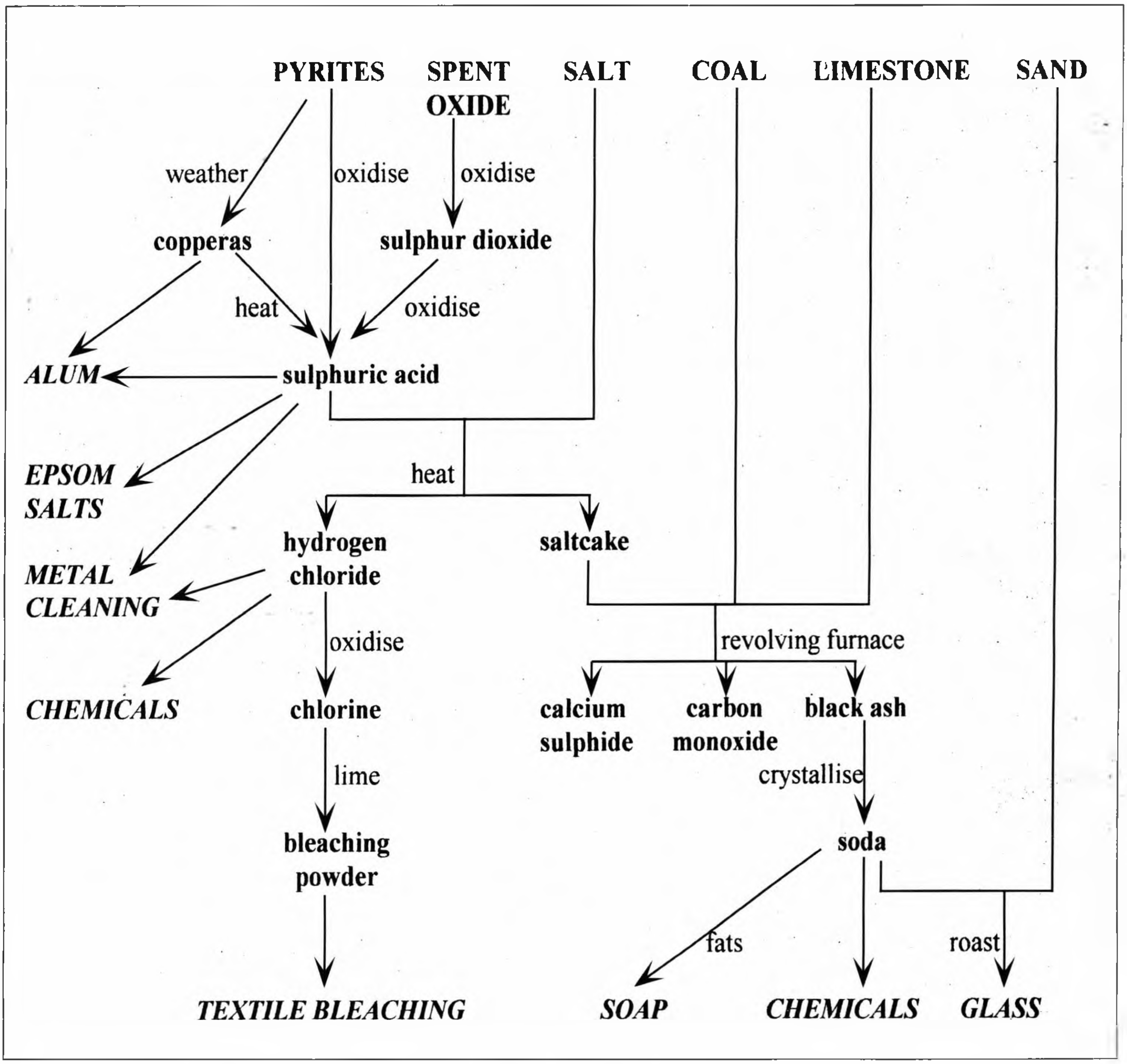

Figure 3. Simplified flow diagram for soda and sulphuric acid around 1800.

pages, much of which is concerned with matters other than industrial relics. This is not the author's fault, for the simple reason that very few such relics survive. And that sad circumstance is itself a result of the industry's notorious susceptibility to fires and explosions as well as to its need to replace worn-out plant with more modern equipment. Nor is there generally any public incentive to preserve sites of this industry, much less glamorous than stately homes, medieval churches, Victorian railway stations or even vernacular domestic architecture.

However the situation is not quite so hopeless as one may imagine, even for the 18th century. Most of the strategy I suggest will be familiar to professionals in industrial archaeology, though perhaps in a few cases its application may not. The following would seem reasonable steps to take:

Recognise, record and examine those relics that do exist above ground

In two areas of the chemical industry there are many relics still visible from the 18th century and earlier. The first of these is the industry devoted to the extraction and refinement of metals. For iron production Ironbridge occupies a singular place of honour, but other sites may be identified.[9] Installations concerned with the extraction of lead[10] and arsenic[11] have been studied. For non-ferrous metals sites in Cornwall, West Durham and the Lake District are among the most obvious to call for further examination. The manufacture of gunpowder may not be strictly a case of the chemical industry since (except for accidental explosions!) no chemical reactions took place. But if it is allowed on the grounds of its utilisation of pure chemicals then many survivals may still be traced, most

Figure 4.
Lead chamber plant for sulphuric acid at Bradford, 1956.

notably at Faversham and Waltham Abbey. An early in-depth study of the industrial archaeology of one gunpowder works relates to that at Woolley, near Bath, established in the 1720s.[12] The remains of coke ovens at collieries in Derbyshire[13] and Somerset[14] have received some attention, as has the alum industry of North Yorkshire.[15] Other industries that used chemicals, though did not make them, include leather-making, though it was stated some years ago that only two post-medieval tannery sites had been excavated.[16]

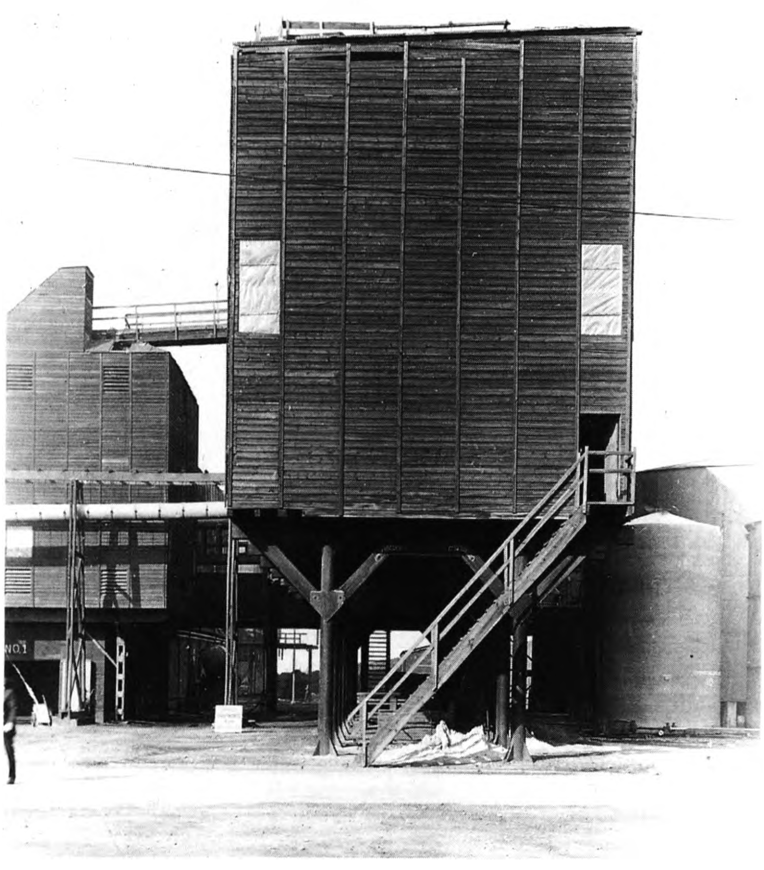

Figure 5.
Lead chamber plant at Seaton Carew, 1972.

Moving into the 19th century we find rather more survivors, such as the coke ovens at Rowlands Gill, and a tar distillation plant at Falkirk. Details of these and a few other examples of conventional chemical works have been recorded.[17] The industrial archaeology of 19th-century metal production has been extensively studied. To give but one example, an illuminating paper describes the remains from zinc production at a site in eastern Cumbria.[18] In the case of the alkali industry, work on one important archaeological site has revealed many substantial remains.[19] And now, of course, gas-works come into their own and much can still be seen. In London alone a short gazetteer lists offices, houses, gas-holders, miscellaneous buildings and much else.[20] Neverthless it has to be admitted that many opportunities have now vanished for ever. Lead chamber plants for sulphuric acid survived well into our own lifetimes, including installations at Bradford and at Seaton Carew. Now, alas, not one remains (Figures 4 and 5).

Examine and analyse materials in and beneath the top-soil

Obviously excavation will continue at sites where remains of buildings exist below ground. But it is not only buildings but also materials that can yield valuable data on the chemical industry, which has been notorious for its past failure to dispose effectively of unwanted by-products or other substances. On Tyneside, for example, there are mounds of galligu which on occasion still reek of hydrogen sulphide. Large deposits of all manner of chemical waste may be uncovered. Often their chemical identity is assumed: red deposits must contain iron, green crystals must be copperas, and so on. What is needed is competent chemical analysis of such material. This can replace presumption by certainty, or else afford unexpected new insights into the conduct of the works. For purely qualitative analysis simple portable equipment is adequate; two hundred years ago wonders could be accomplished with the aid of a flame, a charcoal block and half a dozen simple chemicals. But for quantitative analyses advanced techniques like mass spectrometry are essential.

Such analyses may appear in other contexts. A potential building plot near a river in Gloucestershire was routinely tested for toxic substances at a series of trial pits up to 2m deep. It was known that a dye works had existed nearby in the early 20th century, and in one (of eight) pits the level of toluene-soluble material (organic chemicals) was extremely high, so indicating precisely where the dyeing took place. At

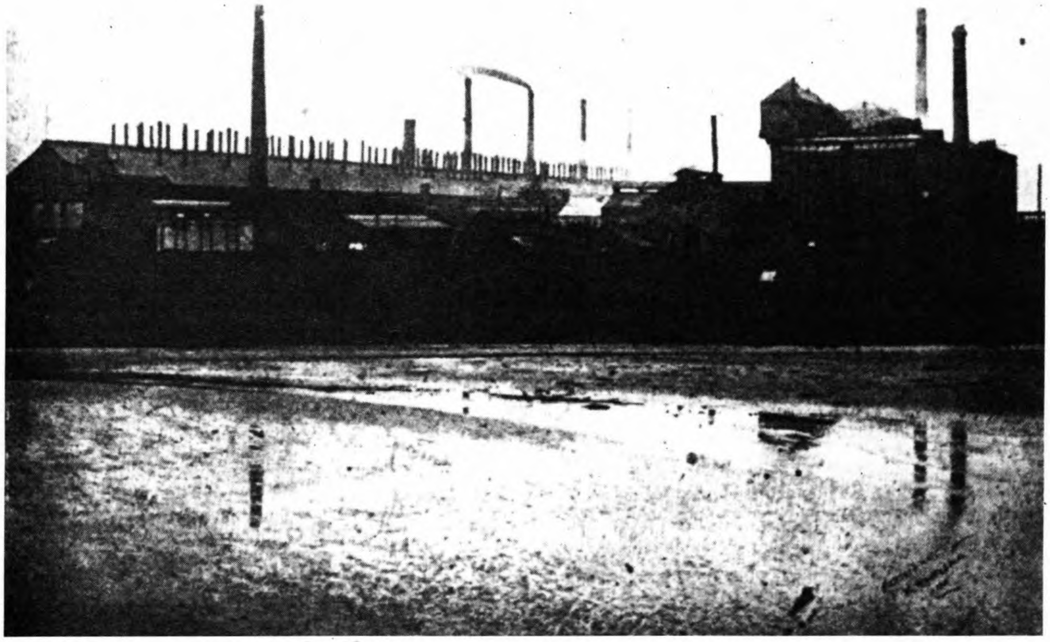

Figure 6.
The sulphuric acid/zinc smelting plant at Seaton Carew in the early 20th century.

the same point maximum concentrations were found for iron, aluminium, tin, lead and arsenic. Compounds of both aluminium and tin are well-known as mordants for certain dyes. It is possible that lead and arsenic might have been derived from the pigments lead chromate and copper arsenite respectively, though they were being phased out in the 19th century. The frighteningly high concentrations of those metals disclosed something of working conditions in the dye-works; they also dictated stringent precautions before the site could be developed.[21]

This kind of study for industrial archaeology is still to be developed. It can afford much information as to what materials were used, the nature of the waste-products, whether and how they were disposed of, conditions for the workers and the environmental impact of the establishment on the surrounding area.

Utilise archive photographs and film

The importance of documentary research is of course undisputed. For installations well beyond the 18th century photographic evidence may be crucial and may add information not present in written or printed documents. Thus, an old photograph of a lead chamber sulphuric acid works near Hartlepool reveals a huge complex of furnaces nearby. They were taken down soon afterwards, but their presence shows that, originally, the acid works was situated next to a zinc smelting plant. Since the raw material for this was imported zinc sulphide, the smelting process was a source of combined sulphur that could be converted into sulphuric acid. This indeed happened (and is confirmed by zinc ore residues that once littered the site). It is a good example of tandem technology, but also of the value of photographic evidence (Figure 6).

During the early 1970s the BBC had occasion to make many programmes in conjunction with Open University courses on history of science and technology. We were just in time to record many industrial processes that have now disappeared without trace, and several of these were in the chemical industry. One was at Seaton Carew, the plant near Hartlepool that was the last lead chamber process in the UK (and probably in the world). We recorded it only weeks before its closure! Unlike still photographs such film can display actual processes in action, of particular importance for the chemical industry where their reproduction in museums or preservation sites is hardly feasible. It may also be possible to find early film records in industrial establishments; such was the case with the last puddling process for wrought iron in Britain, and a rotary furnace for the Leblanc process for alkali. Other examples of relevant Open University archive film are given in Figure 7.

A few other institutions are believed to carry some archive film footage relating to the chemical industry. It might be helpful if a complete list could be compiled showing what is available from all sources.

Additional methods

There is space only to refer briefly to a few other techniques. One is the interview, when

Process/objects	Location	OU Course	no
Beehive coke-ovens	Blaydon-on-Tyne	AST281	2
Production of coal-gas in 1840's style horizontal retorts*	Newton Stewart gasworks	AST281	2
Distillation of coal-tar	Scottish Tar Distillers, Falkirk	AST281	2
Nitration of benzene	Disused factory, Derbyshire	AST281	2
Lead chamber process for sulphuric acid*	Leathers Chemicals Ltd., Seaton Carew	AST281	3
Alkali waste tip	St Helens	AST281	7
Alkali works	ICI Mond, Winnington	AST281	7
Leblanc Process: black-ash converter*	[ICI archive film]	A283	7
Alkali waste tips	Tyneside	A283	6
Gunpowder factory	MOD Waltham Abbey	AST281	8
Nobel's explosives factory	ICI Ardeer	AST281	8
Lab. scale production of nitro-glycerine*	ICI Ardeer	AST281	8
TNT factory	Disused factory, Powfoot	AST281	8
Ironbridge and Coalbrookdale	Ironbridge	AST281	9
Puddling process*	T. Walmsley & Sons, Bolton	AST281	9
Bessemer steel-making process*	Workington [Bessemer Steel Corp. film]	AST281	9
Forth Bridge: showing construction	Forth Bridge	AST281	9

Figure 7.
The chemical industry on archive film.
** = working processes*

the story of the chemical industry becomes part of oral history. Clearly time is of the essence, but elderly operatives of long-vanished equipment may be able to record something of their day-to-day work. Again, this was something we sought to do in the OU archive films. Two memorable interviews were of men who had worked at the Rowlands Gill coking plant and the Seaton Carew acid works.

The use of museums may seem a last resort, but many interesting artefacts or equipment may await inspection — and even interpretation — in the hidden stores of some large museums. A rich collection of models and real apparatus exists in the Science Museum. In Widnes, the Halton Chemical Industry Museum soon changed its name to Catalyst and has much material on view by the general public, as well as a site of rich archaeological importance.

Finally, perhaps, it may be as well to emphasise the need for constant vigilance and the unexpected opportunity to urge the preservation of sites which have just been discovered. Despite wholesale destruction of the evidence enough remains to indicate the reasons for siting particular establishments, the interactions between chemical and other industries, the growth of tandem technologies, and the related and immense problems of waste disposal and how these were (or were not) solved. Recent work on the environmental effects of the infant chemical industry needs to be supplemented by complementary studies of such questions on (or under) the ground. There is much to be done if ever we are to have an accurate overall picture of how the British chemical industry came to be a world leader, and to affect profoundly the lives and fortunes of millions of ordinary people.

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MASS PRODUCTION AND CONSUMERISM, 1850–2000

PRODUCTION DE MASSE ET CONSUMERISME, 1850–2000

'People, process, power and place': an archaeology of control in East Midlands outworking, 1820–1900

Garry Campion

Buildings and industrial landscapes of the lace, framework-knitting and footwear industries reveal the often overt nature of control over both production and development, itself a reflection of the drive for profits in early modern capitalism. Within the English East Midlands survives considerable evidence of these once extensive outworking industries, reflecting a major speculative expansion in the often competitive market for housing and workshop provision throughout the 19th century. 'People and process' issues within family and 'team' working are addressed within the three industries, seen as critical to the identification of both implicit and explicit, imposed structural control within outworking. In all three industries reliance was placed upon the putting-out of work, the chimera of independence a dogged bulwark against the transition to centralised factory production made possible by British and North American technological developments. This paper emphasises the spatial nature of outworking within homes, workshops and landscapes during the 19th century, a reflection of working and living constraints imposed by builders unlikely ever to directly experience their ideas in practice.

'Ouvriers, procédés, pouvoir et lieux': l'archéologie du contrôle social dans le travail à domicile dans les East Midlands, 1820–1900

Des bâtiments et des paysages générés par les industries de la dentelle, de la bonneterie et de la chaussure peuvent révéler des formes non-dissimulées de contrôle social exercé sur la production, traces de la soif des bénéfices d'un capitalisme industriel naissant. Les East Midlands, en Angleterre, conservent d'importants vestiges physiques de ces formes de travail à domicile, autrefois très répandues. Ces vestiges témoignent d'une expansion spéculative des marchés du logement et du lieu de travail, souvent en concurrence au XIX^e^ siècle. La questions des 'gens et des processus' au sein des familles et du travail 'en équipe' sera examinée dans les trois industries, permettant d'identifier les formes de contrôle structurel imposé, de manière explicite ou implicite, sur le travail productif. Ces trois industries dépendaient toutes du travail à domicile; la chimère de l'indépendance des travailleurs servait de rempart solide contre toute production centralisée en usine, pourtant à portée de main depuis les progrès technologiques vus ailleurs en Grande Bretagne ou en Amérique du Nord. Cette communication porte une attention particulière à l'organisation spatiale du travail à domicile au XIX^e^ siècle, dans l'habitat, les ateliers et les paysages. Cette organisation offre un reflet des conditions de travail et de vie imposées par des constructeurs de bâtiments qui n'allaient jamais vivre directement la matérialisation de leurs idées.

Introduction: An Archaeology of Outworking Control

Outworking within industrialised society equates to a dispersed factory system in homes or workshops — East Midlands industries relied upon framework-knitting, machine-made lace and footwear outworkers.[1] They were not independent craft producers, but depended upon piece-work from manufacturers. Buildings and landscapes reveal the imposition of control within the outworking system.[2] Most housing provision was determined by builders and speculators responding to local and regional trends, implying an element of diffusion — but the extent to which speculators *drove* the growth of outworking is less clear.[3] Critically, houses and workshops were built by speculators unlikely ever to live and work in them.[4]

The formal separation of home from work created a psychological and physical divide between the two, the workshop or master's house environment an 'acceptance' of work beyond the family domain. A workshop builder hoped to reconcile several tensions: achieving the minimum cost of construction in land, material and labour terms; anticipating the profit and loss equation of the structure in an industrial system; the production process and space needed to accommodate it; a flexible building design allowing a number of individuals to work together; and finally, locating it for reasonable access to materials and a workforce. Design blandness affirms a concern on the part of the owner to avoid unnecessary expense by not squandering money on a building whose purpose may not endure. Workshops symbolise thrift, a lack of concern about expressing 'power' and a monotonous uniformity. Masters' houses sought to reconcile this aspect within working areas, but not at the expense of presenting an affluent impression to the world at large.

Assessed in turn, each industry's buildings and several sample towns are discussed, the emphasis upon outworking control imposed through the built environment.

FRAMEWORK KNITTING

Researchers have identified the extent of framework knitting in Nottinghamshire, Derbyshire and Leicestershire.[5] Its distribution by 1812 revealed involvement from Matlock, Mansfield and Southwell in the north, running south almost to Hinckley and Lutterworth, its western and eastern edges defined by Derby and Melton Mowbray respectively. By 1844 the industry was at its greatest extent, where interpretation of the 'putting-out' centres revealed Belper, Nottingham, Loughborough and Leicester to be major centres, and to a lesser extent, Sutton in Ashfield, Derby, Ruddington, Shepshed and Hinckley. The industry contracted in the late 19th century due to increasing centralisation in factories.

The narrow gauge stocking frame, a muscle-powered machine, evolved through a series of developments leading to the 'wide' stocking frame. Narrow frames could be operated at home — wide frames encouraged a 'team' approach to producing socks, gloves, stockings, jackets and caps. Individual workers bore production costs including child-labour for winding yarn.[6]

A typology of hosiery buildings:[7]

- an individual operating a stocking frame in the corner of a family area — 1650s
- an individual stocking frame operated in a living room, with an adapted window for lighting
- purpose-built single or terraced houses with work room for family operation of frames — 1780s
- a house designed by a master hosier integrating work rooms for workers and his private quarters — 1830s
- a very small family, garden workshop designed for several hand-operated stocking frames — 19th century
- a larger garden workshop holding 20 plus stocking frames, for separate knitters — 19th century
- a separate house and large workshops built by a master hosier for employment of piece-rate workers — 1840s
- a small steam-powered 'workshop', or factory employing 20 plus workers — 1860s
- a larger steam-powered factory employing several hundred workers — 1870s
- a substantial steam-powered textile factory complex employing perhaps 2,000 workers — 1870s
- the adaptation of electricity to power textile machinery, resulting in a modern textile factory — 20th century
- some reversion to small-scale 'craft' production in 20th century — Dovey's, Calverton, operated until *c.* 1955

The transition from house to factory was erratic. Many approaches were adopted, where the ascendancy of one did not eclipse another. Much housing provided for outworkers predated local by-laws from 1848 onwards.[8] Few masters had capital to provide outworkers' housing on a large scale, but speculative builders profited from the industry, knitters paying rent in an unregulated market.

House building materials varied by regional availability: brick was common in Nottinghamshire and Leicestershire, limestone more frequent in Derbyshire. Purpose-built housing featured a workroom for several narrow frames. A wide-span segmental-headed window provided workroom lighting, against which frames were placed. Rooms might face front or rear, and could be located on the ground, middle or upper floor. Timber for roof-joists, stairways, ladders, floor-joists and -boards and trap-doors was usual; reinforced working floors, supported on substantial joists, might have a thick skin of gypsum, or lath and plaster. Red-clay pantiles or Welsh slate were common roof coverings. Wooden workroom window frames were capable of withstanding the vibratory impact of bolted machines — casements might have opening lights, or Yorkshire sashes.

Table 1

Felkin's Survey of Frame Figures[12]

	Narrow	*Wide*	*Total*	*Shops*	*Frames: shops*
Calverton	409		409	128	3.1
Hucknall	837	5	842	301	2.7
Ruddington	104	229	333	69	4.8

Table 2

1881 Census — Outworkers

Total population		*Total outworkers*	*Percentage of population*
Calverton	1,246	350	28.0%
Ruddington	2,638	575	21.7%
Hucknall	10,023	680	6.7%

The transition from home- to workshop-working was not simple. Workers rented space and a machine from the owner of a workshop, who may not have provided them with work. Workshops were purpose-built, cheaply-constructed, single or two-storey buildings, often separate from a dwelling, using materials similar to those in houses — wide-span segmental-headed windows were common. Pitched roofs were rarely hipped; extensions, even of an extra bay were rare, indicating either a satisfactory design or insufficient capital for modifications. Bricks were laid in stretcher or Flemish bond, rarely enhanced with decorative elements — stone was uncommon. Bricks, or red clay tiles were laid for ground floors. Cast-iron ventilation grilles were fixed within walls. Doors were simple, and few. More rarely, a first floor taking-in or putting-out door and winch provided access for movement of goods. The movement of heat from grates was unhindered by internal partitions, but escaped through thin walls and roofing.

Masters' houses were uncommon. As argued previously,[9] this building type represented an important link in the progression from individuals working at home to factory production — it enabled control through physical and work restrictions, and gender segregation of processes. Extant examples feature spatially separate living and working areas (the latter often later converted for domesticity), yet which may have been physically attached — i.e. a workshop adjoining a house, or, separate workshop(s). Investing in a building with a sizeable working element was a carefully assessed business risk, business volatility making profit predictions difficult. Building materials reflect local patterns, scale rather than architectural embellishment dominating streetscapes.

Centres of framework knitting outworking

Close to Nottingham city, Calverton is 12.9 miles (20.8km) to the north-east; Hucknall[10] is 12.9 miles (20.8km) to the north-west; and Ruddington[11] is 8.4 miles (13.5km) to the south. Tables 1 and 2 reflect the dependence upon outworking within all three.

Rural Calverton village is a ribbon development along its Main Street, and erratic housing at its margins or along lanes. It has no obvious centre, and no clear pattern of outworkers' housing. To the extreme west and east were Foxwood Terrace and Windles Square.[13] Building plots were established at the margins of land as it became available from local farmers. Most knitters worked in ground-floor workrooms in brick-built housing, workshops being rare.

Ruddington in the late 19th century was urbanised and affluent, housing and public buildings concentrated around the church to the north and the green to the south. The village straddles the High Street at its centre, from which radiate roads and lanes. Knitting was undertaken in large workshops, built separately, rather than at home in terraced housing. During the 19th century two 'colonies' of knitters' terraced housing evolved — the area around Savage's Row in the north of the village, and The Leys to the south. Its prowess continued into the 1900s,[14] workshops continuing to be built when the industry declined elsewhere — few of the 69 workshops recorded in 1844 survive.

Hucknall, originally Hucknall Torkard, is the largest of the three centres, developing during the later 19th century with two collieries. Most knitters worked in home work rooms, usually on the middle floor, to the rear of stone, three-storey dwellings. Shetland shawl manufacture from *c.* 1865 encouraged purpose-built hosiers' houses. By 1880 the village had expanded haphazardly to become an untidy town. In addition to housing within the town centre were four developments: Butler's Hill to the west; Broomhill to the south-east; two large areas straddling Watnall Road to the south, and to the north-west, development north and south of Annesley Road. Hucknall had a railway link but failed to attract the success enjoyed by Ruddington.

Fieldwork suggests that Hucknall has undergone the most dramatic redevelopment, a third of its 1880 map stock of *c.* 1878 buildings surviving to the present, a loss of 66%. Ruddington's loss of some 56% of its 1900 map stock of 873 buildings is surprising, much of this occupied by framework knitters. Calverton's 1900 map stock of 358 has reduced by some 48%, reflecting dwellings suitable for modern living.[15]

In all three centres, a major issue is the diversity of building forms, despite the similarity of process and their close proximity to each other and to the major hosiery and lace centre of Nottingham. Locally available materials are a determinant, but the consistency of some forms is as striking as the implicit rejection of others. Hucknall had sufficient land available for workshop construction, but this was instead used for rows of terraced housing. Calverton eschewed both workshops and workers' terraces on a large scale, Windles Square and Foxwood Terrace being the exception. Ruddington prospered with workshop production and separate housing.

MACHINE-MADE LACE

Analysis of the lace industry suggests a widespread if low intensity East Midlands involvement during the early 19th century, much of it undertaken on knitting frames. Smith's analysis of the lace industry shows a major concentration upon Nottingham in 1831. By 1855 manufacturing had contracted with production centred upon Nottingham and Long Eaton where it declined before the First World War.[16].

The history of machine-made lace is complex. Its concentration in Nottingham is partly explained by the lead in machine technology, and the availability of framework knitters — early 19th-century working conditions and processes were therefore similar. Most extant buildings relate to bobbin-net outworking in the 1820s and '30s. Slightly later, women and child outworkers repaired and finished lace net, usually for companies in Nottingham's Lace Market. Further experiments to adapt the stocking frame for lace led to a factory-based industry from the 1850s, producing net curtains, antimacassars, drapes and clothing.[17]

The lace building typology suggests a more straightforward progression than that for framework knitting, reflecting lessons learned:[18]

- former knitter operating a lace machine in a knitter's workroom as family unit (late 18th, early 19th century)
- operating a lace machine in a purpose-built house as family unit (also for Jacquard looms) — 1820s
- piece-rate finishing processes within houses, workrooms and mistresses' houses — early 19th century
- establishment of large, unpowered workshops — 1820s
- operation of lace machines within workshops, sometimes powered (also for Jacquard looms) — 1820s
- rapid decline of home-based lace manufacture due to workshops and nascent factories — 1840s
- individual or partnership renting of stalls and machines in powered tenement factories — 1880s
- finishing processes in Lace Market warehouses from the 1850s (and putting-out work)
- large factories built for individual companies in Nottingham and Long Eaton — decline towards World War I

Housing development in Nottingham during the 1820s was constrained by a failure to enclose common lands until the mid-1860s: Nottingham's infrastructure reached crisis point. In the 1840s several inquiries investigated: dense overcrowding in slums, high volumes of cheaply built back-to-back, court housing, inadequate ventilation, privies under dwellings, little drainage and occupants with poor health, often working long hours in crowded work rooms, were noted. One report includes a plan of Sussex Square, showing 'back to back houses' — an archival photograph records the block inhabited some 90 years later.[19] The housing comprised 43 back-to-back brick dwellings of three and four storeys — two tunnels gave alley access to the courtyard. Twelve privies are provided at three points, two oversailed by a house apiece. Reminiscent of a prison, a cobbled yard, entirely lacking in vegetation, has high-sided buildings blocking out daylight. Cross sections of a three- and four-storey house are provided, the latter incorporating a workroom on the top floor.

Within lace, a transition from houses to workshops was brought about by technological change — a diverging industrial system[20] established workshops and tenement factories from the 1840s. This shift from homes to workshops, and thence to factories, was clearer than for framework knitting — lace workshops endured until the 1880s and '90s.[21] These tended to feature large, rectangular windows, different to those in knitters' buildings — otherwise, materials were similar. Few survive, but these varied in size, number of floors and production capacity. Early, large workshops were built, such as Wild's five-storey warp-machine complex completed in 1825, on Mansfield Road, Nottingham.[22]

It is difficult to identify lace masters' or mistresses' buildings comparable with those in hosiery. Many premises employed young women and girls in finishing and repairing lace, often in overcrowded conditions. The concentrated nature of lace production and finishing encouraged the evolution of large premises in a way uncharacteristic of hosiery, resulting in buildings provided with fenestrated finishing attics.

Mansfield Road, Nottingham

Of a once massive industry, a small concentration of lace housing survives in Nottingham city, comprising three narrow, broadly rectangular blocks between North Sherwood Street and Mansfield Road — one mile due north of the Market Square at its nearest point. Bluecoat Street forms the southern boundary; Forest Road East its northern, while the Forest Ground remains as open land to the north.[23] This pre-enclosure block comprised back-to-back housing, courtyards and workshops in gardens between the two main rows of housing. In an advanced state of development by 1830, census and directory evidence shows lace outworkers resident within this area during the 1830s and '40s. Most houses along Mansfield Road were dwellings whose ground floors were later converted to retail shops. Of some 96 houses identified in 1880, only 22 had workrooms — with five possibles. Occupants listed as 'private' may have operated machines in such premises, or undertaken lace finishing. Façades along Mansfield Road are often of fine quality with workrooms on upper floors to the rear, while houses in North Sherwood Street had workrooms to the street-side. Wild's, noted above, survives to the south of this concentration.

Footwear

In later 19th-century Leicester, footwear supplanted framework knitting as a staple industry and by 1899 accommodated several hundred manufacturers. Secondary centres were close to Leicester, including Shepshed, Wigston, Hinckley and Loughborough. Within Northamptonshire the industry was mostly in the central region, within a crude equilateral triangle of Northampton, Desborough and Raunds.[24] A total of 376 factories operated by 1903,[25] with Northampton the largest footwear centre.

Cordwainers were eclipsed by industrialisation from the 1850s. Footwear production of boot and shoes involved six processes — clicking (cutting leather), closing, lasting, welt sewing, sole attaching and finishing, each requiring few specialised tools.[26] Production was often based upon the 'basket-work' system. Materials from the warehouse or factory would be 'put-out' to the organising town or village, transported in wicker baskets to outworkers in garden workshops or a room in the house. Although new technology such as the treadle-powered sewing machine was accommodated, village outworking endured into the 20th century.

This industry's buildings were typologically less diverse than those developed within hosiery and lace outworking:[27]

- cordwaining, craft tradition of working with fine leather at home or in singly-built workshops — to the 1850s
- cobblers working on boots and shoes as individuals, at home or in singly-built workshops — to the 1850s
- establishment of warehouses in towns for the distribution of cut leather to home-based 'outworkers' — 1850s
- singly-built workshops in towns to handle machine closing put-out from warehouses — 1860s
- evolution of large factories in Northampton and other towns, with putting-out of closing and finishing to workshops or homes
- mass development of factories, housing and uniform workshops in county towns: basket-work system
- few large, two-storey workshops for organised work — superseded by factory production
- large factories incorporating all production led to a decline in outworking

It is misleading to suggest that footwear manufacturing during the later 19th century was polarised between factories within which all production was undertaken, or the single-storey garden, or home-

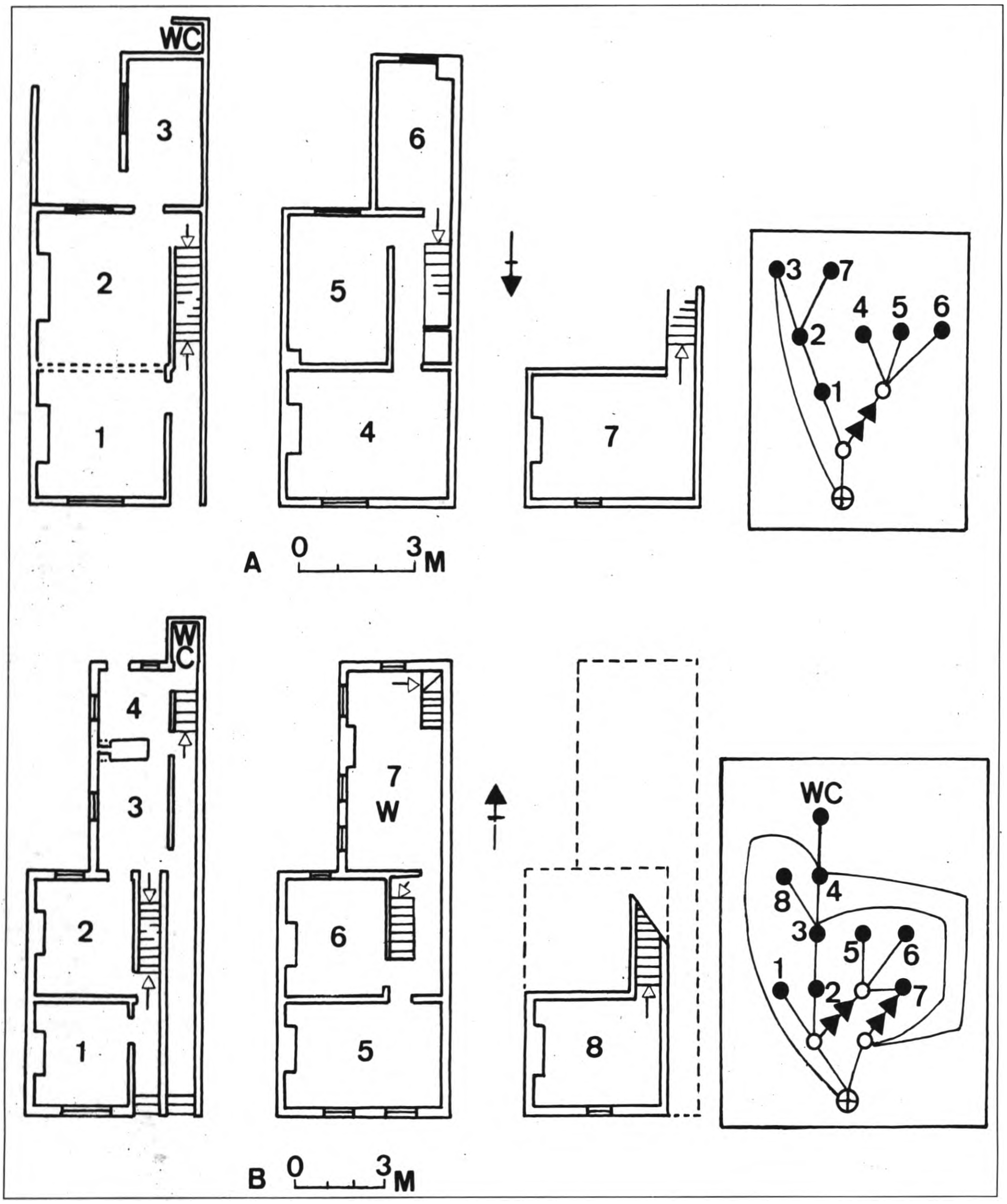
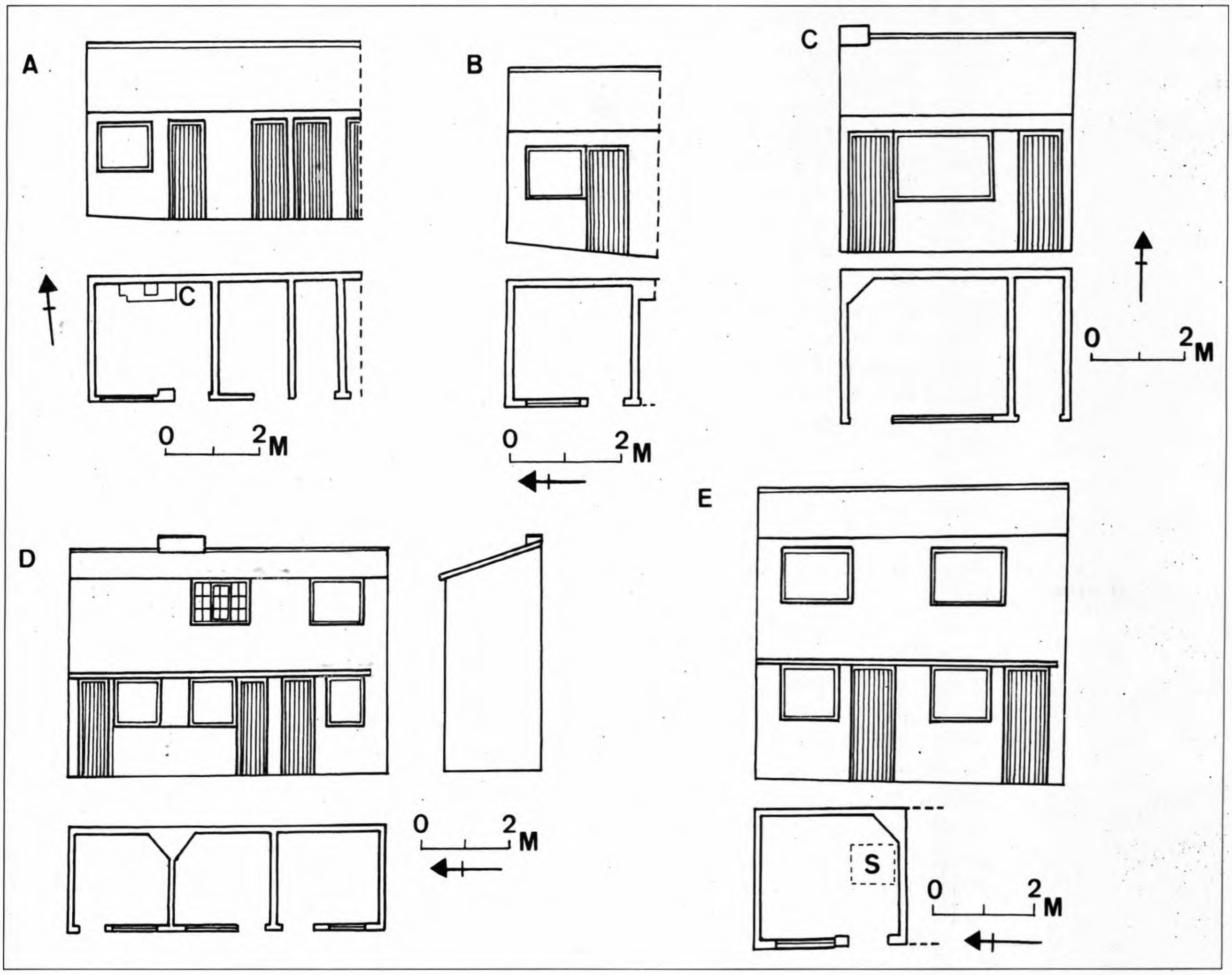


Figure 1a–b. TOP. 46 Alcombe Road, Northampton (1 & 2 = living; 3 = kitchen; 4, 5 & 6 = bedrooms; 7 = cellar with coal chute; WC to rear. Wall removed between rooms 1 and 2). BOTTOM. 53 Alcombe Road, Northampton (1 & 2 = living; 3 = kitchen; 4 = scullery/WC; 5 & 6 = bedrooms; 7 = work room; 8 = cellar). (NNAO: BLG, dated 1.4.77). Note the variations in the spatial maps.

based workshops working to them: production was undertaken in both contexts. There were also two-storey workshops, few of which were intended for employment beyond the family itself, in contrast to mature lace and knitters' workshops.

By-laws impacted upon internal and external house elements, engendering standardised layouts, materials and styles. Terraced housing of humble, but solid façades by speculative builders or co-operative societies was widespread.[28] Two house plans are illustrated, on Alcombe Road, Northampton, opposite each other: Figure 1a is a 'typical' design with no workshop; Figure 1b is rarer, featuring a workroom to the rear. In each, the left-hand plan is the ground floor, the centre plan the first floor, and at right, the cellars. Comparatively, despite the similar width and overall area, the two houses are configured differently: Figure 1a's plan is simpler than that for Figure 1b, the latter more complex because of the separate street access to the first-floor workroom (7w), above the kitchen and scullery (3 & 4) — note the three windows provided, typical of other workroom examples. Cellars are rooms 7 & 8. Spatial maps (right-hand side) illustrate the reconciliation of space and function.[29] Numbered black dots correspond with rooms in the house — lines between 'rooms' represent connections, most easily comprehended by comparing maps with house plans. Open circles are transitional spaces such as corridors; the circle enclosing a cross represents the external space from which the houses are entered. Arrowheads between rooms and corridors indicate stairways (but omitted for cellars). Figure 1b has a separate corridor access to reduce the tension between home and work, as would be the



case of a house with a separate garden workshops accessed via an alleyway.

Northamptonshire's byelaw housing, often occupied by footwear workers, can be understood in its marketplace context. Northampton, Kettering and other footwear centres expanded between *c.* 1860 and 1900, with incoming workers providing a market for speculators[30] — despite this, home ownership remained a myth in Northampton.[31] Enhancing terraced house façades suggested finer dwellings to potential owners or occupiers, their builders aiming to sell or rent housing in a competitive market. Widely available Welsh slate, encaustic tiles, glass, wood, materials for stucco, stone and mouldings enabled mass-production of housing — brick was supplied locally. Red-brick façades included sash window entablatures, semi-circular arches and fanlights for doors — or mock-classical fluted stucco/stone pilasters, cornices and consoles. Doorways might feature a stone step, supported by a cast-iron riser to ventilate the cellar — and door steps inlaid with decorative encaustic tiles. Doors were panelled and footscrapers were common. Chimney-stacks featured oversailing brick-courses, some with extraordinary decoration. Roofs had firewall parapets: eaves dentilation of several courses, in red, blue or yellow brick was common, as were string-courses. Humbler dwellings incorporating sometimes fine, but widely available, architectural features had the effect of diminishing the impact of such detailing in larger dwellings, with the result that houses owned by the professional classes seemed perhaps socially less remote. Therefore, for those workers wishing to exhibit social status, but constrained by a house front of only two storeys and immutable width, one possibility was to indulge in extravagant expression, hence the sometimes bizarrely decorated, probably commissioned façades using the range of architectural mouldings and features to be seen in these terraces.

Garden workshops in the footwear industry all followed a very similar pattern, single storeyed incorporating a workroom with heating grate. Brick-built, these featured a single doorway, one window and a bench (Figure 2a–e) — rarer are two-storey examples, the ground floor used for storage and the upper floor for work. These examples reflect the similarity in form, despite construction behind housing in different areas, probably by various

Figure 2a–e. Boot and shoe workshops in Rothwell, Northamptonshire. A. Behind 1 Ragsdale Street with store and privy (C = copper sink, a most unusual feature in original workshops). B. Behind 4 New Street, which has no obvious fireplace. C. Behind 57 New Street, one of a series built after 1900. D & E. Two-storey workshops behind 40 & 42 New Street respectively, built as part of a mixed assemblage of single and two storey units. Note the original window style to the first floor of Figure D (S = stair or ladder access).

builders. Workshops, often out of sight, were detached from the house, forming the rear garden party wall, often in long 'terraces'. Domestic outworking in centres such as Kettering and Rothwell was so widespread that attempts to provide architecturally striking workshops were unnecessary.

The organisation of the boot and shoe landscape was more explicit than for hosiery or lace. Access to workshops was through alleys, or 'tunnels' between houses, or, alleyways running between blocks of housing, allowing basket-work deliveries direct to the workshops without interfering with domestic activities. It is only possible to provide this at the design stage, regardless of whether one, or several builders were responsible for the accompanying terraced housing. The original planning for spatial relationships between factories, warehouses and garden workshops is hard to gauge, and it is misleading to posit evidence for manufacturers or builders *creating* composite landscapes. More likely, factories and workshops were *ad hoc*, each element responding to the other organically — but, which speculator decided that garden workshops were a good investment for new building plots? If footwear outworkers can only be accommodated once housing and workshops exist for them, it is difficult to consult with an unformed outworking population — an imposed production landscape results.

In footwear, two factors inhibited centralised outworking within masters' houses: first, technological change rendering outworking increasingly, but not entirely, obsolescent by the 1890s; second, the omnipresent arrangement of garden workshops militated against restructuring to accommodate a new working system — such as larger workshops. Masters' complexes are therefore rare, but at 4 Oakley Street, Northampton, an end terrace survives of slightly broader width than those adjoining, it is indistinguishable from adjacent houses. To the rear, taking up the garden, is a large, two-storey workshop extension, for the closing of footwear. Simply built of brick, it features four large rectangular windows on its upper floor, ideally sized for the operation of sewing machines by a moderate workforce — access was gained from the yard.

Centres of footwear outworking

Twelve miles (19.3km) separate Northampton and Kettering, whilst Rothwell is about 3.7 miles (6km) to the north-west of Kettering. The 1881 census populations were: Northampton 59,042, Kettering 11,095 and Rothwell 2,755. Northampton experienced massive expansion from the 1860s — greenfield sites, mostly to the east and north-east, were consumed for terraced housing, footwear factories and other amenities. In the 1840s the field systems there were intact, with little development. Three decades later, by *c.* 1880, this area had been progressively exploited for the mass provision of housing and factories, but some streets associated with footwear manufacture had not yet matured, e.g. St Michael's Road.[32] East of the centre, a slightly earlier development occurred to the east of York Street during the 1860s, bounded by Wellingborough Road to the north, Billing Road to the south, and East Street to the east — a survey revealed factories and some workshops.[33] The lack of workshops in Northampton may be explained by outworking within houses, in contrast to other large centres — there are very few of the type in Figure 2a–e.

Kettering's development is striking between 1835 and 1900, especially north and north-east of the centre.[34] Some 2,400 garden workshops and the alleyways and paths allowing the basket-work system to function are evident, as described above.[35] Less dramatic expansion appears to the west and south, bounded by the railway in the west. Outworkers' housing, enclosed by Wood Street to the north and Princes Street to the south, reveals piecemeal investment by speculators on land from auctions, not provision by footwear manufacturers.[36]

Little has been published on Rothwell's evolution. Although expanding in the 1880s in tandem with Northampton and Kettering, its shape in the 1830s remained recognisable. The boot and shoe industry provided impetus for expansion: by 1884 rows of terraces are in evidence,[37] with housing and workshops to the south and to the extreme east on greenfield sites.[38] Although evident in Rothwell, semi-detached houses (and bay windows) are rare in Northampton and Kettering.

MEANINGS

Within dwellings there are multiple 'solutions' for the provision and reconciliation of living and working spaces, with minimal or passing attention to outwardly directed statements of status: understandable with the humbler outworker, but less so with masters *influencing* local industrial activity. Lace workers tended to fare well in new housing developments such as Nottingham, where incomes met rents during the 1820s and '30s in new suburbs.[39] However, housing just south and south-west of the city centre exceeded all standards of notoriety and building ostentation would do little in allowing occupants to transcend such awfulness. This contrasts unfavourably with footwear housing a few decades later, of undeniably higher quality in appearance and conditions, speculative builders dictating styles in a market context. Even so, earlier housing in Ruddington and Calverton was solidly built by the standards of the time.

Workshops are a different matter, in many ways repeating the bland motifs of outworkers' houses. It is easy to see cost as the mitigating factor, but the real logic lies in a sense of impermanence (uncertain profits), an awareness that embellishment was irrelevant for such buildings, even when publicly visible. In a town or village dominated by a single industry, it was superfluous to seek visibility through the medium of architecture. Masters' houses provided real opportunities to assert power — when commissioning buildings they might seek to impart status, dependent upon available capital, the effect of which could not fail to intrude upon the consciousness of humbler outworkers.

Conclusion

Homes, places of work and landscapes are valuable sources when seeking to understand outworking as it was experienced — mirrors of social control. Houses and workshops reflected this tension, their façades indicating not so much the barren spirit of their occupants but more the speculator's drive to enhance profits. Masters' houses reflect a sizeable element of control, both of appearance and spatial organisation. Irrespective of industry, a consistent factor is the imposition of power through the medium of the built environment. This occurs both within buildings (at the level of family or overseer), but is also expressed through building styles and their locations. Economic and legislative conditions made it possible for speculators to react in similar ways to demand, despite the wide regional spread of outworking. House and workshop styles, street layouts and outworking systems were therefore erratically imposed upon an often impotent, mute workforce.

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[39] Chapman, ref. 3.

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Swedish engineering industry during the 19th century: from diversity to mass production

EVA DAHLSTRÖM

The first Swedish machine shops were set up during the early years of the 19th century, and by the turn of the 20th century the engineering industry was one of the largest industrial sectors in the country. During the 19th century production was varied and the customers came, with few exceptions, from within the region. By the turn of the 20th century certain companies began to specialise and also to supply customers in other parts of the country.

The subject of this paper is how the change of production affected methods of work, the need for skilled workers and consumer demand. Buildings can be used as source of evidence to explain production methods, work organisation and working conditions. The discussion is based on examples from three machine shops founded around 1850. The analysis will be carried out using the concepts of proto-industry and paternalism. The author will try to apply them to the built environment and see how older forms of production can be traced in the workshops.

La construction mécanique Suédoise au XIX^e^ siècle: de la diversité à la production de masse

Les premiers ateliers de construction mécanique en Suède ne datent que du début du XIX^e^ siècle, mais, à la fin du siècle, ce secteur industriel était l'un des plus importants du pays. Au cours du XIX^e^ siècle, la production était très variée et, sauf exception, le marché pour les produits restait confiné à la région. La fin du siècle, en revanche, voit des usines spécialisées approvisionnant des marchés devenus nationaux. La communication examine cette évolution de la production, liée à l'organisation du travail, les besoins en ouvriers spécialisés et les demandes de la clientèle. Les bâtiments peuvent être considérés comme des sources pour expliquer comment les procédés de production s'agençaient, comment le travail était organisé et à quoi ressemblaient les conditions de travail. L'étude est fondée sur l'examen de trois usines de construction mécanique fondée vers 1850. Leur analyse a recours aux notions de proto-industrie et de paternalisme. On s'emploie à en lire les traces dans le bâti, en s'attachant à identifier les vestiges, dans les ateliers, de formes de production plus anciennes.

INTRODUCTION

In this article the author discusses the Swedish engineering industry during the 19th century.[1] Its aim is to show how production slowly changed from hand craft to specialised and even mass production by the end of the century. How were these changes in production related to the work organisation, the need for skilled workers and the demands from customers? A further aim is to examine what an analysis of buildings and mechanical equipment, together with information from written sources, can bring to industrial history.

Engineering industry is defined as industry which, with the help of machine tools — lathes and drills in the beginning, and later other machines too — made products out of metal.[2] An analysis of how the production changed from diversity to mass production in the Swedish machine shops during the 19th century has been carried out using the concepts of proto-industry and paternalism, which in different ways link up with the changes which occurred in connection with industrialisation. Franklin Mendels introduced the concept proto-industry in the early 1970s. He stressed that the production was carried out within a rural framework, that the products were sold outside the region they were made in, often by a tradesman who put out materials to the workers. The concept of proto-industry has been further discussed and developed by other historians.[3] The critics have, among other things, debated that proto-industry only occurred in rural societies and not in towns and they have shown that proto-industry did not always lead to industrialisation. Proto-industry is used here to designate manufacture carried out within the framework of the older form of production. However, there must have been elements of a division of labour, the products must have been sold outside the home region and the household must have had sources of income other than that provided by manufacture for sale.

The paternalistic relation between the employees and the owners is another persistent characteristic in early industry.[4] The concept of industrial paternalism is used to illustrate both change *and* continuity: how the social relations and how the organisation of work and life outside the factory went on, even when production changed and the liberal market ideal characterised economic life. This can also be seen in the Swedish engineering industry.

THE SWEDISH ENGINEERING INDUSTRY

During the 19th century Sweden changed in several ways.[5] Laws were passed making it easier to start up and run companies, transport was expanded, and technological training was re-organised, becoming more theoretical. Moreover, population growth, urbanisation and a changed ownership structure in the countryside, as well as an increased demand for machines from agriculture and from the developing industry, also had a direct or indirect effect on the growth of the engineering industry.

The first engineering shops in Sweden were started at the beginning of the 19th century. The sector grew and by the turn of the century was one of the largest branches of industry in the country — a position it still occupies. Most of the examples considered are from three engineering companies.[6] The first is the machine shop in Överum, a rural industrial community in the Småland province in the south-east of Sweden. The second is Ludvigsberg machine shop in Stockholm, where several industries and machine shops were already located. And the third is Köping machine shop located in a small town on Lake Mälaren, in central Sweden and in the border area of Bergslagen where many ironworks were situated. All three grew to become large, successful firms, although none of them were among the largest enterprises in Sweden. Three periods in the history of the engineering industry during the 19th century are identified in this paper.

The pioneering phase

The first phase, pre-1850, has the character of a pioneering phase. The first machine shops were set up in Stockholm during the early years of the 19th century. Many British people were involved in the early companies, and it was through them that British technology came to Sweden. The Swedes who worked in foreign workshops also supplied knowledge about British engineering technology, and so new products and new manufacturing methods were brought into the country.

However, it was not only novelty which led to the establishment of the sector; but also a connection with older forms of metalworking. Even if new machines like lathes and drills were used, they were not plentiful in the early workshops, and hand craft played a big role. The manual skills needed within the engineering industry had long been available in Sweden, not least within the iron industry, and the new sector could make use of this knowledge.

Ever since the 17th century, ironworks had been central to Swedish economic life. The concept *bruk* is a Swedish phenomenon which is difficult to translate and is used to describe the societies which grew up around iron production. Farming and forestry were also generally associated with the *bruk*, and several *bruks* were more or less self-supporting. They were characterised by a strong paternalism. The *bruk* provided housing and necessities of various kinds and was even responsible for social activities, such as schooling and taking care of older workers. Iron production was concentrated in certain parts of the country, particularly those areas with good access to iron ore. The early engineering companies were also located in these areas, as well as in the big industrial cities of Stockholm, Gothenburg and Norrköping.[7] The *bruks* were important for the early engineering industry partly because they constituted important customers, and partly because skilled workers could be recruited from them. The *bruks* also set up machine shops. Even under the auspices of guild-run hand craft, in the state-supported manufacturers and in farming circles, work was carried out which was similar to that undertaken within the earlier workshop industry.

During the first half of the 19th century, there were few workshops and they were located in larger towns or in areas with an iron industry. Production was varied and for the most part simpler machines and tools were manufactured, and the customers came, with few exceptions, from within the region. The first machine shops were based on hand craft and skilled workers. Several products were more or less unique and made on order from the customer. The machines used in the engineering industry during the first half of the 19th century were few, lathes and drills were important, but hand work with the help of files and other tools was essential as well. It is hard to recognise, in our sense of the word, a rational organisation of production. It was not unusual for those who worked in the machine shops in the early and mid-1800s

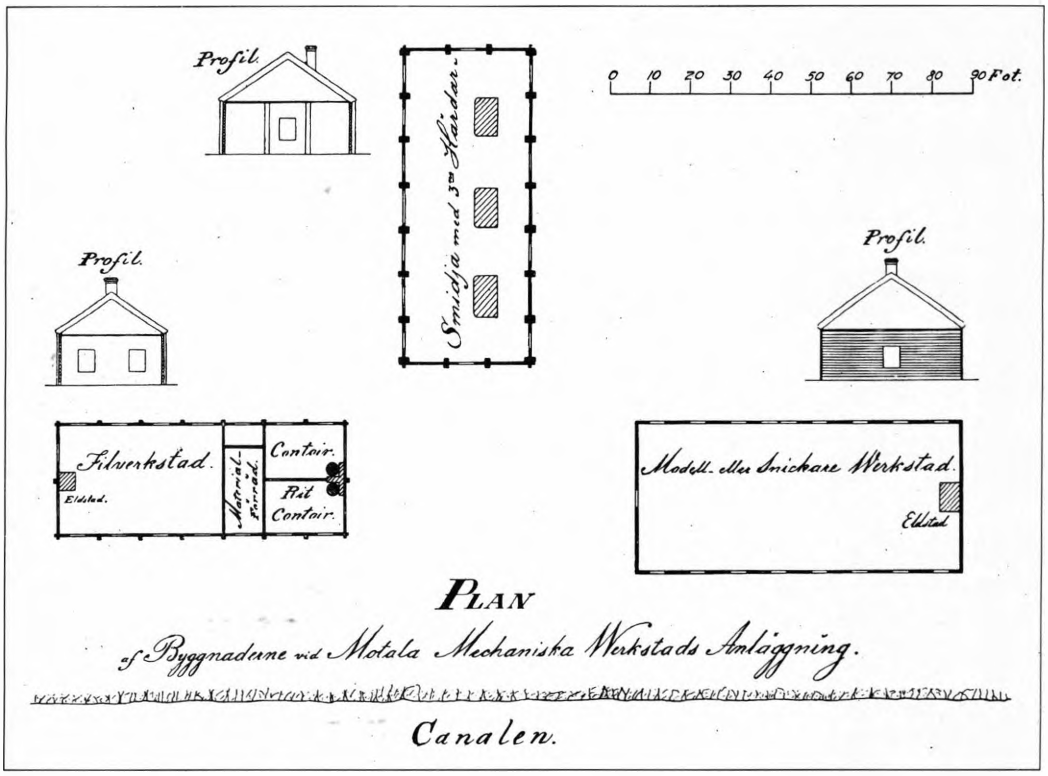

Figure 1. The first workshop at Motala verkstad, 1822. This was started in close connection with the building of the Göta canal which linked the east part of Sweden with the west. The first workshop buildings were erected in 1822 and Motala verkstad soon became the most important and biggest engineering enterprise in Sweden during the 19th century. The first buildings, though, were modest in form and size. Drawing from Motala verkstad 100 år *(Motala: Motala verkstad, 1922).*

to have a background in ironworks or in a craft industry. The methods used in the hand crafts and in the engineering industry were basically the same; the workforce needed skills similar to the artisans. Neither were the buildings different from those used for hand crafts, metal workshops and manufactories. But there were dissimilarities. One important difference is the use of machine tools such as lathes and drills. Later, production was divided into separate operations with different kinds of workers who were not, as in the craft industries, responsible for the whole production but only for one part of it.

Is it possible to say that the Swedish engineering industry originated in proto-industrial manufacture? The answer to that must be no, not always. There is, for example, no general pattern in manufacture carried out within the framework of the older form of production or a system of putting-out which developed into workshop industries. But as we have seen there are elements of proto-industrial production within the engineering industry, and this is more easily recognised in engineering workshops founded at ironworks.[8] At Överum there was a connection between the ironworks, with their old *bruk* traditions, and a proto-industrial manufacture. Even when the main income came from the workshop, the *bruk* character and the older traditions were clearly apparent. However, the workshop buildings were not dissimilar to those of other contemporary workshop companies. They were placed in the same way in Överum as elsewhere. This, together with information about the size of the machinery and its composition, suggests that the workshop manufacture in Överum was not different from other workshops, but was organised along the principles of rationality which characterised the modern workshops described in contemporary periodicals. The difference lay in the fact that the workshop was included in the *bruk* and was a part of the traditional environment.

It is hard to find a direct connection between a proto-industrial manufacture and the workshop companies at Ludvigsberg and in Köping, but older forms of manufacture were of importance for these companies. There were characteristics of hand craft workers' houses in the older buildings at Ludvigsberg and the demand for products from the ironworks in Bergslagen was of great importance to the machine shop in Köping. In all three cases traditional manufacture was important in that some of the skilled workforce had worked in that system.

The time of establishment

During the second period, approximately 1850–80, there were two important periods of growth, the early 1850s and the early 1870s. In the former, the number of workshops and employees increased substantially and spread throughout the country, even if there was still a concentration in the big towns and traditional ironwork areas. There was no mass production in the Swedish engineering industry during this period, nor

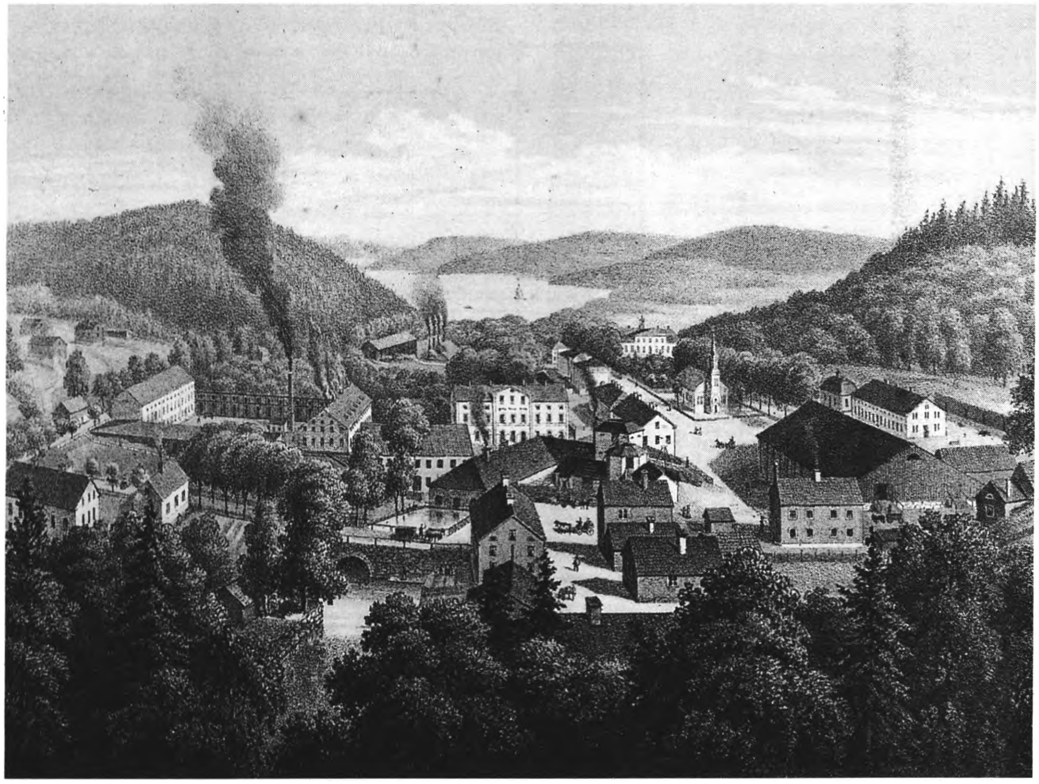

Figure 2. Överums bruk *in the 1870s. The big, white building in the centre of the picture is the office, with two machine shops to the left of it. The buildings for the ironworks, the blast furnace and the foundry are situated in front of the office. The lavish manor house can be seen to the rear of the church. The workers' dwellings surround the production site. Lithograph from Pabst, G.,* Sveriges industriella etablissementer *(Stockholm, 1870s).*

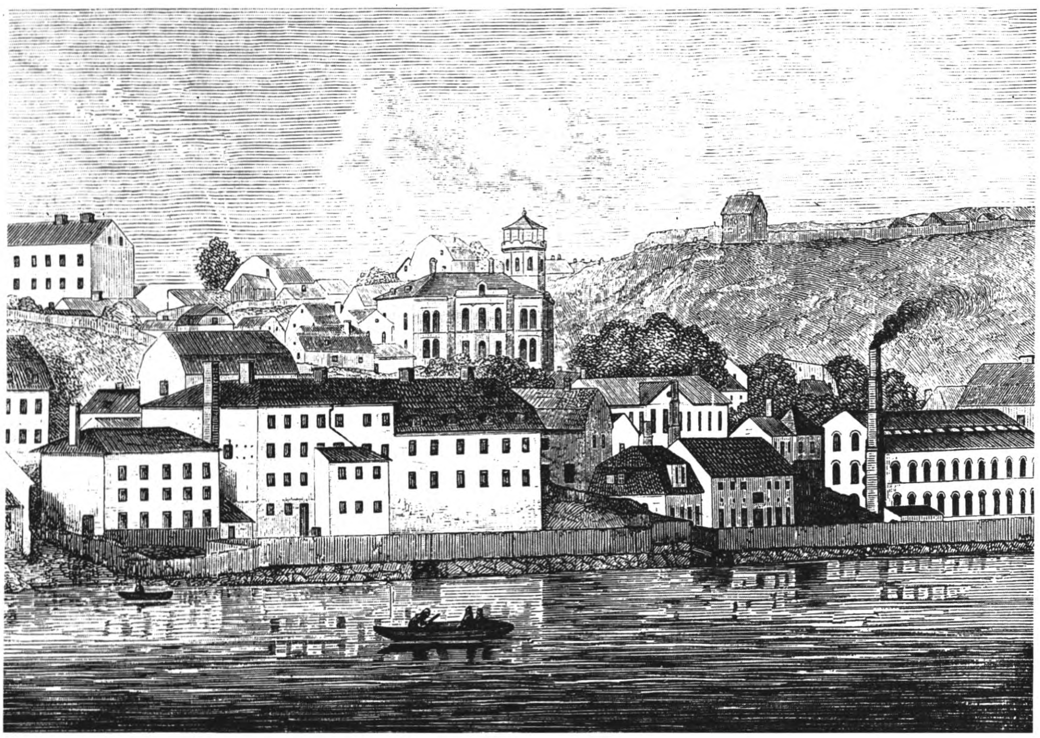

Figure 3. Ludvigsbergs mekaniska verkstad in the 1860s. The building to the left is a textile mill. To the right with a chimney is a new machine shop erected in 1863. The smaller buildings by the water were used as a foundry. Behind them, further up the hill, is the machine shop from 1850s. In the centre, dominating the production area, is the impressive house for the manager. Lithograph: Stockholms stadsmuseum.

did the companies specialise in a few products. For the most part the companies manufactured for individual orders. The skilled workers were essential but with the more frequent use of machines they became more specialised. The three machine-shops in Överum, Stockholm and Köping were founded in this period.

The machine shop in Överum (Figure 2) was founded in the 1850s, although the related ironworks were set up in the 17th century. The engineering shop made ploughs, other agricultural implements and household equipment, but at the same time iron production was continued. Two new workshop buildings, a new hammer mill, an office and new houses for workers were constructed in connection with the establishment of the engineering shop but these new additions were made within the framework of the ironworks.

Ludvigsberg machine shop in Stockholm was founded at the same time on a steeply sloping site by Lake Mälaren (Figure 3). It was a difficult place to operate a workshop, but the situation by the lake was attractive,

Figure 4. Köpings mekaniska verkstad in the 1860s. The machine shop, distinctly different from the surrounding buildings, is the large white building in the centre while the smaller one to the right was the foundry. Further to the right is the manager's house which was more modest than the owners' homes in Överum and at Ludvigsberg. Photo: Köpings mekaniska verkstad's archive, Volvo, Köping.

since many Swedish towns could be reached by boat. Production at Ludvigsberg was diversified, small-scale and manual. Castings were an important product, for building construction and also for various kinds of tools and machines. The settlement consisted of several buildings and there does not appear to have been any structured planning related to the production process. The buildings had a lot of characteristics in common with the older town craft industries and the earlier manufacture in the city. Just as with the hand-workers' houses, the housing was directly connected to the production sites.

The situation was quite different for the machine shop in the small town of Köping (Figure 4). It was the first industrial works built in the town. The site could be chosen with a view to future expansion without taking the older buildings or difficult topography into account. Right from the beginning, Köping machine shop had a relatively large amount of mechanical equipment, some of which was imported from abroad. The managers of the company also went to England and later to Germany and the USA to acquire knowledge of the latest technology. The workshop was characterised by new methods and machines: it also manufactured machine tools and was quick to seize new ideas, as shown by the manufacture of the first Swedish lathe in 1858, for example, and later the production of milling machines based on the American model. However, they only manufactured individual machine tools and the works' products were sold primarily on the local market where the ironworks in Bergslagen became important customers.

The first mass production

The third phase covers the last decades of the 19th century and the first years of the 20th. Then the sector changed and several of the so-called 'genius industries' — SKF, ASEA and Alfa Laval, among others — were set up, concentrating on a single product, albeit on a small scale, for a big market with customers all over the country and even abroad. But this was not the case in all Swedish machine shops and most engineering companies continued with a wide and varied production.

Machine shops began to be constructed on the edges of the towns. It became more common for the workshop buildings to be built on one floor and often they were furnished with a saw-tooth roof. Their style was often eclectic, with stepped gables and round arches. As manufacturing increased and more employees were hired, the buildings became bigger, and the layout was obviously planned to improve efficiency in production. The machine shops were also given a more deliberate shape, indicating that they were meant to demonstrate the successes of the company and the engineering industry.

For example, at the Ludvigsberg machine shop greater economic incentives and technical opportunities enabled it to get the better of the topography of its awkward site. At the end of the 19th century, some of the differences in height were levelled out, so that the placement of the workshop buildings became more rational and a larger part of the land could be utilised (Figure 5). The machinery increased at Ludvigsberg and production concentrated on pumps and fire-fighting equipment, not only for Stockholm but also for other markets abroad.

The changes were less obvious in Överum where the company gradually changed from a traditional ironworks to an engineering industry with modern methods. The workshops can be characterised as a proto-industrial manufacture, but this does not mean that production methods did not change and that new machinery was not used. At

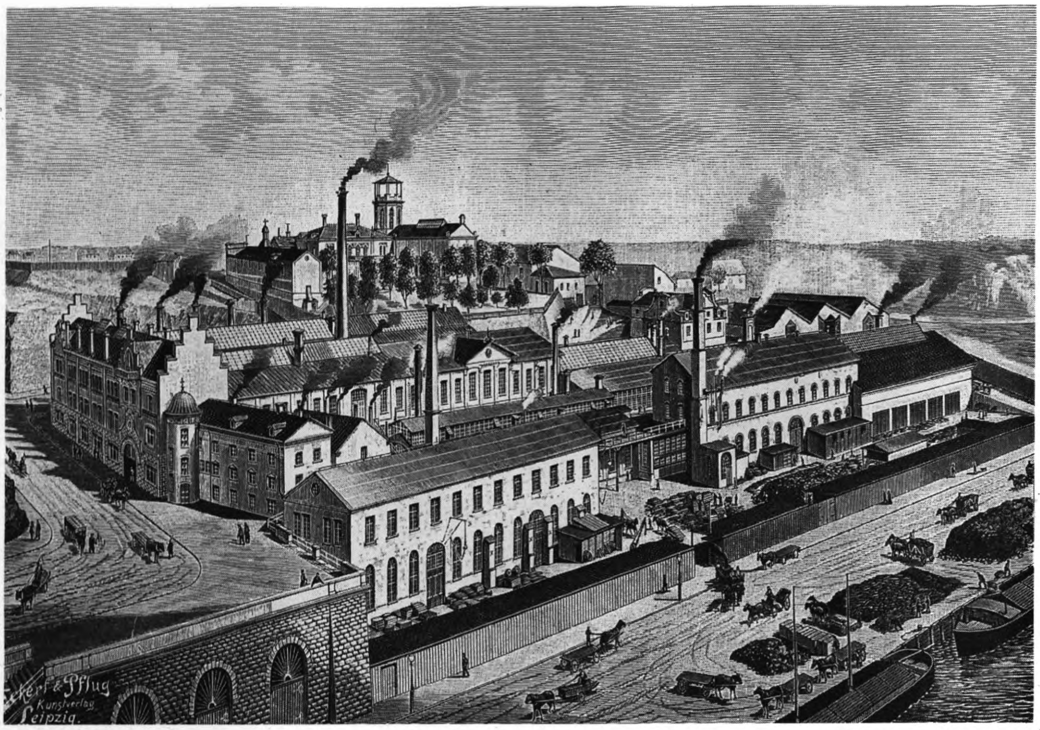

Figure 5. Ludvigsbergs mekaniska verkstad at the end of the 19th century. When compared with Figure 3, new and larger buildings can be seen. The workshops had also been connected to each other and the area is more efficiently planned. Print: Stockholms stadsmuseum.

the beginning of the 20th century the blast furnace was blown out and the company became a pure engineering industry specialising in ploughs.

The machine shop in Köping, as we have already seen, is an example of the early interest in mechanisation and modern machines, but it was not until the turn of the century that it was possible to specialise in machine tools and to make them in series production. The buildings in Köping, as at Ludvigsberg, became bigger and more rationally planned. The workshop area covered several blocks and the buildings were given a distinct style. The relationship between the workers and employers at Köping machine shop were more typical of a capitalistic than paternalistic employment. The paternalistic traits were few and weak: the workers' dwellings were not sufficient for all the employees, neither was the owner's house part of the workshop surroundings.

Generally, however, the paternalistic relationship between the employees and the owners is a persistent characteristic in the Swedish engineering industry.[9] The different characters of the companies meant that paternalism was expressed in different ways. It was strongest in Överum and at Ludvigsberg in Stockholm, where it appears in the buildings, the written record and the way the companies treated their workers, whereas it was very weak in the smaller town of Köping. However, the nature of paternalism changed during the period under study in all three companies because of the new market-oriented way of running a company and can be summarised in the concept of industrial-paternalism. In many Swedish companies at this time the personal relationship between the owner and the workers weakened and was replaced by more formal employment conditions. This can be seen in the way the owner's house and the office were built in a style which clearly distinguished them from the manufacturing areas and the dwellings for the workers, as in Överum, Ludvigsberg and Köping.

The placing, planning and design of the buildings therefore tells us about the paternalistic relations and about the status of different employees. In the archive material information is generally given about how much the different groups earned, but apart from that the written sources remain silent about this question. An analysis of the buildings can thus strengthen the information extracted from the written sources, but it can also give another picture, and supply a whole new perspective.

THE BUILT ENVIRONMENT AND THE ENGINEERING INDUSTRY

Machine workshops were heterogeneous in terms of the size and form, and this was reinforced during the course of the 19th century. However, the three companies studied here were more or less the same size. Their workshop buildings were similar in size and form, but the other buildings and their layout were different: they were characterised to a large extent by surrounding buildings and topography. What united the three companies was that they all started with mechanical engineering in the mid-1850s. They were situated in three different kinds of social environment, a *bruk*, a city and a small town, where economic life, the local market, access to land and transport possibilities were not the same. The backgrounds of the owners, their education and networks, and the professional knowledge available to them also differed.

Generally, the manufacturing area consisted of one or more workshops as well as a large number of smaller buildings. This changed in the course of the 19th century, when larger buildings were erected and more directly linked to each other, allowing a production line system. These often surrounded a courtyard, which was used for storage and even for assembling bigger products. Only at the turn of the century did big firms build even larger workshops to a plan aiming at efficient mass production. The changing modes of production — different products, new machines and different work organisation — leave discernible traces in the buildings and so the physical environment can help to reconstruct the course of history. It is possible to see traces of older forms of manufacturing which have been of importance to the present activities there. These traces can be re-used buildings or new workshop buildings which contain certain features from older production buildings. Alteration and additions to industrial buildings are therefore important since they illustrate changes within the firm such as the orientation of the production, the use of new forms of energy or the introduction of new machinery.

It is often difficult to find information from written sources regarding the production systems in the workshops, what the different working operations consisted of and where they took place. The physical environment is a source where information of this type can be found. From the workshop floor we can gather information about the machines and mechanical equipment, which different operations took place in the course of the manufacturing process and how raw materials and products were transported between the company's workshop buildings. But we can also, to a certain extent, obtain knowledge of what it was like to work there, with regard to, for example, heating and lighting conditions.

Changes in a building are a sign that something radical has happened there. The buildings were transformed when the production changed; they were added to and rebuilt, new materials were introduced, windows were taken out, walls knocked down to make new rooms. For instance a big new iron foundry was built in Köping in the 1870s, when they began to make combine harvesters, and in Överum new workers' housing was built in the 1880s, when workshop manufacture, and accordingly the workforce, increased.

At Ludvigsberg the physical environment and the site topography impeded the growth of the workshop and kept the manufacture the most diversified of the three companies studied here. This was despite the fact that the workshop was in Stockholm with a big market, and the owner had an advanced technological education and good contacts with workshop managers in Sweden and abroad. In Köping and Överum the buildings were organised according to a plan itself decided by rational production, to enable transport between the different parts of the workshop complex to run smoothly. The layout of the Köping workshop reinforces the picture of the company as the most modern of the three, where the elements of older manufacturing methods were limited and the paternalistic element was weak. Unlike the two other workshops, housing was not part of the complex itself — even if it was in the neighbourhood.

Buildings can thus be used as source material to explain how production was carried out, how the work was organised, what conditions it was carried out in, and what status the work itself, and thus also the buildings, were accorded. Through an analysis of the form of the buildings and their placement in relation to each other, to the sources of power and to other buildings, it is possible to procure more qualitative information about our industrial heritage.

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[5] The economic history of Sweden has been studied by, among others, Montgomery, A., *The rise of modern industry in Sweden* (P.S. King and

Stockholm: Norstedt, 1939); Gårdlund, T., *Industrialismens samhälle* [The industrial society] (Stockholm: Tiden, 1942); Magnusson, L., *Sveriges ekonomiska historia* [The economic history of Sweden] (Stockholm: Tiden, 1996).

[6] The archives of the three companies have survived, though in various extent and all of them have also published company histories of different kinds.

[7] During this period all companies were obliged to report to the Swedish National Board of Trade. From these reports one can see where the companies were situated, what they produced, what machinery they used, how many workers there were, etc. This information is an important source for the survey of the Swedish engineering industry.

[8] For a discussion on Swedish ironworks and proto-industry see Isacson, M., & Magnusson, L., *Proto-industrialisation in Scandinavia: Craft skills in the industrial revolution* (Leamington Spa: Berg, 1987); Florén, A., & Rydén, G., *Arbete, hushåll, region: Tankar om industrialiseringsprocesser och den svenska järnhanteringen* [Work, household and region: The process of industrialisation and the Swedish iron industry] (Uppsala: Department of Economic History, 1992).

[9] For a discussion on paternalism in Sweden see, for instance, Svensson, T., *Från ackord till månadslön* [From piece-rate to monthly salary] (Göteborg: Svenska varv, 1983); Magnusson, L., *Arbete vid en svensk verkstad: Munktells 1900–1920* [Work at a Swedish machine shop: Munktells 1900–1920] (Lund: Arkiv, 1987); Magnusson, U., *Från arbetare till arbetarklass* [From workers to working class] (Uppsala-Stockholm: Almqvist & Wiksell International, 1996); Ericson, C., *Vi är alla delar av samma familj* [We all belong to the same family] (Stockholm: Carlsson, 1997).

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Swedish blast furnaces in India

Jan af Geijerstam

In the 1860s two Swedish metallurgists, Julius Ramsay and Nils Wilhelm Mitander, were employed in India to build ironworks based on European technology. Although neither was completed, these two projects are interesting examples of technology transfer. It has been possible to highlight the balance of different factors determining the development of the Indian iron industry — cultural and social factors, technological difficulties in transfer and, most importantly, the setting of a colonial economy. The investigation exposes areas of contact — or lack of contact — between the projects of transferred European iron technology and the indigenous Indian iron-making with its deep roots in Indian history and society. In this sense the paper transgresses the border between industrial and pre-industrial development. Concentrating on Ramsay's Kumaon Iron Works, it discusses harmonies and conflicts in the three part encounter between indigenous Indian iron-making, the rapidly expanding and changing British steel industry (in the form of iron and steel imports to India) and Swedish charcoal-based iron technology.

The study makes use of material from widely different sources: primary material of contemporary Swedish origin (drawings, reports, photographs and diaries): official records concerned with Britain and colonial India (protocols, correspondence, reports and maps): and studies of sites in India.

Hauts fourneaux suédois aux Indes

Au cours des années 1860, Julius Ramsay et Nils Wilhelm Mitander, deux métallurgistes suédois, ont été employés en Inde pour établir des usines à fer fondées sur des technologies européennes. Les deux projets n'ont pas abouti, mais ils offrent néanmoins des exemples intéressants de transfert de technologie. Il a été possible ainsi de souligner l'équilibre des facteurs différents qui ont sous-tendu le développement de l'industrie sidérurgique indienne: facteurs culturels et sociaux, difficultés techniques dans le transfert même et, surtout, le contexte d'une économie coloniale. La recherche a mis au jour les zones de contact — ou de non-contact — entre ces projets et la production indigène, profondément enracinée dans l'histoire et la culture indienne. Ainsi cette communication ignore les frontières entre le développement industriel et le développement préindustriel. Centrée sur l'usine créée par Ramsay à Kumaon, elle analyse les convergences et les conflits entre les trois parties en présence: la production indigène du fer, la sidérurgie britannique alors en pleine expansion (sous la forme des importations en Inde de fers et d'aciers d'origine britannique) et, enfin, la technologie suédoise, encore basée sur la production au charbon de bois.

L'étude fait appel à des sources très diverses: sources archivistiques contemporaines d'origine suédoise (dessins, rapports, photographies et journaux); documents officiels concernant la Grande Bretagne et ses rapports avec la colonie (protocoles, correspondance, rapports, cartes); et études sur le terrain en Inde.

Introduction

In 1864 Julius Ramsay, a Swedish engineer, submitted a long report to the ironmasters association in Sweden. The subject was his experiences in India during the previous last few years, as manager of a privately-owned iron industry in India. The works were situated in the foothills of the Himalayas north of New Delhi. Ramsay described their setting:

> The landscape was both beautiful and magnificent, but lacked the traits that usually distinguish tropical landscapes: fertile plains with groups of palms and banana trees intermixed with villages and temples among weeping willows and acacia. Here everything was more wild and although the vegetation was rich, the palms had already given place to trees of a temperate climate. In the background the majestic Himalayas rose against the sky with their barren and blue crests. Their lower parts, although steep and inaccessible, were wooded. Dechauri was just below the mountains on a wide terrace, forming the first stair of the staircase of mountains. A small stream, tumbled down, out of a narrow and deep gorge and watered some beautiful and fertile fields. The water was collected in a masonry channel, winding on the mountain side several miles inwards

the ravine. On the south side, below the fields, the view was limited by a vast forest of hardwoods, mainly Saal and Haldoo. The trees were pretty big and gave a solid and good wood, constituting the fuel on which the works were based.

These works, the Kumaon Iron Works, are the focus of this article.

Research on these works will be a part of a PhD thesis on the transfer of iron technology from Europe to India in the mid-19th century. It will also include a parallel and contemporary case of technology transfer, the Burwai Iron Works in the Narmada valley, south of Indore, in present-day Madhya Pradesh. A Swedish engineer, Nils Wilhelm Mitander, was also involved there. An important source of inspiration has been Ian Inkster's studies of development and economic growth, history and dependence, which analyse problems highly relevant to present-day discussions on technology transfer and development policy [Ian Inkster, *Science and Technology in History: an approach to industrial development* (Basingstoke, 1991)].

SWEDEN 1985

My personal starting point in this research into Indo-Swedish iron history was the Swedish steel crisis of the 1980s. In 1985 Steel Mill 2 of Fagersta, in central Sweden, was closed down. This met strong protests in the local community. The mill was only fifteen years old and was technically up to date. It was steadily achieving new and excellent production results.

At that time, I was employed as a journalist in Fagersta and met a worker at the steel mill, Peter Nyblom. He had documented the processes at the steel mill with his camera and, together, we began to explore the causes and consequences of the Swedish steel crisis. One result of the continuing concentration and centralisation of production was the re-use of equipment from closed down steel mills, which was shipped to countries in Asia, Africa or Latin America and re-installed. The steel-workers in Sweden asked: 'why there and not here? Why scrap all investments and all our knowledge only to rebuild it somewhere else?' The rationality of the market seemed hard to grasp.

In 1987 Peter Nyblom and I visited India and studied a small steel mill, Bhoruka Steel in Bangalore, which had bought a used furnace from Sweden but not yet installed it. I do not know if we ever were able to answer the question raised, why there and not here, but we were forced deeper into history. More questions were added, with a changed perspective. A short note on a Swedish engineer in a book on the history of Indian iron aroused my curiosity and as time passed I was able to trace his history and other names were added. A story was gradually unveiled and it carried important clues to the situation of today. There is a historical colonial legacy in the distribution of work and power in the world of iron and steel production.

EUROPEAN IRON TECHNOLOGY

In 1892 an industrial conference was held in Poona., M.G. Ranade, a judge in Bombay, made a speech on Indian ironmaking and deplored its state. He criticised the inability of the colonial government to grasp the historical chance to create an Indian iron industry while Indian railroad building was at its height during the second half of the 19th century. In all, Ranade knew of no more than seventeen attempts to build steel industries with European technology in India during the 19th century. In my judgement, this is not far from the truth and only two of these attempts involved Swedes. One was the Burwai Iron Works founded by the colonial government and constructed under the auspices of Nils Wilhelm Mitander. The other was the Kumaon Iron Works. Although neither of these two projects reached sustained production, they have proven to be significant case studies of a formative period of deep political, economic and technological changes. They are a substantial part of colonial iron history in India.

THE KUMAON IRON WORKS

The Kumaon Iron Works were started as a government undertaking in the late 1850s, but in the early 1860s a private joint stock company was formed and took them over. As the works were based on charcoal, not mineral coal fuel as in Great Britain, the owners were anxious to engage a Swedish metallurgist as manager. The Swedish iron industry was solely based on charcoal and Swedish steel had gained world renown for its quality. In October 1861 Julius Ramsay (1827–74) and the trustees of the North of India Kumaon Iron Works Company Limited signed an agreement of employment in London. Ramsay was a well-educated Swedish engineer and metallurgist. He was to make iron, and most importantly, to improve and extend the Kumaon Iron Works. Two months later, after a long journey by sea and land, Ramsay arrived at the site of the works. He soon discovered that he needed reinforcements to manage the works and the owners agreed to recruit a

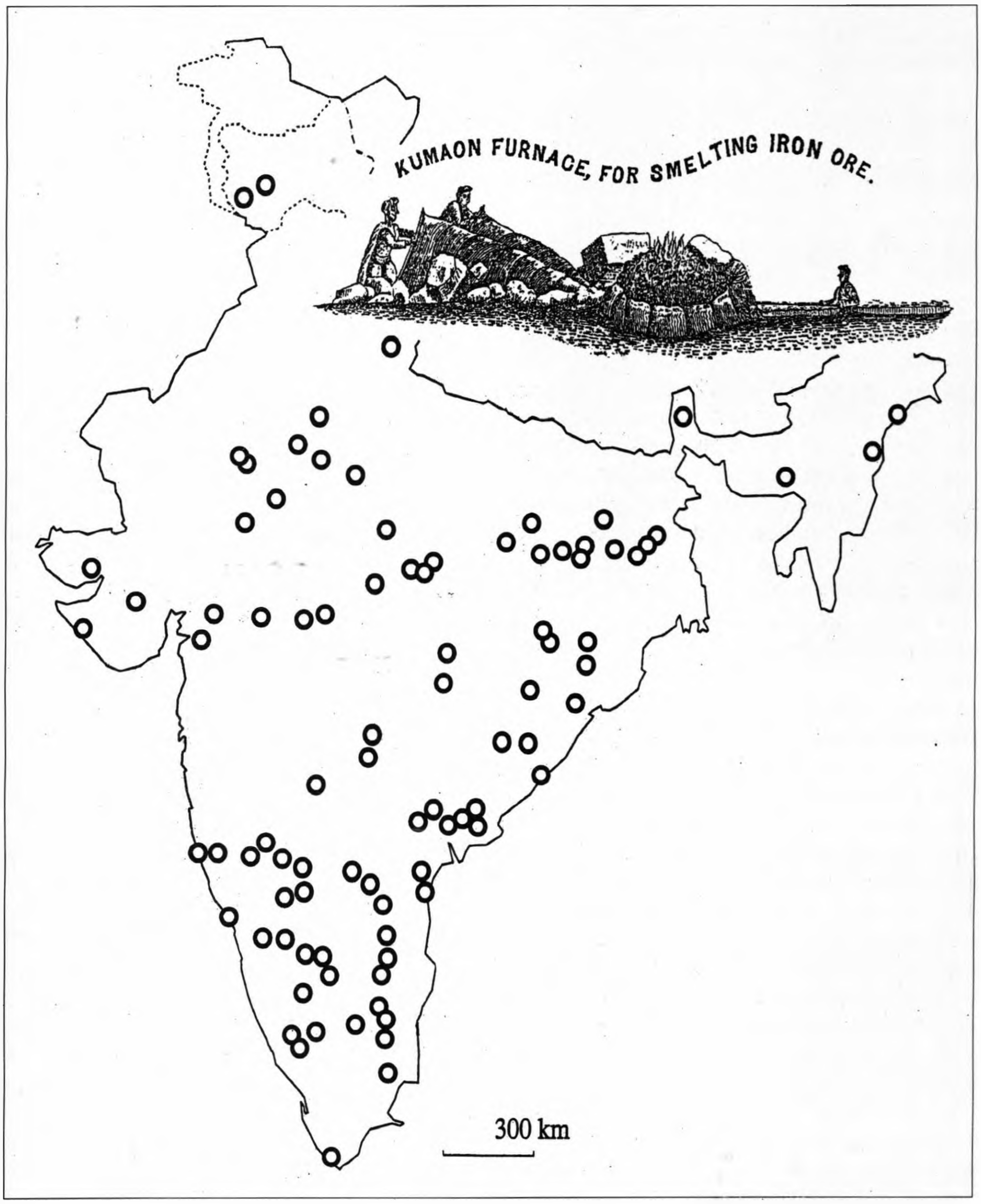

Figure 1.
T.H. de la Touche's A bibliography of Indian Geology and Physical Geography with an annotated index of Minerals of economic value *(London, 1918) includes* c. *300 references to surveys on Indian iron ore deposits. About half of these mention indigenous iron-making, some of which are shown on this map. Inset is a furnace for smelting iron ore, as shown in J.O'B. Beckett, 'Iron and Copper mines in the Kumaon division',* Selections from the records of Government, North-West Provinces, *10/3 (1855), also published as 4 in volume 3 (1863) of the same series.*

colleague from Sweden. Approximately one year after his own arrival, Ramsay was joined by his colleague and friend Gustaf Wittenström. When Ramsay arrived in Dechauri there was one blast furnace in running condition, built of brick and approximately 10.8m high. It had been erected under the management of his British predecessors, William Sowerby (Figure 3). Some 100m further down towards the river Ramsay began building the new works (Figure 4). These were ambitious, two blast furnaces, some 14m high, were to be built, both equipped with hot blast and — most extraordinarily — Bessemer converters (Figure 5). These converters were never built, but Ramsay reported that Wittenström carried out some experimental blowings in a small trial converter. No details on these experiments are known, but Dechauri might thus have been among the first sites in the world where trials were made to blow Bessemer steel, a process which was about to revolutionise steel-making. Apart from this central part of the works there were to be charcoal kilns, rolling mills, forges, workshops, etc. Ramsay planned to reach a total production to 6,330 tons of pig iron per year, finished into 4,220 tons of rolled and wrought iron.

The Kumaon Iron Works was a clear-cut case of technology transfer, but the origin of the technology is complex. Julius Ramsay and Gustaf Wittenström had a solid education and experience as Swedish engineers, and Ramsay corresponded with their former master and teacher in Sweden, Andreas Grill. The Bessemer method was a joint Anglo-Swedish development and Ramsay writes about Finnish charcoal furnaces. The iron and steel technology was, and is, international.

Figure 2. Julius Ramsay, sitting on the steps of his bungalow in Dechauri together with some of his workers. Photo: Gustaf Wittenström, National Museum of Science and Technology, Stockholm, C15058.

Ramsay and Wittenström never had the opportunity to finish their work, due to lack of funds, and returned to Sweden in 1863. All construction work was stopped and iron production brought to a standstill. The works were later reopened in 1876–9, but this last trial to explore the possibilities of making iron in Kumaon did not show a profit. The works were finally abandoned in 1879 (Figure 6). A new period in colonial iron-making was now under way, the coal-based project of the Bengal Iron Works being the most important before the advent of the Tata Iron and Steel Works.

THE STAGES OF ANALYSIS

To explore why the Kumaon Iron Works were unable to reach any sustained production, further analysis was undertaken in five stages. As a foundation I had to establish the chronology of the works and describe the technology used, as indicated above. Secondly I had to study the relationship between production and the physical setting, including the resources of iron ore, wood supplies and power, and also the topography and the climate. The social and cultural aspects were analysed at the third stage, including conflicts and contradictions in the triangle between the Swedes, Indians and the British. The fourth stage of the analysis widened the context to the Indian subcontinent, the Raj, and its big potential markets, especially the extensive public works and rail-road building. In summary, these four stages have tentatively shown that there was enough iron ore, extensive forests to make charcoal, and running water to provide energy. There was labour to do the work and an enormous potential market in the public works and railroad building of India. However, despite this potential, there were big difficulties to be overcome: the ore was of low or uneven quality; an extremely difficult topography made transport cumbersome and expensive; an unhealthy climate caused disease and heavy summer rains brought work to a standstill; there were conflicts of culture and a lack of competent personnel. But, all the same, these difficulties combined do not fully explain the fate of the project.

INDIA IN THE WORLD, IN COLONIALISM

A fifth stage of the analysis is to put the works into a global setting, in this case a colonial system, with close and tight ties between England and India. These connections were in terms of political and military power, in investments, technology transfer, ownership and trade. These were times when the industrial economy was being worked out on a global scale. In iron it was in the interests of producers back home in England to secure an Indian market. Sir C.E. Trevelyan, financial member of the council of the colonial government, put this quite clearly when the fate of the Burwai Iron Works was being discussed and finally decided in the General Council in Calcutta:

> ...it is a misdirection of the resources of India to enter into competition with England in the branch of iron production. India should concentrate on the rich products of her prolific soil and climate, not to compete, at the public expense against the English iron trade and the English mercantile community.

In the case of the Kumaon Iron Works it is harder to find such a direct connection between imperial interests and the fate of the works. Here, it was the result of a lack of perseverance and consistency in the project, an inability to make decisions and an ever-present readiness to leave vital decisions to the market forces. The Kumaon Iron Works was a case of technology transfer, but never formed part of a technological system. In Sweden there were hundreds of blast furnaces working. In India, during the years of Ramsay and Wittenström, there was only one, the unfinished project of the Burwai Iron Works.

The tasks of the engineers in Kumaon became enormous. They not only had to manage the technology at the site itself, but also build systems of supplies, raw materials, workers, markets, etc. They had no one to talk to on technical matters. In the industrialised and industrialising countries of the world, as in Europe, these systems were built or developed in close co-operation between the state and private business. In India there was no such cooperation — but it was badly needed. In a colonial setting, where the aim of the government was to let

Figure 3.
The blast furnace was already built in 1861 when Ramsay arrived. In the early 1980s this furnace and the access bridge leading to its top were still standing. Photo: Gustaf Wittenström, National Museum of Science and Technology, Stockholm, C15247.

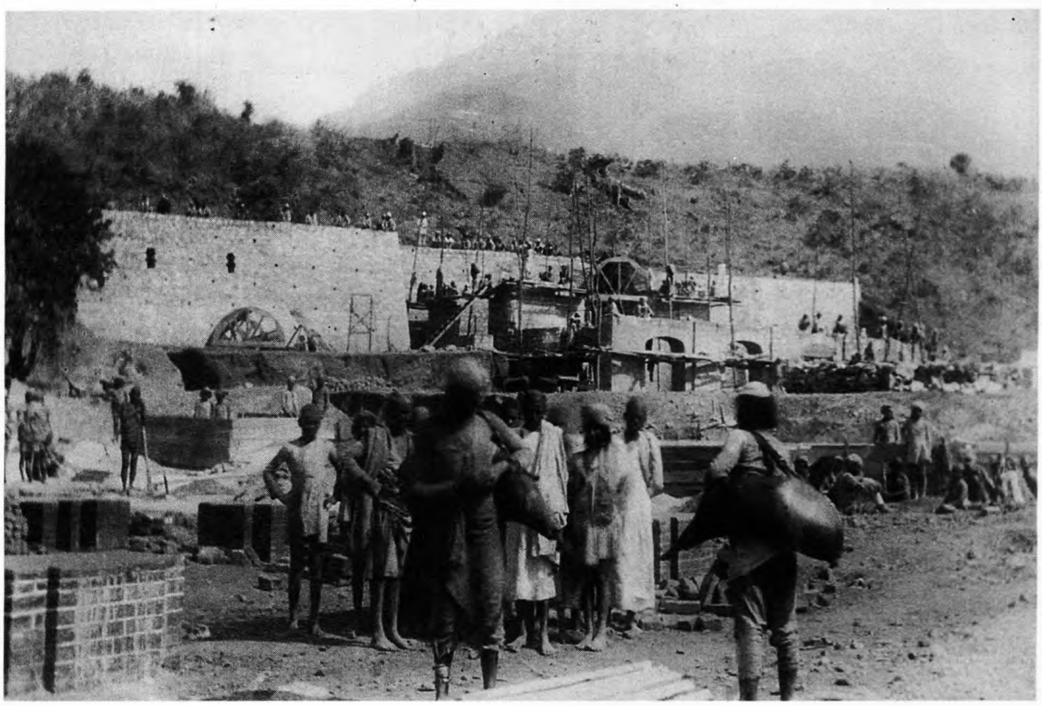

Figure 4.
The new iron- and steel-works in Dechauri under construction in early 1863. The number of workers engaged at the site was up to 2,000. Photo: Gustaf Wittenström, National Museum of Science and Technology, Stockholm, C15057.

the company manage its business without any involvement while holding the doors wide open to British imports, the obstacles became insurmountable.

A Common Heritage — Crossing Borders

In order to understand the complexities of technology transfer — as in the case of the Kumaon Iron Works — it is necessary to use elements of different disciplines such as history of technology, natural geography, anthropology, sociology, economics and political science. It is also necessary to transgress borders between countries, cultures and classes in order to see structures as a whole. We too often concentrate our attention on the obvious, often still existing, expressions of success in the centre. We forget the systems supporting them. Studying 'failures' can be more revealing than studies of 'successes'. This transgression in the study of the Kumaon Iron Works involves combining sources from different geographical locations in India, Great Britain and Sweden. Until now this archive material has never been studied in detail in its parts and even less in its combination, but doing this gives new knowledge. This lesson is certainly not

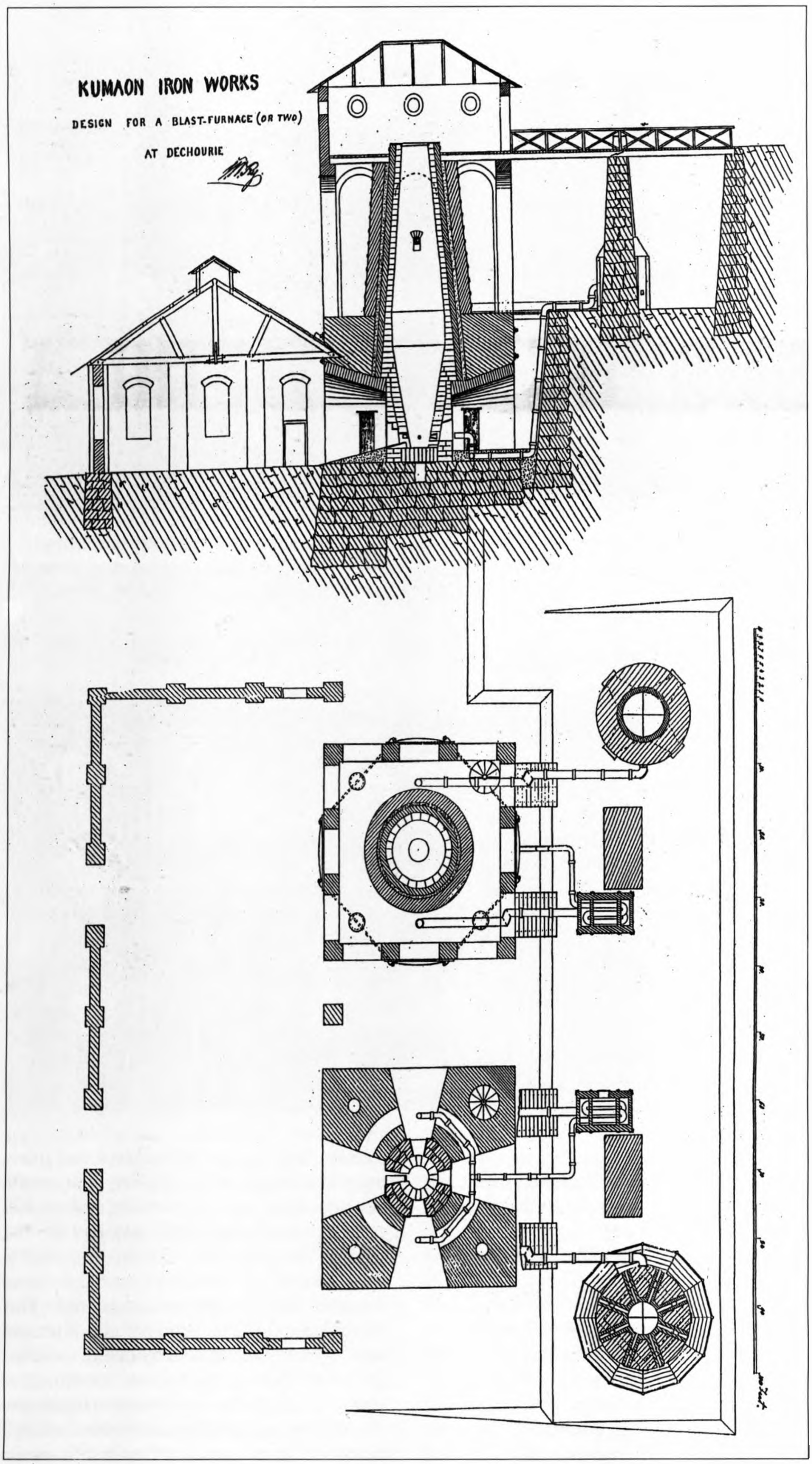

Figure 5. 'Kumaon iron works. Design of a blast-furnace (or two) at Dechauri.' Drawing by Julius Ramsay, undated (Ramsay papers, Royal Museum of Science and Technology, Stockholm).

Figure 6.
When first studied in 1997, only remnants were left of the blast furnace in Dechauri. Today every stone is removed, replaced by a flourishing field of growing wheat. The only building of the Ramsay works which remains is one of the bungalows. A massive stone wall, some 47m long and 6m high, at the site of the planned new works, is most impressive. Photo: Author, 1997.

confined to this single case: bringing material together has considerable potential, all too little implemented.

Cultures and Classes

There is often a strong social or class bias of historical sources, which in the case of the Kumaon Iron Works is also combined with a Eurocentric bias. Nowhere in the sources is there any mention of the Indian workers — where they came from, who they were, what they said. This lack of perspective, let us call it from below, is not only a colonial problem and is all too easy to regenerate in research and exhibitions.

Indian iron-making, using direct reduction, was well developed and widely spread. This industry was obliterated during colonial rule and almost no connections were established between existing Indian iron-making and the new industry, as represented by the Swedes referred to in this paper. There is a vast field of research on iron-making in Asia, Africa and Latin America. Extended research on traditional iron-making in India will be a source of increased knowledge of countries in Europe and other parts of the industrialised world. We have a history in common, in India and in Sweden, and thus our industrial heritage is common.

A Responsibility

From the closure of Fagersta's steel mill 2, we were led into the question of unequal distribution of power and wealth, not only in Sweden, in the steel-making community of Fagersta, but also in the world at large.

Sweden has a long history of iron- and steel-making, which has expanded and developed through the centuries. It has survived recurring deep crises and is still in many cases world leading. India, with its rich mineral and coal resources and an even longer history of iron and steel production, has shown an extremely late and sluggish development and expansion of production, and, compared to Sweden, the *per capita* production of iron and steel is far behind.

Perhaps my query, 'Why there and not here?', in relation to the study of European technology transfer to India, is very Eurocentric. From an Indian standpoint, looking at Sweden, the most relevant issue is really the opposite: 'Why not here, why there?'

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Technology and Tradition: the English Heritage Survey of the Northamptonshire boot and shoe industry

Adam Menuge

Since its earliest beginnings industrial archaeology has emphasised those industries — iron and steel, textiles, engineering, railways — that set the pace of technological change. The boot and shoe industry, which dominated 19th- and early 20th-century Northamptonshire, lay outside the vanguard of technologically progressive industries. It was slow to mechanise, yet it fulfils admirably that fundamental prerequisite of modern industrial production, the division of labour. An industry in which craft skills and outworking have persisted virtually until the present day offers an historical corrective to sometimes exaggerated notions of the Victorian industrial achievement. More importantly, it invites a more generous re-interpretation of industrial archaeology as what might be termed the 'archaeology of work'. The current English Heritage survey will, it is hoped, inform a range of specialist interest groups, as well as focusing future recording initiatives and protection strategies, and assisting with the wider implementation of planning policy.

Technologie et Tradition: l'inventaire d'English Heritage des industries de la fabrication des chaussures à Northamptonshire

Depuis ses débuts, l'archéologie industrielle s'est surtout attachée aux industries — la sidérurgie, les textiles, le génie civil, les chemins de fer — à l'avant-garde des changements technologiques. La fabrication des bottes et des chaussures qui dominait Northamptonshire au cours du XIX^{e} siècle et le début du XX^{e} n'appartient pas à ces secteurs à la pointe des progrès techniques. Mais, malgré sa mécanisation tardive, elle illustre parfaitement la condition de base d'une production industrielle moderne, la division du travail. Cette industrie, où des savoir-faire artisanaux et le travail à domicile ont survécu presque à nos jours, offre donc une vision susceptible de tempérer les notions parfois exagérées des acquis industriels de l'ère victorienne. Elle invite, de surcroît, à donner à l'archéologie industrielle une interprétation plus généreuse: ce qu'on pourrait appeler plutôt une archéologie du travail. L'inventaire actuellement en cours, sous la direction d'English Heritage, apportera, nous l'espérons, des informations à de nombreux spécialistes, tout en confortant les stratégies de documentation et de protection et contribuant à la mise en place de projets d'urbanisme.

Introduction

A definitive account of the boot and shoe industry has yet to emerge.[1] On the face of it, this is a daunting task. The industry has a long history and extends — at least at the level of the small-scale (or bespoke) shoe*maker* — into every corner of the kingdom. The built heritage of the industry, on the other hand, presents a more manageable body of evidence. It is overwhelmingly the legacy of the wholesale boot and shoe industry, whether conducted through outwork or in factory conditions, and the wholesale industry, while quasi-national in distribution, exhibits a much greater degree of concentration. There are well-known centres scattered widely across the country, in Kendal, Leeds, Stafford, Bristol, Street, Norwich, East Tilbury, London and elsewhere, but the largest concentration of production occupies an area of the East Midlands stretching from Northamptonshire into Leicestershire. While Leicestershire matches Northamptonshire in some respects, it is the latter county that is most decisively shaped by the industry — towns such as Northampton, Kettering, Wellingborough and Rushden, and smaller settlements such as Long Buckby, Earls Barton, Bozeat, Finedon, Irthlingborough, Wollaston, Higham Ferrers, Raunds, Rothwell and Desborough.

The surviving buildings of the Northamptonshire industry cover a range of types, some highly idiosyncratic. Many have been adapted to other purposes, but a still far from negligible industry continues to operate. Some of it (like the Dr Marten brand of John Griggs & Co.) supplies a mass market, while many firms (Church's, Tricker's, Loake's, etc.) exploit the cachet attaching to 'traditional' methods of production. The decline of the industry, however, particularly in the last 30 years, has left many buildings in need of a new use. These are now vulnerable to radical conversion and demolition: in late 1999 no less than 21% of leather-trades buildings (excluding small backyard workshops) were either vacant or undergoing redevelopment.

Given this conjunction of opportunity and threat, it was felt that the chance to document and analyse process in relation to built form should be seized. An approach from Northamptonshire Heritage (the planning arm of Northamptonshire County Council) to the Royal Commission on the Historical Monuments of England (RCHME) led to the formulation of a project design. The first phases of the project were carried into effect in late 1999 and early 2000 following the merger of RCHME with English Heritage, and this paper draws on initial results. A further stage, involving selective further investigation and research, will commence in 2001.

METHODOLOGY

Briefly, the survey methodology of the initial phases began with the sampling of a range of documentary sources. These were then verified and enhanced in the field, where, in addition, attention focused on identifying building types which are ill-served by the documentary record. The emphasis in the field, in the interests of rapidity, was on identification, classification, and a brief external assessment concentrating on the discrimination of original fabric and the charting of significant phases of development. For each site a short written record was prepared, illustrated by photography. On the basis of these a *Summary Report* was produced, outlining preliminary findings.[2]

From the outset it was seen as vital that the industry should be viewed systemically, to encompass the various activities that coalesce around shoe-making. While space does not permit discussion of these ancillary trades here, they have been accorded equal weight in the project design. They include the preparation of leather by curriers and leather dressers and its handling by leather factors or merchants; the manufacture of boot- and shoe-making machinery, iron and wooden lasts, shoe linings and cardboard boxes; and the supply of hardware items known to the trade as 'grindery'. It is in the profusion and proximity of these interlinked activities that much of the distinctive character of the county's shoe-making towns and villages resides; hence it was important not to impose on too narrow a selection of 'monuments' the burden of narrating the industry as a whole.

More than 450 extant sites were identified in Northamptonshire, ranging from large factories to isolated workshops (this figure excludes the largely repetitive backyard workshops that survive pre-eminently in Kettering, and to a lesser extent elsewhere). It should be emphasised that at this stage the available data is weighted heavily towards the external form of buildings. While some aspects of internal organisation can be inferred from this evidence, much remains to be explored in further work. Drawing even tentative conclusions at such a stage is always risky, but this is an appropriate time to take stock, and to consider future directions.

The sites date principally from the mid-19th century onwards — a strikingly restricted range for an industry with three-and-a-half centuries of documented history in the county. Why should this be so? Northamptonshire's rise to prominence is traditionally attributed to the English Civil War, and to the ability of factors, or middlemen, to satisfy large orders for the Parliamentarian forces. But the system of outworking meant that relatively large-scale production could be handled in very small productive units, multiplied across the towns and villages. Early images of the industry are scarce, and this in itself tells us something about the place which it occupied in the contemporary imagination: with its small scale and retention of traditional craft skills, it did not startle. It is clear that the norm, up until the mid-19th century, was a working environment that required no substantial modification of ordinary domestic accommodation. This is in marked contrast to contemporary outworking in the textiles industry. All that was needed was sufficient light to work by, room for a chair, for small hand-tools and for the storage of limited quantities of materials and finished work, and a source of heat for the winter months. Most outworkers did not even require a bench. It might be desirable to remove this work out of the everyday living accommodation of the family, but it was certainly not essential. The result is a minimal architectural legacy, and one that would in any case be hard to distinguish from those of other local outwork traditions, notably in textiles.[3] The possibility that a widespread tradition of boot and

Figure 1. Newman & Sons' factory in Newman Street, Kettering; the initials on the adjoining house, dated 1885, may be those of William and Nathaniel Newman (BB 001741). *© copyright English Heritage.*

shoe outworking may have influenced house design before about 1850 cannot be ruled out, but the systematic inspection of housing in pursuit of subtle variations in planning and fenestration lay beyond the scope of the rapid survey. The buildings of the factors, merchants and manufacturers who controlled the outworking sector are equally elusive.

The Factory Environment

Mechanisation began to alter the methods and structure of the industry in the late 1850s with the introduction of the sewing machine, quickly followed by other innovations. The immediate impact of these can be exaggerated. The outworking sector remained vigorous for the rest of the century, and throughout this period the achievements of progressive manufacturers need to be viewed alongside the activities of their more conservative (or impecunious) contemporaries. Some factories incorporated steam engines, typically of only two or three horse-power, but the sewing machine was capable of being powered by human muscle, and many new buildings, before the advent of small gas engines in the late 1870s, were probably not powered. Aggregation of labour, rather than provision of motive power or other major industrial plant, characterised them as factories.

The more eye-catching images of this era are the large factories that sprang up in modest numbers in Northampton and Kettering. Manfield's former factory in Campbell Square, Northampton, was representative. The earliest examples, typically Italianate in style, have disappeared, but in Kettering two outstanding buildings remain from the 1870s: Abbot & Bird's 1873 Dalkeith Works in Green Lane, and Newman & Sons' factory in Newman Street (Figure 1). Impressive in scale though these are, much space was probably devoted to warehousing rather than manufacturing at the outset, though as the variety and effectiveness of machinery increased, manufacturers brought more and more processes inside the factory walls.

Smaller factories were much more common. but few examples survive which can be dated confidently to before 1870. Among the earliest, typologically at least, are examples in Long Buckby, Rothwell and Wollaston, small settlements which escaped 20th-century development pressures. They have the typical complement of three storeys but their proportions are broad and low by comparison with dated shoe factories of the 1870s. This is particularly evident at the former Castle Factory in Long Buckby, where a factory of about 1875 stands directly alongside the earlier building.

From the 1870s onwards factories survive in large numbers. The vast majority originated as modest three-storey factories (street ranges are most commonly of four to eight window bays, sometimes supplemented by original rear ranges), and grew incrementally over the ensuing decades. They are simply built of brick, with stone or polychrome brick detailing, and timber floors supported on cast-iron columns. Widths were limited by the need to light processes, and consequently the factories placed no great technical demands on their builders. Early examples can be distinguished from factories of the late 1880s and beyond by their smaller windows and, where pier-and-panel walling is employed, by the narrowness of the panels.

The three-storey factories (many early examples also incorporate a basement) sought to bring a number of processes — hand or mechanised — under one roof, and therefore under direct supervision. It has been estimated that the manufacture of a pair of shoes by traditional methods involves between 250 and 300 distinct operations. Though these divide naturally into a much smaller number of key stages, the fragmentation of the task emphatically favours a loose-fit building. Some or all of the cutting and forming of the rough stuff, the clicking, closing, lasting, sole and heel attachment, and finishing, could be gathered into a single building or complex, together with limited storage capacity and a counting house or office. There were some practical constraints on the distribution of functions within the building — heavy machinery was invariably located on ground floors or in basements, while more delicate processes occupied the better-lit upper floors — and the distribution of processes was certainly capable of standardisation. In practice, however, the intricate and varied organisation of the trade resulted in many permutations.

While there was no fundamental obstacle in the way of integrating all the processes under a single roof, the industry remained reliant on outworking and sub-contracting, with firms concentrating on closing, sole-sewing or the manufacture of cut-soles or heels ('rough stuff'), for example. Even firms which were capable of handling all the processes in-house might contract out one or more of them during periods of peak demand. Different kinds of footwear required different methods, and sometimes resulted in geographical variations. Machine-sewn soles, for example, were made from the 1860s, but Long Buckby specialised in hand-sewn soles, Earls Barton in hand- or machine-pegged, and Kettering in hand- or machine-riveted, with consequent variations in the type of machinery used, or the potential dependence on outwork. Even where two firms carried out the same processes using the same method, different degrees of mechanisation might result in different allocations of space within the factory. All these variables were subject, in addition, to change over time, as factories changed hands or fashions changed, and in accordance with a long-term (if uneven) tendency towards greater mechanisation. A loose-fit building disguised many of these variations, but some required specific modifications. For example, the position of outworking or sub-contracting within the chain of production determined the optimum number and position of loading doorways, since part-made items would have been brought in and out at various stages in the process, and thus at various levels within the building. This may go some way to explaining the variation encountered in the number and position of loading doorways, both original and inserted.

In these circumstances, generalisations in matters of factory design are problematic. It is notable that a comprehensive manual of shoe-making, including sample plans of the main departments of a shoe factory, does not specify the floor on which each department would normally (or ideally) be situated.[4] In advance of more detailed internal observations, Goad fire insurance plans, prepared for Northampton in the period 1899–1956, have provided some illumination. The 1899 plans indicate that in the majority of factories the process moved from the bottom upwards. Heavy machines such as rough-stuff cutters were accommodated in the basement or on the ground floor, clicking on the first, and closing, finishing and the shoe room on the second. But making (including lasting and the attachment of the bottom-stock), which occurs between the closing and finishing stages, was most often on the ground floor, presumably because by the late 1890s it involved heavy machinery. Finally the finished product would be lowered from a second-floor doorway using an external wall-mounted crane or 'lift'. This arrangement was common but not universal. Strictly this kind of analysis, comparing factories built at different dates, manufacturing various kinds of footwear, involved in varying degrees of outwork and contract work, and varying proportions of hand and mechanised production, must be acknowledged as a crude and imperfect instrument, and one which runs the risk of yielding a spurious mean.

OUTWORKING

The industry's continued reliance on sub-contracting and outworking resulted in the construction of large numbers of smaller factories and outworkers' workshops. These exist cheek-by-jowl with large powered factories, forming a single flow of production. The distinction between workshops and factories, however, is fraught with difficulties, and contemporary usage is not always decisive. Here 'workshop' will be used to describe the small, usually single-cell, buildings suitable for a single shoe-maker (closer, riveter, etc.) and perhaps an assistant or two. These occur in a variety of forms. One of the earliest appears to be the garret situated on the upper floor of a rear range: 22 Regent Street, Finedon, is a good example dating from no later than the 1870s. Here the fenestration clearly distinguishes the upper floor as industrial in function, but in many houses the distinction between domestic and working space may have remained blurred. First-floor workshops enjoyed better natural light, particularly in confined situations. Examples combining a first-floor workshop with other ground-floor accommodation — usually a privy and a small compartment for a steep stair — are widely scattered, but occur in relatively small numbers. The example of Rotton Row, Raunds, built around 1890, consists of four workshops forming a lean-to row at one end of a short terrace of houses (Figure 2). Their diminutive scale underlines just how easily the shoe-maker's craft might be accommodated within the home.

Much the commonest workshop type, however, is single-storeyed and comprises a single heated and well-lit room. It usually occurs in lean-to or gabled rows at the rear of the house-plots, typically with alternative access from a communal passage or back-lane. The type proliferates in Kettering between the 1880s and about 1900, and is found as far afield as Bozeat to the south and Desborough to the north. Most appear to have been speculatively built along with the housing. It may be doubted whether they were all used for boot and shoe manufacture, even in Kettering where the noisy process of riveting made the separation of outwork and home desirable. What they probably indicate is that boot and shoe outwork was sufficiently prevalent that speculators chose to make workshops a standard accessory, in order to optimise letting potential.

Closers and sole-sewers 'to the trade' tended to be small masters occupying small factories. Most commonly these form the rear range to a house, with both internal access and a distinct employees' entrance. They are distinguished from domestic rear ranges by their long narrow proportions, first-floor loading doorway and ample fenestration, often with cast-iron window frames. Most are attached to modest houses, only slightly larger or more decorated than their neighbours. For example, 20 Bailiff Street, Northampton, dating from *c.* 1880, has a four-bay rear range, the first floor of which is documented as a machine-closer's workshop in the 1890s. The windows are closely spaced, and confined to the south-facing street elevation, but supplemented by a north-facing roof-light. As with the smaller workshops, the type was simple and versatile; some are found occupied by individuals describing themselves as boot and shoe manufacturers, suggesting that they undertook a wider range of processes than merely contract closing. Numbers 41 and 43 Colwyn Road, Northampton, built shortly before 1890, are exceptional in having six-bay closing workshops attached to the rear of substantial houses in a favoured location, backing onto the former racecourse.

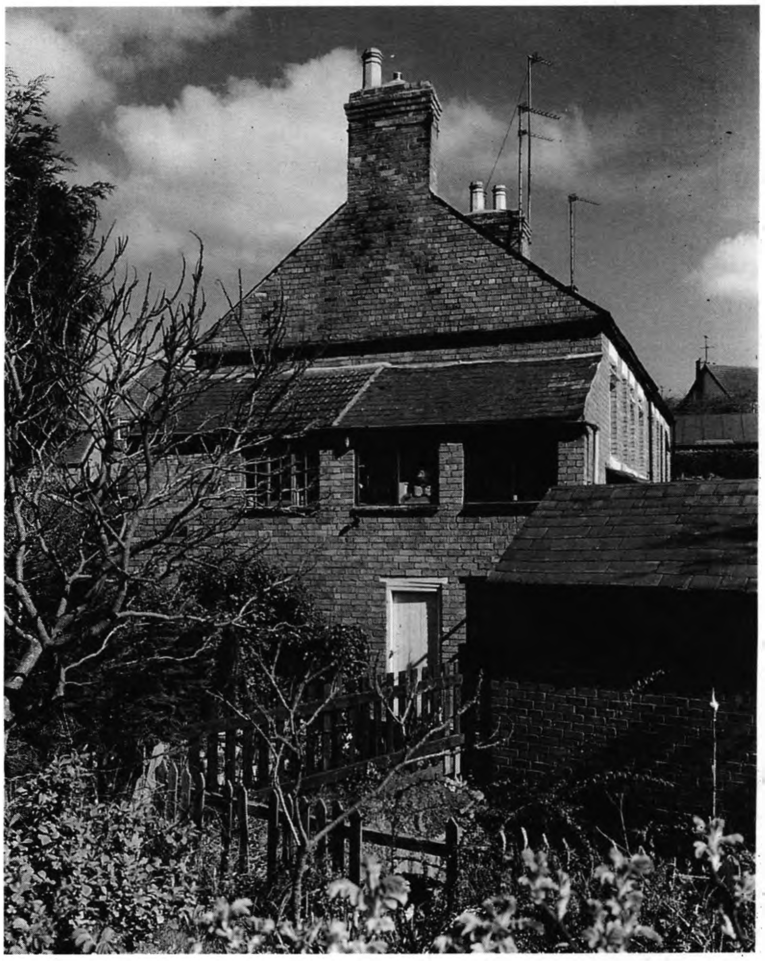

Figure 2. Four small first-floor workshops at Rotton Row, Raunds (BB 001817). © copyright English Heritage.

The Entrepreneurial Environment

This proximity of domestic and manufacturing space is an enduring feature of the boot and shoe industry.[5] The social status of the masters can be seen in a gradient of architectural expression of which Rushden

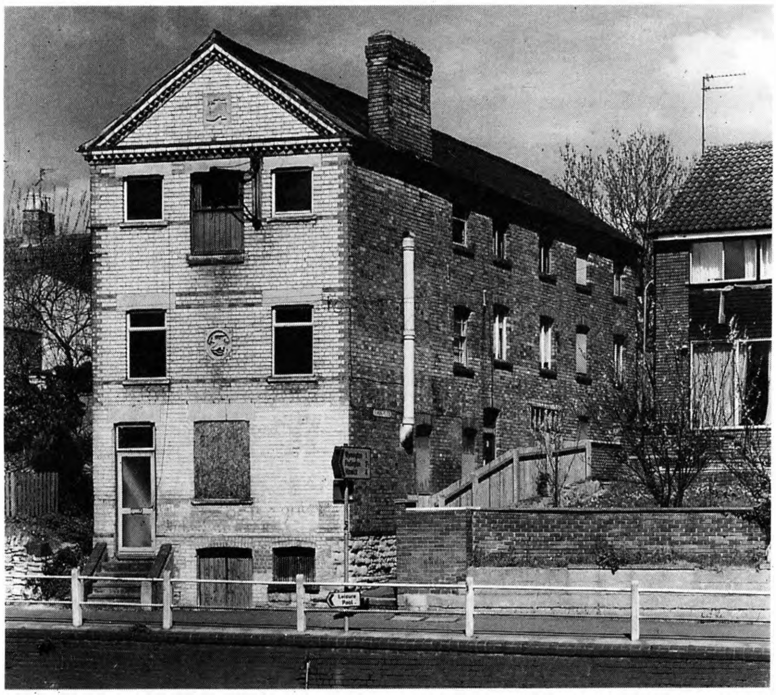

Figure 3. House-and-factory, dated 1874, at 83 High Street South, Rushden (BB 001996). © copyright English Heritage.

furnishes numerous examples. Most remained close to their businesses in a manner that in other industries would have been seen as increasingly archaic. Small masters occupied terraced houses that were distinguished from their neighbours only by a slightly taller, wider or more elaborate frontage. Number 70 Harborough Road, dated 1887 and attached to a three-storey factory, is one among many. Besides its greater width, it is marked out by a canted bay window and a timber porch. Less frequently a more substantial detached house was built alongside, as at 59–61 Moor Road, of *c*. 1890. Here the house, which in 1906 was home to Frederick Noble, boot and shoe manufacturer, takes the form of a detached villa on a modest garden plot. Later developments saw the rear garden sacrificed to improve access to the growing factory. The Tecnic Boot Factory on Bedford Road illustrates the longevity of the practice and its wide social range. It is a large factory, built for single-storey working on a greenfield site around 1925. Immediately to the north, separated only by the grounds surrounding it, is 'Durlands', 55 Bedford Road, a substantial contemporary neo-Tudor house, home of the Tarry family who directed the business. Only a minority of wealthy 'bootocrats' removed themselves and their families to genteel suburban villas.

More unusual is the combined house-and-factory under one roof. Again, Rushden furnishes an example, dated 1874, at 83 High Street South (Figure 3). The building stands gable-on to the street, and consists of three storeys over a basement. The house occupies the front of the ground and first floors, sandwiched between factory space on the upper and lower levels, allowing goods to be taken in from, or put out to, the street. The use of a pale buff brick and a pedimented gable on the street elevation dignifies the residential end of the building, but it is the broad domestic stack on the flank wall that draws the eye to its mixed uses.

The social diversity which these examples proclaim, coupled with the broad spectrum of productive units ranging from large factories to virtually one-man operations, built considerable flexibility into the industry. While a systematic analysis has yet to be attempted, there are strong indications from directory and anecdotal evidence that the industry was highly volatile. Many masters figure only briefly in directories, suggesting that the failure rate may have been high, particularly among smaller manufacturers. For others, however, this constituted an ideal entrepreneurial environment. The almost infinitely graduated range of available premises allowed the determined craftsman or salaried employee to secure a foothold as a master, and the successful master to climb a new rung of the ladder every time an opportunity offered.

One example must suffice. The well-known firm of Church & Co. originated in a workshop at 30 Maple Street, Northampton, in 1873.[6] In the following year they opened a three-storey factory at 24 Duke Street (Figure 4). Typical of its period, it is built in pier-and-panel construction on an L-plan, and has a street range of seven bays. The original entrance occupied one end bay, where it was positioned beneath a second-floor loading doorway. The Maple Street workshop was relinquished in 1880, but in Duke Street the firm rapidly burst the bounds of the original site. By 1890 they had absorbed the adjoining boot and shoe factory of Isaac Powell on one side, and built a large and prestigious new factory, with five storeys over a tall basement, on the other. The new factory was powered by a gas engine, and was supplemented by a single-storey roof-lit finishing shop. Between 1899 and 1905 Church's swallowed up the former house and curriery of Thomas Heggs at 30 Duke Street, and Booth & Co.'s shoe factory on the opposite side of the road at No. 5. Before 1912 they had taken over the adjoining curriery of Frederick Tyler at No. 3, and had acquired and demolished a string of houses in Craven Street to enlarge the yard behind their earlier factories. Finally, in 1956, they acquired the former Padmore & Barnes Moccasin Works in St James's End, where production was subsequently concentrated.

It is likely that some shoe factories were built speculatively. This can be inferred

Figure 4. Church & Co.'s extensive former factory in Duke Street, Northampton. The original seven-bay factory of 1874 is in the centre; to the right is the roughly contemporary four-bay factory of Isaac Powell, absorbed before 1890; to the left is Church's new factory, erected in the late 1880s (BB99/05253). © copyright English Heritage.

from a handful of examples which combine two similar factory units within a single building envelope, such as the Unicorn Works, built probably in the late 1880s in St Michael's Road, Northampton. From architectural evidence alone it is impossible to draw the same conclusion from single units, but some of the plainer factories may also have speculative origins. Directory evidence, its many pitfalls notwithstanding, demonstrates the fluidity of the wholesale boot and shoe industry, suggesting a field of entrepreneurs likely in many cases to have lacked the capital required to build industrial premises. It is possible, too, that aspects of the design of shoe factories reflect the rapid turnover of tenants rather than the prolonged occupation of owners. Many large factories, and some smaller ones, have the identities of owners or brands inscribed in limestone, but many small factories are anonymous. This might indicate no more than a modest economy on mason-craft. Alternatively, it might be argued that a significant stratum of manufacturers did not enjoy the privilege of marketing shoes under their own brands, and thus had less to gain from self-advertisement. But the architectural evidence may suggest otherwise. A common phenomenon is the provision, typically in the form of a fascia or entablature at first-floor level, of a signboard on which painted lettering could be applied and over-painted as required.

The Decline of Outworking

The last decades of the 19th century and the first decade of the 20th witnessed the steady encroachment of mechanisation in shoe manufacture and a corresponding erosion of outworking. By about 1900 nearly every process had been mechanised, though the take-up of machinery was patchy. The Goad plans show that by 1899 most of Northampton's three-storey factories operated a small gas engine to supply their growing power requirements, though in the smaller closing factories these remained unknown. Shoemaking machinery evolved as a series of stand-alone machine tools, each replacing one or more hand operations. Single-storey factories adopted the north-lit shed, already proven in other industries, and reflected a general need to accommodate more and heavier machines, while retaining the organisational flexibility inherent in a series of discrete operations. Manfield's 1892 factory on Wellingborough Road, Northampton, appears to have pioneered single-storey working, but others rapidly followed, such as Loake Brothers' factory of 1894–5 in Wood Street, Kettering, and a number on the eastern outskirts of Rushden.

Three-storey factories of the old type were seldom built after about 1900, though multi-storey factories continued to offer a solution on cramped sites, and steel-framed construction was in use before the First World War. The building of wholly new large factories remained fairly steady up to 1914; then, after the wartime hiatus, resumed until the mid-1920s, the Co-operative Wholesale Society being the most conspicuous investor, with large new factories in Rushden (Rectory Road), Wellingborough (Westfield Road) and Northampton (Christchurch Road), all built before 1925. Thereafter investment in new buildings seems to have been more sporadic. It is probably no coincidence that the vitality of the late 19th-century industry, as epitomised by the three-storey factory, was sapped very early on. Some survived, often by cramming existing yards with north-lit accommodation. But many foundered: there is clear documentary evidence for a sizeable shake-out of the older elements of the industry in the years around 1905, with many small and medium-sized factories passing into alternative uses, some after prolonged periods of vacancy.

CONCLUSION

The wider landscape of the late 19th-century industry has parallels elsewhere in Britain, but the extent of its survival raises methodological questions. A diverse but closely linked range of leather-trades activities engendered a dense urban fabric, criss-crossed by connections of trade, or process, and (as masters clambered up — or tumbled down — the entrepreneurial ladder) by connections of history, or lineage. The architectural face that it presented sometimes amounted to continuous rows of large industrial buildings, as in St Michael's and Dunster Roads, Northampton. More commonly it produced a gentler intermingling of housing and modest factories, many of the latter on the more prestigious and better-lit corner sites. In areas of widespread outworking there is an almost total saturation of the wider landscape. It is proper to consider — and this was a principal objective of the rapid survey stage of the project — the characteristics and qualities of individual buildings. But we also need to step outside the 'mentality of monuments' if we are to understand the industry in all its complexity, and the intricate historic landscape that is its legacy. With the results of the rapid survey to guide us, where should we direct more detailed work?

The approach is one that should be shaped by the industry itself. Industrial archaeology's primary focus on material remains means that it has often been less attentive to transient skills of hand and eye than it has been to the tangible legacy of mechanical innovation and architectural form. In this it has been powerfully reinforced by the instincts of economic historians, who have sought to 'explain' the origins and course of the industrial revolution by reference to those industries which are seen as propelling the juggernaut forwards, either through technological breakthrough or via the medium of capital formation. Hence the historiographical dominance of coal, iron and steel, textiles, the canals and railways, shipbuilding and engineering; more recently of chemicals, the motor industry and the defence industries.

The boot and shoe industry quietly challenges such traditional emphases. It is characterised, as we have seen, by the late adoption of mechanisation and factory-scale production, together with an enduring dependence on outworking. It is an industry in which labour organisation, as much as technical innovation, exerted a determining influence. Nineteenth-century commentators — and they were not numerous — were more likely to group it with the sweated trades than among the industrial vanguard. Yet there is an underlying *mechanism* that is impressively intricate. As Thomas Carlyle recognised in his 1829 essay, 'Signs of the Times', the Industrial Revolution is characterised by much wider-ranging transformations than merely the introduction of the machine, though the machine remains the aptest metaphor for the whole.[7] In the boot and shoe industry *mechanism* is expressed in a number of ways.

First, it has a spatial expression, which encompasses both the distribution of tasks within a single factory, and the dispersal of functions across a number of sites and enterprises, at the same time overlapping with issues of status and gender. The arrangements frequently seem pitifully un-ergonomic, but clearly there was an underlying, empirically based rationale to them. The grain of this geography needs at the very least to be sampled and its salient characteristics understood.

Second, the mechanism has a human dimension, and this operates on two levels. There is the division of labour, Adam Smith's classic multiplier of industrial productivity, pursued to breathtaking levels. Of the 200 to 300 operations which go to make a shoe, an individual might be master of just a handful. The organisation of these manifold tasks — the flow of intermediate products — warrants close attention. And there is a more difficult territory: that combination of skill and dexterity, with the knowledge and experience of tools and materials, that makes for fluent actions, and swift, dependable results. Because it is evanescent this is something that has rarely been captured by those of us who attempt to recover and document the industrial past. Without losing sight of the surviving buildings (which we must either understand and manage, or lose forever), the exploration of these more fugitive issues will be a major objective of our continuing work on the boot and shoe industry.

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Notes and References

[1] The most substantial scholarly account to date is Alan Fox's specialised study, *A History of the National Union of Boot and Shoe Operatives 1874–1957* (Oxford, 1958); its title conceals a more broadly-based examination of the trade. In general, labour relations within the industry have been more fully discussed than the built legacy, but there is an overview of the latter in Palmer, Marilyn, & Neaverson, Peter, *Industrial Landscapes of the East Midlands* (Chichester, 1992), particularly 192–203. All histories of the county and of the main shoemaking centres devote some attention to the industry. Among publications dealing with it specifically, Kettering is examined in Church, Roy, 'Messrs Gotch & Sons and the Rise of the Kettering Footwear Industry', *Business History*, 8 (1966), 140–9, and Greenall, R.L., 'The Rise of Industrial Kettering', *Northamptonshire Past and Present*, 5/3 (1975), 253–66; Northampton in Goodfellow, A.V., & Starmer, G.H., 'A Survey of Part of Victorian Northampton', *Bulletin of Industrial Archaeology*, CBA Group 9, 11 (Jan. 1970); while Long Buckby is treated in Greenall, R.L., 'The History of Boot and Shoemaking at Long Buckby', *Northamptonshire Past and Present*, 5/7 (1977), 437–45. Other significant articles include Church, R.A., 'The Effect of the American Export Invasion on the British Boot and Shoe Industry, 1885–1914', *Journal of Economic History*, 28 (1968), 223–54.

[2] Cooke, Jonathan; Hilsden, Kathryn; Menuge, Adam & Williams, Andrew, *The Northamptonshire Boot and Shoe Industry: A Summary Report* (English Heritage, 2000).

[3] See, for example, Randall, H.A., 'The Kettering Worsted Industry of the Eighteenth Century', *Northamptonshire Past and Present*, 4/5 (1970–71), 313–20, and 4/6 (1971–2), 349–56; and Hatley, Victor A., '"Blaze" at Buckby: A note on a forgotten Northamptonshire industry', *Northamptonshire Past and Present*, 4/2 (1967–8), 91–6. Other industries included silk- and lace-making.

[4] Swaysland, Edward J.C., *Boot and Shoe Design and Manufacture* (Northampton, 1905), *passim*.

[5] See Campion, Garry, '"People, process, power and place": an archaeology of control in East Midlands outworking, 1820–1900', PhD thesis, University of Leicester, 1999.

[6] The account of Church's is based on Crawshaw, John, *Made to Last: The History of Church's Shoes*, [Northampton] (n.d. [*c.* 1998]), *passim*, and successive editions of the Ordnance Survey, Goad insurance plans, and trade directories.

[7] Carlyle, Thomas, 'Signs of the Times' (1829), in *Critical and Miscellaneous Essays*, 5 vols (London, n.d.), 2 (vol. 27 of the Centenary Edition of *The Works of Thomas Carlyle*), 56–82.

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Developing consumption: the case of electric home appliances and plastic consumer goods in Norway

Liv Ramskjaer

The introduction of electricity, and the development of new materials and mass production techniques have had a strong impact on the consumer society. New materials and appliances made it necessary to develop markets and change consumer behaviour. Technology and design, rather than consumer demand, created new industries. A strong belief in the spirit of progress, functionalism and the helpful effect of new materials and appliances in the daily life of the consumers was typical in the marketing of both electric home appliances in the inter-war period, and plastics consumer goods in the first decades after World War II. According to one of the strong believers in plastic in Norway in 1946: 'Our children will ... live their lives surrounded by beautiful, strong, light, clean and cheap consumer goods of plastics'. In the inter-war period the electricity producers and their associations collaborated with the electro-technical industry and women's organisations to promote the new electric home appliances.

Stimuler la consommation: le cas de l'electroménager et les articles en matière plastique en Norvège

L'introduction de l'électricité et le développement de nouveaux matériaux et de techniques de production de masse ont tous eu un impact considérable sur la société de consommation. De nouveaux matériaux et de nouveaux appareils ont nécessité l'extension des marchés et des modifications dans le comportement des consommateurs. De nouvelles industries découlent alors de la technologie et du design, plutôt que de la demande. Une grande foi dans l'esprit de progrès, dans le fonctionnalisme et dans les effets bénéfiques des nouveaux matériaux et appareils pour la vie ordinaire du consommateur caractérise le marketing des appareils électroménagers entre les deux guerres et des nouveaux articles en matières plastiques dans les décennies immédiatement après la deuxième guerre. Selon un observateur norvégien de 1946, convaincu des avantages des matières plastiques, 'Nos enfants mèneront des vies entourés d'objets légers, propres et peu chers, tous en plastique ...'. Entre les deux guerres, les producteurs d'électricité et leurs associations s'alliaient avec les fabricants d'appareils électroménagers et des organisations féminines afin de promouvoir les nouveaux appareils domestiques.

Introduction

The introduction of electricity, and the development of new materials and mass production techniques have had a strong impact on the consumer society. New materials and appliances created need to develop markets and consumer behaviour. They are good examples of, not demand pull, but technology push. A strong belief in the spirit of progress, functionalism and the helpful effect of new materials and appliances in the daily life of the consumer was typical in the marketing of both electric home appliances in the inter-war period, and plastics consumer goods in the first decades after World War II. According to one of the strong believers in plastic in Norway in 1946: 'Our children will ... live their lives surrounded by beautiful, strong, light, clean and cheap consumer goods of plastics'. In the inter-war period the electricity producers and their associations collaborated with the electrotechnical industry and women's organisations to promote the new electric home appliances.

In the last two decades of the 19th century the introduction of electricity and the development of new materials and mass production techniques had a strong impact on the shaping of consumer society. The story of Alcoa's invention of the process of making cheap aluminium is one good example. From the 1890s the highly expensive and exclusive material aluminium could be produced in mass quantities at low prices. The new process made it necessary to create a new consumer market for the material. Until then aluminium had a limited market in luxury goods. The reduction in price led to larger consumption of aluminium in the steel industry. Small-scale experimental production of aluminium tea kettles and cooking utensils was soon set up. Alcoa went 'downstream' by adding new factories for end products. From the mid-1890s into the first decade of the 20th century, the fastest growing application of aluminium was in cooking utensils. The kitchenware market grew through aggressive marketing campaigns, demonstrations and education. After the takeover of a Massachusetts aluminium 'thickware' utensil company in 1901 the company adopted a successful direct-marketing strategy of door-to-door sales. It was organised as 'an educational campaign to housewives — which would probably pay its own way in sales'.[1] The company employed a sales force mainly of college students for the campaign.

The example of Alcoa is in no way unique. Other producers used similar technology-push strategies in promoting their products. In Norway the producers of electricity started their first promotional campaigns for electricity and electrical home appliances around 1900. It was, however, in the inter-war period that they staged promotional campaigns most heavily. Both the target for the marketing, the housewives, and the strategy behind the activity, have clear similarities to the Alcoa story.

SELLING ELECTRIC HOME APPLIANCES TO NORWEGIAN HOUSEWIVES IN THE INTER-WAR PERIOD

> War is the greatest of all agents of change. It speeds up all processes, wipes out minor distinctions, brings realities to the surface.
>
> (George Orwell, *The Lion and the Unicorn*).

World War I represented the first big boom for increased consumption of electricity in Norway and World War II the second. Imports of coal and kerosene were limited during the first War. The price of coal increased by 2,000% from 1914 to 1920. The formerly rather costly electricity became a very cheap and attractive alternative and led to increased consumption for lighting and cooking. The producers had problems with meeting demand and many new hydroelectric generating plants were built during the war, even though building costs were extremely high. Many Norwegian consumers were introduced to the new world of electrical home appliances for the first time. Even if they were taught to use electric water-boilers, lamps, hot-plates and irons, and learned about the great advantages it brought them, many consumers returned to non-electric cooking and kerosene lamps after the war. The prices of coal and kerosene went back to normal, with the result that the price of electricity became high again. Many power-plant owners got into serious economic trouble as a result of expensive development costs and falling consumption.[2] Even though electricity prices decreased to a certain extent in the 1920s, they were still too high for many consumers.

Electric lighting got its breakthrough in Norwegian society during the First World War. The number of bulbs increased from 804,935 in 1911 to 5,092,357 in 1923.[3] Electric motors in factories were well established and increased in number through the inter-war years. In 1900 only 417 electric motors were installed in Norwegian industry. Forty years later more than 97,000 motors served industrial machinery, and the installed power increased from about 3,000kW to more than 700,000kW.[4] However, consumption of electricity in households and agriculture was low compared to that of the electro-chemical industries. From 1930 the statistics of power consumption shows a slight increase in the private sector, but industry still consumed three-quarters of Norwegian electricity production.

Electric irons were the most popular and widespread electrical appliances among the consumers in the late 1920s. Almost 70% of the electricity subscribers in Oslo owned electric irons in 1927. They were not too expensive and could easily be adapted to the lighting current. Nearly 60% of the subscribers in Oslo had hot-plates and more than 44% had electric heaters at this time. In contrast to this only 17% had vacuum cleaners and 11% had electric stoves.[5] A 1928 study in Berlin found that only 45% of all households had electricity. Of these 56% had electric irons and 28% had vacuum cleaners.[6] Norwegian consumers, however, were slower than Americans in adopting the new electrical appliances. Neither the Norwegians nor the Germans were able to rival the comparatively widespread ownership of durable goods that characterized American society. In 1921 40% of the lower middle class in Philadelphia used vacuum cleaners.[7] In Norway in the late 1920s it was still a luxury appliance (Figure 1). The electric iron, heater and hot-plate were the most widespread home appliances in Norwegian homes in the 1920s.

Low coal prices led to low interest in electrical cooking in the early 1920s. The later increase in fuel prices contributed to a strong increase in electric power consumption for cooking and heating, from 50,000kW in 1917 to 426,000kW in 1926. Per Kure, a pioneer Norwegian producer of electrical generators and home appliances, stressed in 1928 that the growth of consumption would have been much larger without the economic depression.[8] In the post World War I depression the Norwegian electrotechnical industry had to find a new market to survive. Few new orders for generators appeared and many producers switched to electrical home appliances. Increased production of these contributed strongly to the recovery in Norwegian industrial growth in this period.

Promotion

During the inter-war period the producers of electric appliances actively began to use several different means to promote the use of electricity and home appliances to the consumers; magazine articles and advertisements, pamphlets and books, posters, school campaigns, films, speeches, demonstrations, courses and consultatory activity. Personal influence through home visits was considered extremely important. Many of the larger electricity utilities had their own permanent exhibitions of home appliances. Stimulation of the market by offering cheap or free supplementary current, free test-installations, loans or reasonable hire of appliances or free connection were deemed necessary.

Different electricity producers published pamphlets and booklets promoting the utilisation of electricity and home appliances. *Norske Elektrisitetsverkers Forening*, NEVF, the organisation for the electrical utilities, was an important actor in the promotion of electricity. The ideology in the promotional campaigns was that electrical home appliances, and especially electric heating and cooking, would make the work of the housewife much easier. The producers of the appliances focused on their time- and labour-saving qualities. They were also less expensive than usually assumed, but above all they were clean and easy to use.

The promotional activities had roots back at the turn of the century. In 1908 NEVF published *The practical utilisation of electricity*. This small booklet explained the different stages in the production of electricity from the hydropower-plant through the grid to the user and the different ways of utilising it for power, lighting, cooking and heating. The booklet stressed the significance of electricity in the transformation of daily life. Cheaper current and better cooking utensils would, as NEVF saw it, lead to more widespread diffusion and attributed the modest diffusion so far to a lack of knowledge about the available appliances. The acceptance of the new household technology would come when the consumers realised its advantages. The same attitudes constituted the central core of the ideology in promotional activity in the inter-war years, which

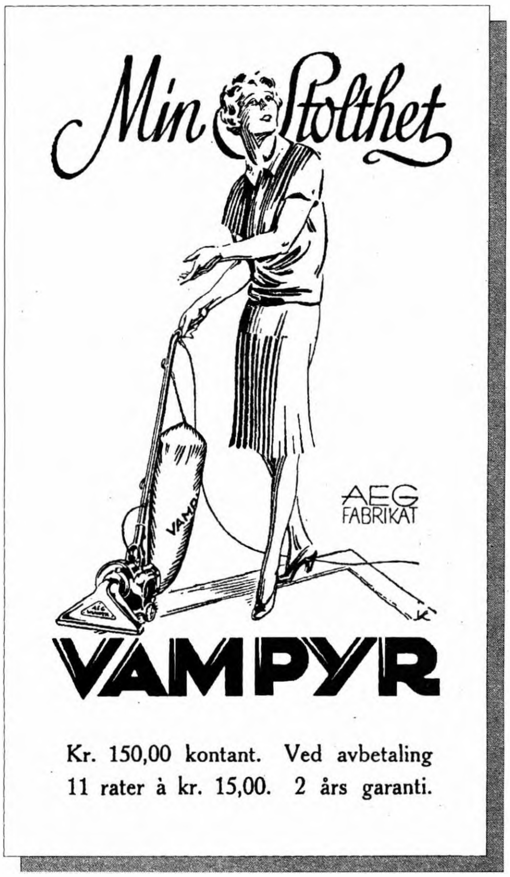

Figure 1.
My pride. *Vacuum cleaner, type AEG Vampyr. From booklet, Norwegian Museum of Science and Technology.*

was then linked to a more widespread ideology about improved hygiene, nourishment and more functional housing.

The ability to compete with other energy sources and the quality and price of appliances was crucial for the diffusion of the new household technology. Strong competition from gas up to the 1930s limited the adoption of electric cooking in several Norwegian towns. The electric stove was rare until 1925 and got its final breakthrough in the 1930s. In *Diet and the standard of living* from 1941, the economist Knut Getz Wold concluded that there had been few visible changes in dietary habits in the last 15 years. The amount of butter and sandwiches consumed indicated that coffee and sandwiches still held a strong position in the Norwegian town households. Increased consumption of electricity and stoves would come naturally with a change from cold to hot meals.[9]

Several groups participated in the promotion of electricity and electrical home appliances in addition to NEVF. The electrotechnical industry was interested in selling more home appliances, and engaged home economists to give demonstrations of the new gadgets. Several strong and independent women's organisations cooperated with NEVF. They shared the view that new appliances would lead to the simplification of the housework, and that the housewife would get more time for the family. Advertisements focused on housewives as better mothers with more spare time for reading to their children if they began using electrical appliances to a larger extent. In Norway, like the US and other countries, home economists played a central role in teaching the new scientific ways of cooking.[10]

The most outspoken Norwegian promoter of electricity in the homes in this period was a man, the engineer Halfdan Steen-Hansen. He viewed the use of electricity as revolutionary: 'It lays a new foundation for work and the standard of living'.[11] Steen-Hansen had a strong faith in the spirit of progress and technological optimism. In his opinion women were standing on the threshold of a new era characterised by rationalisation of housework and alteration of old methods. Women's work had to be valued much more highly. It was equal to men's work, and women should have the same opportunities to share in the advantages of new technology. New household appliances would help women to get more time for recreation and child care and also make them more self-sufficient in household management. Women would also gain opportunities for individual growth and active participation in the community and in politics.

Steen-Hansen saw the prejudices of men, and women's conservative attitude towards the organisation of the home, as the greatest hindrances to progress. Ideologically he was inspired by functionalism and had a strong faith in the 'machine age' with its industrial and technological development. He was also influenced by Fredric Winslow Taylor's ideas of scientific management and the ideas of American home economists such as Christine Frederick, which were also taken up by other Norwegian home economists. The 'rationalisation' of housework had to include rearrangement of the workplace, the kitchen, and the reform of work through time-and-motion studies. Kitchens must be reduced in size to avoid unnecessary steps. Norwegian women's magazines printed numerous articles on the new and modern kitchen during the 1930s. A strong belief in modernity and the new woman is evident in Steen-Hansen's progressive writing.

In 1928, after a decade of promotional engagement, Steen-Hansen was employed by NEVF as a 'propaganda engineer'. In the following three and a half years he gave about 240 speeches to more than 135,000 listeners, many of whom were children. Bringing knowledge of the advantages of electricity to the consumers-to-be was given high priority. In the autumn of 1931, during a campaign in the county of Oestfold, he made 50 speeches in 28 days. The NEVF propaganda policy had a strong social attitude. To establish confidence between producers and consumers was important in order to fulfil the social aim of the electric utilities. They had to give impartial advice, but with the hope that their propaganda would lead to increased sales of home appliances.[12] In the 1930s they addressed the housewives directly, stressing the ability of the appliances to help them save time and money, and to utilise raw materials in a better way.

Change in household routines involved making fewer things at home and purchasing more. Competence in buying and using mass-produced goods became important for the woman in charge of the household, and made her an important target for advertisers. They wanted to instil the need in her to buy the new branded products, as Susan Strasser stresses in *Satisfaction Guaranteed*.[13] The rational consumer of neo-classical theory balances personal concerns about price and quality and chooses among competing producers. The new marketing repudiated the neoclassical doctrine. As real income rose and cheaper manufactured products proliferated, the consumers could afford to make decisions about their purchases based on other considerations as well.

Anthropologist Mary Douglas and economist Baron Isherwood, in an attempt to define consumption in a way that could apply to human culture, maintain that: 'consumption starts where markets end. What happens to material objects once they have left the retail outlet and reached the hands of the final purchaser is part of the consumption process'.[14] In this way, creating modern consumer culture involved both introducing new products and establishing market demand for them, as well as the creation of new domestic habits and activities. The manufacturers had to ask themselves if there already was a market for their product or if they had to create one. In neoclassical economic theory, decisions about what and how much to produce are made by the market operating to the benefit of the consumer. In the modern consumer society those decisions are made by managers wanting to maximise benefits for their companies.

The general role of women changed in the inter-war years. In *A Century of Women*, Sheila Rowbotham describes the new sexually, politically and professionally more conscious, independent and liberated women of the inter-war years. New opportunities in jobs appeared for women in this period, and slowly altered the old gender patterns. The women were becoming less dependent on male support, and more visible in politics.[15] Halfdan Steen-Hansen's writings show how progressive engineers accepted and promoted these changes.

Consuming Plastics in Post-World War II Norway

Many of the general ideas used in the promotion of electric home appliances were also used in the promotion of the new plastic materials in the early post-war years. 'Our children will ... live their lives surrounded by beautiful, strong, light, clean and cheap consumer goods made of plastics', maintained one of the true plastics believers in Norway in 1946.[16] There are traces of the ideas of the hygiene movement in this statement, but also ideas about equalisation, technological and industrial progress, and above all hopes of post-war prosperity.

Mass consumption of synthetic plastics, with decreasing prices, in the post-war years, stand in contrast to the consumption of the more exclusive early plastics in the inter-war period. The plastics revolution made former luxury goods available to a whole range of consumers. Many new groups of consumer goods were introduced. The 'plastic age' was proclaimed as early as 1927. In 1942 the economist and historian of chemistry William Haynes stated that synthetic materials would have 'more effect on the lives of our great-grandchildren than Hitler and Mussolini'.[17] The science-based inventions of new polymers in the 1930s made possible the post-war revolution in plastic materials for consumer goods. The technology push created by the scientists and inventors in polymer chemistry produced materials the world had never seen before. The development of new markets and new areas of application were a necessity in order to get a return on money invested in research and development. These markets started to grow faster when a demand was created for new innovations, which in turn stimulated the producers to increase investment. Most of the innovations were developed by large international chemical concerns.[18] In *Paths of innovation*, David Mowery and Nathan Rosenberg stress that the most important innovation in the 20th century is the systematic institutionalisation of the innovation processes inside the industrial firms. The economist Joseph Schumpeter stressed in 1942 that 'innovation itself is being reduced to routine. Technological progress is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways'.[19]

The ability to commercialise the products represented the strength in the research and development activity of Du Pont in the post-war years, not science and innovation as in the German I.G. Farben. American consumers represented a huge market for new plastic goods. New products, like refrigerators and cars, changed people's habits. Changing trends in clothing increased the necessity for cheaper dresses. The social, economic and technological changes gave plastic manufacturers like Du Pont an opportunity to introduce and sell their new products. Advanced plastic materials were developed and later manufactured by many firms in large quantities. Advertising was used to a large extent to increase demand.[20]

Although the Norwegian plastic manufacturing industry is mainly a post-war phenomenon, a handful of manufacturing firms began production of certain consumer goods in the late 1920s and 1930s. Norsk Teknisk Porselensfabrikk was the first, with its production of bakelite electrical insulation components which was established as a direct result of an electric materials control Act. Bakelite replaced porcelain in installation materials such as plugs, sockets and switches and also replaced other materials in electrical consumer goods, like irons, telephones and hot-plates. After the war thermoplastics like PVC, polyethylene, nylon and later polypropylene came to replace thermosetting plastics (e.g. bakelite and melamine). These new plastics represented the foundation for the mass consumption of plastic consumer goods in the 1950s and 1960s. In the post-war years Norwegian industry was enriched with a number of new entrepreneurial plastics manufacturers, many of whom had some experience with plastics production from the US or UK during the war. When they returned to Norway, they took advantage of the possibilities of the new materials and also the post-war flow of money. New consumer goods were easily sold to customers hungry for new dolls, toys and other products not available during the war.

Schumpeter stresses the role of the entrepreneur in the innovation process. In his view the entrepreneur was more than a successful businessman: he also had the ability to make strategic choices and break with routines. In post-war Norway the plastics entrepreneurs contributed positively to the country's industrial and economic growth, in their innovative transformations of the new plastic materials to consumer goods for the market.

A surplus of money amongst the consumers and a deficit of consumer goods, gave many of these entrepreneurs a flying start. In the first post-war years production of 'luxury goods' like dolls and toys was crucial to the industry, although they also began manufacturing more useful articles for industry and family homes. Many

Norwegian plastics manufacturers began producing goods that had earlier been imported. Aasmund Laerdal in Stavanger, for example, established the production of toys during the war to fill an empty space in the market. He had no former experience with plastics, but managed to utilise the closed post-war market to found a new business and in 1950 the company was the first in Europe to produce dolls of vinyl plastics. He believed that consumers would be willing to buy the product to avoid damage to furniture, and that parents would give their children toys that lasted longer than the traditional toys. Mass production of plastic toys enabled Laerdal to meet increased competition from free imports later in the 1950s.

Returning from England to Notodden with test samples of polyethylene, Johan Aasheim began experiments in his kitchen. He melted the polyethylene and produced decorations for women's shoes and other accessories. In England he had seen polyethylene moulding, but not extrusion or compression moulding through jets. With a rebuilt mincer and with power from a sewing machine, he gathered experience for the building of a larger machine: Extruder number 1. The founding of Norsk Extruding in 1948 was based on this machine. The new firm manufactured products which had earlier been imported. Decorations for ladies' shoes and belts were among the first popular products, but insulation sleeves represented the first real mass-produced commodity. Unbreakable bottles for the pharmaceutical industry and cosmetic products became important core products.

Vestfold Formstoff Industri, Vefi, was established in a garage in Larvik in the autumn of 1949. Entering the market for traditional extruded products such as pipes, hoses and tubes, the firm met stiff competition. Creativity led the firm to the production of a maintenance-free kitchen in PVC and Darvic, a rigid form of PVC. Vefi addressed housewives in promoting their complete pre-fabricated plastic kitchen which was easy to clean, labour-saving with good working conditions, and designed for the modern woman (Figure 2).

The firms mentioned here are all representative of early Norwegian plastics manufacturers. The study by the Norwegian Central Bureau of Statistics in 1958 clearly showed that plastics had been integrated to a large degree in Norwegian households. Consumers demanded the utilisation of the new materials because of bad experience with substitute materials during the last war. The consumption of plastics was most apparent in categories like furniture and equipment, clothing and footwear. Nylon stockings had become a natural part of daily life. Lingerie and shirts of rayon became extremely popular in Norway in the 1950s. Plastic materials revolutionised raincoats. Producers switched, more or less willingly, from oil-cloth to plastic in the post-war years. Plastic goods were used most extensively by middle class consumers and less by groups with very low or high incomes, a tendency also evident in the consumption of different synthetic fibre products and in nylons.

The plastics industry felt strongly that information campaigns were necessary to help consumers use the new materials to full advantage. As late as the 1960s many still regarded plastics as a single material. Few consumers understood that plastics belonged to a group of materials with widely different qualities. The first exhibition of 1948 promoting the new material was followed by several more, each having a twofold aim. The exhibitions were a showroom for consumers, to meet the new materials and their modern and convenient products, and a meeting place for producers of plastics raw materials and their end-users; the consumer goods manufacturers. During the 1950s the manufacturers were thankful for the educational effects of these exhibitions. The lack of knowledge about plastics was just limited to Norwegian consumers, however; Jeffrey Meikle stressed that the American consumers by and large never learned the differences.[21]

The plastics exhibition of 1968 was too insider-oriented, one critic maintained. It did not address the most important group: the consumers. In his opinion the housewives represented the most important group of these. To avoid misuse of plastic materials, education was very important. As in the case of electrical appliances the role of the housewives was seen as crucial in the diffusion of plastic goods. Changes in household technology gave plastics advantages compared to more traditional materials. The common diffusion of the refrigerator in Norwegian homes in the late 1950s increased the need for efficient storage containers. Tupperware advertised its plastic containers as a solution to this problem. The Norwegian firm Panco was inspired by Tupperware and established production of its own design producing high-quality containers for the domestic market and also for export. In 1962 Panco exported household plastics to 20 countries, with Western Germany as the most important export market. The ideology of easing the working conditions of housewives, so strong in the inter-war period, was also used extensively to further the diffusion of light, bright and easy-to-clean plastic buckets.

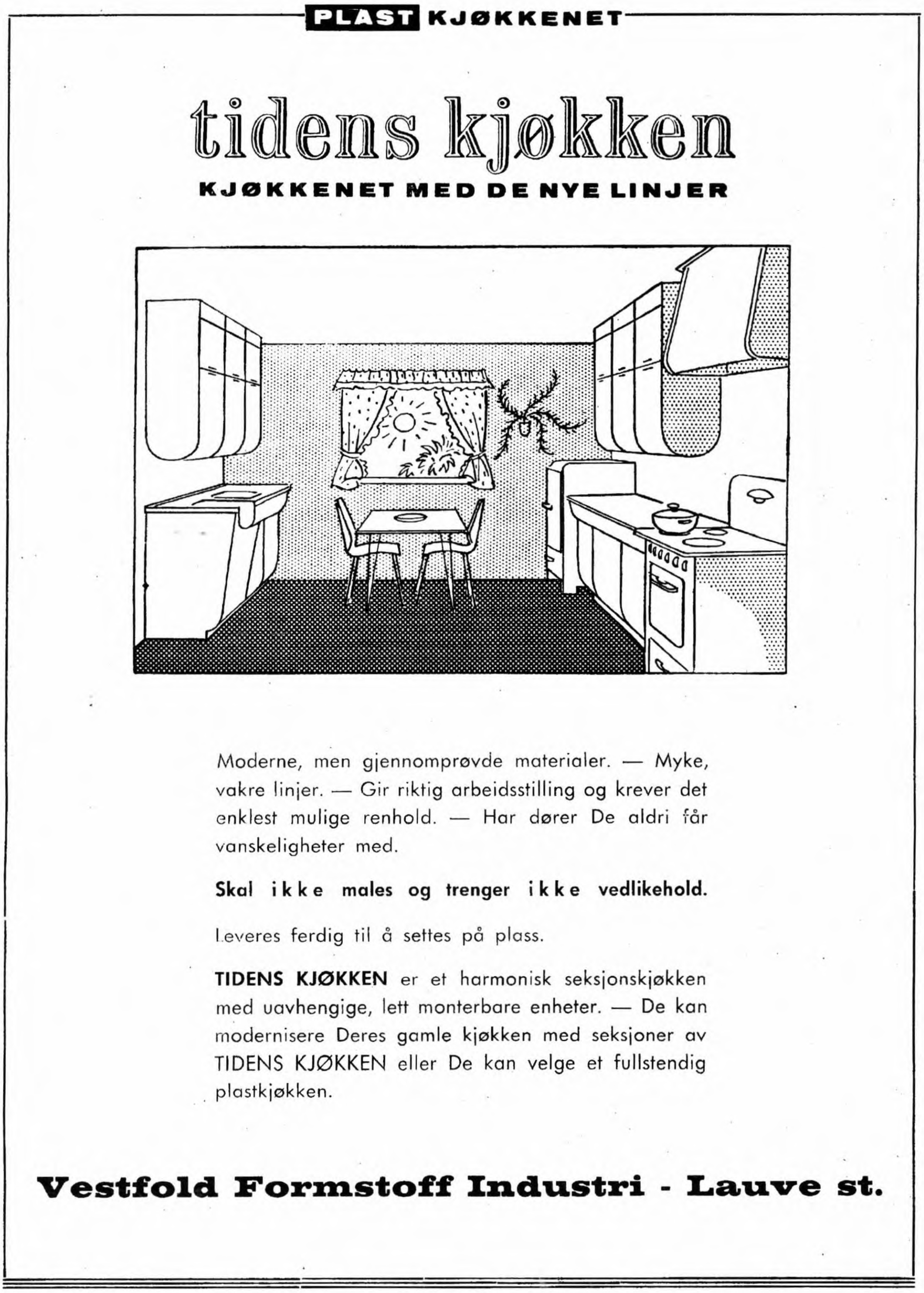

Figure 2.
The kitchen of the time. *A combination of modern materials and soft beautiful lines were seen as the answer to the demands of the post-war era. (Source:* Plastnytt, *2, 1959.)*

When Nordisk Formstoff began marketing Golvflex plastic floor covering in 1953, it was presented as hygienic, easy-to-clean and durable. By 1960, plastic floor coverings made up 35% of the total sales but increased steadily thereafter. Several producers manufactured floor covering of PVC and other plastic materials. Washable wallpaper, tablecloths and aprons of plastics were marketed as indispensable. Helly J. Hansens Helox advertisement from 1953 promoted: 'Helox plastics in the entire house' and 'The right plastics in the right place'. In early advertising the manufacturers tried to educate the consumers by stressing the optimal utilisation of their products and giving them information about the advantages of the new materials.

CONCLUSION

A strong belief in the new materials and their ability to assist, help and liberate the consumers are manifest in the promotional campaigns for the new plastic products in the 1950s and 1960s. New plastics were introduced during the 1950s while the 1960s can be characterised as the decade for their wider and more common diffusion. New plastics consumer goods were often tested and presented in the Consumer Association's Newsletter during these two decades. By the late 1960s, it had become obvious that plastics had become a natural part of the consumer society and no longer excited great interest.

When we look at the promotion and integration of electrical home appliances in the inter-war period and plastics consumer goods in the post-war decades, one is struck by the parallel. They were promoted as time-, money- and labour-saving. Their use would lead to improved hygiene and simplification of housewives' work. The new commodities would bring the liberated modern woman new opportunities and freedom.

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Innovative materials and utilitarian beauty as incentives to the consumption of domestic appliances in Ontario and Québec, 1920–1990

Louise Trottier

The consumption of electrical household appliances took off rapidly in Canada from the 1920s owing to a number of factors. Firstly, the electric power system consolidated in most large cities and, after World War II, 94% of Ontario and Québec homes were electrified. Secondly, the growth of the Canadian electrochemical, electro-metallurgical and steel industries during the 1930s, and the establishment of the petrochemical industry after 1947, made it possible to produce a wide variety of new materials — polymers, ceramic composites, acrylics, aluminium — and use them in home appliances. Thirdly, although Canada was quite accessible to the penetration of American inventions and technologies, the development of a Canadian home electrical appliance industry became very lively between the 1930s and the 1960s.

Based on a selection of the electrical appliances in the collection of the Canada Science and Technology Museum, as well as from relevant images and trade literature, this paper aims to demonstrate the impact of the culture of consumption in the discovery, production and selection of a complexity of materials and innovative design. Questions such as who were the main consumer groups, what were their needs and demands and what were the main marketing strategies will be explored. The conclusion suggests that the analysis of material culture could be used to investigate trends in the present-day consumption of household appliances.

Matériaux innovateurs et esthétisme functionnel comme stimuli à la consommation d'appareils électro-ménagers au Canada 1920–1990

Plusieurs facteurs peuvent expliquer l'essor de la consommation des appareils électro-ménagers au Canada à partir des années 1920. D'une part l'électrification de grandes villes est consolidée et, après la seconde guerre mondiale, elle est répandue dans 94% des foyers en Ontario et au Québec. D'autre part, la croissance de l'industrie canadienne dans les secteurs de l'électrochimie, de l'électrométallurgie et de la sidérurgie pendant les années 1930, et de la pétrochimie après 1947, amène la production d'une grande variété de matériaux — polymères, composés de céramique, acryliques, aluminium — qui sont de plus en plus utilisés dans la fabrication d'appareils domestiques. Enfin, bien que le Canada demeure très accessible à la pénétration des technologies américaines, le développement d'une industrie nationale des appareils domestiques s'affirme particulièrement entre les années 1930 et 1960.

Fondée sur l'étude de la collection d'appareils électro-ménagers du Musée des sciences et de la technologie du Canada, de même que sur des illustrations et catalogues commerciaux pertinents, notre présentation veut démontrer comment la culture de consommation a pu influencer la conception des appareils domestiques et accentuer le développement de matériaux de fabrication de plus en plus sophistiqués. Nous tentons d'identifier les principaux groupes de consommateurs, leurs besoins, leurs demandes, ainsi que des stratégies de mise en marché. L'intégration des tendances et modèles récents de la consommation des appareils domestiques dans les recherches en culture matérielle font partie des thèmes qui sont explorés en conclusion.

Introduction

One of the most popular television series in Québec in the mid-1950s was certainly *La famille Plouffe*, adapted from a novel by Québécois writer Roger Lemelin.[1] This was the story of a working-class family living in an apartment of the quartier St-Sauveur in Québec City's lower town during the Second World War. Joséphine Plouffe is a good illustration of the traditional mother fulfilling her domestic tasks essentially in the kitchen. This is her kingdom, the place where she bakes her famous pies, an activity which could lead to serious debates about the wood stove quality; this is also the place where she delivered at meal times morality speeches either to her husband or to her four grown-up children. Ironically, the character of Joséphine Plouffe attained yet more popularity in a television commercial where she promoted the virtues of an electric stove and ended up with a vibrant 'cri du coeur': 'Ah! Mon beau poêle Bélanger.' The famous 'poêle Bélanger' was a trademark of the Fonderie de l'Islet. Were its beauty and its qualities sufficient to justify a purchase?

Seen in retrospect, the television series and the commercial clip are interesting examples of the incentives that may drive a consumer to acquire an electrical appliance. This decision is influenced by the models offered on the market, the performance, the life-span, the qualities, the dimensions and the style of the apparatus, the organisation of the space where it will belong, and, above all, the availability of electric power in the household.

Our story deals with electrical kitchen appliances — ranges, refrigerators and small devices — manufactured, distributed and used in Ontario and in Québec between 1920 and 1990. They represent a significant part of the electrical industry initiated in the 1880s with public services — lighting and transit — and the infrastructure of hydroelectricity. In turn, the electrical industry cannot be dissociated from the manufacturing industries which had grown considerably in Central Canada throughout the 19th century. The shaping of the industrial corridor between Montreal and Windsor is related to the development of the transportation infrastructure, of related capital and entrepreneurship, and also to the vicinity of the United States, which fostered the transfer of American technologies and joint ventures between American and Canadian firms.

The process of electrification was consolidated differently in Ontario and in Québec. The Hydro-Electric Power Commission of Ontario (HEPC) was created in 1906 and in the following decades set up a provincial grid with the purchase of privately-owned utilities established at the turn of the century, and the construction of large-scale hydroelectric installations; from the 1950s, thermal and nuclear plants were added to the system.[2] In Québec, the nationalisation of electricity began in 1944 with the creation of Hydro-Québec and was completed in 1963. Before then, the development of the power network, initiated in the mid-1880s, remained in the hands of private owners. Local and municipal utility companies that contributed to the beginning of electrification were assimilated progressively by two major 'octopuses': the Montreal Light, Heat and Power (MLHP), created in 1901, delivered electric power to the urban market of Montreal and the Shawinigan Water and Power (SWP), founded in 1898, constructed large-scale hydroelectric plants in Shawinigan Falls where the operations were at first concentrated, eventually extending its arms to most Québec regions.[3]

Although the use of electricity for the household was promoted in both provinces during the Depression years, consumer demand for home electrical appliances expanded after the Second World War. The Canadian industry became stronger and remained lively until the mid-1960s, when it was progressively assimilated into multinational corporations. Environmental concerns, new trends in building construction and heritage conservation influenced the design and performances of home electrical appliances from the 1970s.

Using the methodology of material culture studies, this paper was inspired by the collection of electrical stoves, refrigerators and small appliances now conserved in the Canada Science and Technology Museum, and on related documentation.[4] The long tradition in the making of cast-iron stoves which was initiated at Les Forges du Saint-Maurice in the 18th century, and extended to many Canadian foundries in the 19th century, was a major influence in the formation of the electrical appliance industry from the 1920s.[5] If their material composition is closely related to the expansion of the manufacturing industries — particularly in the electrochemical, electro-metallurgical, steel and petrochemical sectors — their style has also been influenced by earlier trends of industrial design. Aesthetic criteria, high performances of the apparatus, health and safety measures were the key words used in the marketing slogans: did it work? To what extent are these electric stoves, domestic refrigerators and small cooking devices important testimonies to the shaping of a culture of consumption in Canada between 1920–90? These are some of the questions we want to address.

MANUFACTURING ELECTRICAL HOUSEHOLD APPLIANCES

Montreal's industrial structure was firmly established from 1850, before the advent of electricity, and grew considerably by the end of the 19th century, owing to its privileged location in the heart of the transportation system. Constant improvements of the harbour installations and of the Lachine Canal encouraged the development of commercial navigation between the St Lawrence and the Great Lakes. The construction of the railway allowed the city to be connected within Québec, with the rest of Canada and with the United States and thus, to become the one of the major hubs of the railway system in North America.[6]

The entrepreneurs who established the transportation system also contributed to the economic diversification of the city with the establishment of major financial institutions, electric utilities companies and related industries such as the making of rolling equipment and the transformation of iron imported from the United States into finished products.[7] In Southern Ontario, the manufacturing industries that had grown from the 1880s, particularly in the Toronto–Hamilton–Windsor corridor, took off during the first two decades of the 20th century as a result of the merging of small regional companies into big consortiums. This part of Central Canada also attracted a high percentage of American-owned factories, some of which created subsidiaries like Canadian General Electric and Canadian Westinghouse which set up their plants in Peterborough in 1892 and in Hamilton in 1897 respectively. The production of electrical devices, paints and chemical materials, rubber goods, automobiles, steel and petroleum refining were the main sectors in 1961.[8] The production and the distribution of electricity have generated a number of related manufacturing industries. For example, in 1927, there were approximately 130 Canadian firms producing electrical apparatus and supplies such as: copper and aluminium wire and cable, telephone material, batteries, radio, vacuum cleaners, electric motors, power plant equipment and lighting devices; those related to cooking and heating were of least importance. Thirty years later, electrical products occupied the 16th rank of the major industrial groups in Canada, with 513 establishments.[9] Electrification was also an incentive to the discovery, production and consumption of a wide variety of materials. From the 1930s, Canadian manufacturers produced wiring devices and electrical parts such as plugs, sockets, adaptors and refractory plates using materials derived from natural sources such as rubber and gutta percha, ceramic composites like porcelain and transformed polymers like bakelite, synthetic rubber and urea plastics.[10] Shawinigan Chemicals, a subsidiary of SWP, produced polyvinyl acetate and, with the establishment of a plastic moulding department in 1929, Canadian General Electric initiated the making of alkyd resins for coating.[11]

The electrochemical process for making aluminium was pioneered in Canada at the beginning of the 20th century by the Northern Aluminium Company (now ALCAN). All-aluminium wires and cables which eventually incorporated a steel alloy were the first products made by the Company for transmission lines. They established a plant for making cooking utensils in Toronto in 1913 to meet the needs of the Canadian soldiers on the Western Front during the First World War. During the 1930s, the Northern Aluminium Company diversified its activities to produce utensils, seals and welded parts in finished aluminium. Stainless steel and nickel alloys became an important part of their production from the mid-1980s.[12]

Initiated in Canada in the 1880s, steel-making was firmly established in Ontario and Nova Scotia by 1900. The Steel Company of Canada (Stelco), incorporated in 1910 at Hamilton benefited from American innovations in steel-making which came directly from the automobile industry. In response to the demands for electrical household goods after 1945, the Company initiated the production of flat-rolled steel sheets, still used in stoves and refrigerator parts.[13]

Electric ranges were already being made by Canadian Westinghouse in 1923-4, and by the Canadian companies McClary and Moffats in 1926.[14] Between 1948 and 1950, the numbers of electric cooking stoves produced rose from 191,735 to 211,102. By 1959, the number had risen to 266,844 but fell to 235,873 the following year. Domestic electric refrigerators appeared on the Canadian market in 1931, with 9,879 being sold, a number that increased to 51,534 in 1939 and reached a peak of 64,093 in 1941. However these figures dropped dramatically to 358 in 1943 and 237 in 1944, owing to the ban imposed in Canada on the production of household refrigerators during the Second World War.

Between 1930 and 1960, the majority of the Canadian manufacturers of electrical appliances were located in Ontario. Many firms — Beach Foundry, Canadian General Electric, Canadian Westinghouse, Frigidaire, Moffats, Findlay — produced both ranges and domestic refrigerators (Figure 1). Some, like Kelvinator of Canada, Leonard and Servel, specialised in the production of refrigerators, while others, such as Beatty Bros., Gurney, Amyot and the Fonderie de l'Islet, made electric ranges. In 1951, a peak of 278,272 domestic refrigeration units were made in Canada; of a total of 57 manufacturers, 42 were located in Ontario, ten in Quebec and five in other provinces. Nevertheless, large-scale companies had branches in major Canadian cities.[15]

Figure 1. Assembly Line at Canadian Westinghouse, c. 1953. National Archives of Canada, PA 187898.

'MON BEAU POÊLE BÉLANGER'

One of the first images of kitchen electrification in the 1920s remains the 'electric breakfast' scene where a small square two-decker stove, a perco-toaster and a hot-plate are placed on the table. The popularity of these devices is probably explained by their multiple functions: to poach eggs, toast bread, make waffles, and provide a heat source. For example, in the 'Hotpoint' table stoves manufactured by Canadian General Electric, each function is assigned a different material: pressed steel and nickel for the broiler plate, aluminium for the cooking utensils, deep pan, egg poacher and griddle, glistening white enamel as a finish for the heat chamber and a cloth cover for the electric cord.[16] The buffet-style electric range available in the Canadian market in the mid-1930s, such as the model released by the Ottawa manufacturer Beach Foundry, may be considered as a transition since it features a combination of old and modern materials. Reminiscent of the old wood and gas stoves, the cast-iron legs blend harmoniously with the pressed enamelled metal shell, the top cover, oven door and the drawer panels in porcelain, and the ceramic handles.[17]

From the 1950s, the growing affluence of the Canadian population, the 'baby boom', and government contributions to research in housing resulted in the expansion of suburban areas and the construction of bungalows: these are some of the factors that increased the consumption of electrical household appliances. In their search for a better quality of life, many Canadians demanded massive, sturdy, efficient and stylish ranges and refrigerators to fill up their huge kitchens, and these also became symbols of their social identity.[18]

In view of this new reality, Canadian Westinghouse launched on the market the model Super Deluxe range reflecting a coordination of engineering, design and manufacturing. The horizontal planes, visible in the two-oven symmetrical composition, in the drawer handles, knobs and the fluorescent platform running all along the top of the range are a significant illustration of the classical modernist style inspired by American designers Norman Bel Geddes and J.M. Little.[19] A combination of pressed-metal finished in white enamel for the housing, aluminium for the oven grids and drawers, the construction retained some features of the 1940s with the round edges and knobs, and the warmer. The use of plastic for the button switches was the result of recent innovations in the Canadian petrochemical industry. However, the location of the control board, the integration of the timers, knobs and signal lights on the right side of the top unit, and the automatic outlets more likely belong to the early 1950s. The corox burners for surface cooking are improvements on the Calrod elements developed by General Electric in 1934.[20]

From the late 1960s, a result of the growing population in many Canadian cities was the massive construction of high rise apartment buildings where the design of the dwellings allowed the function to prevail upon the space. The large kitchens of the 1950s were reduced literally to a cell partly surrounded by modules of counters or cabinets; now they concentrated almost exclusively in food preparation while the food consumption occurred in the dining room. Generally, these two rooms opened into one another to allow socialisation between the hosts and their guests.[21]

Concerns about conservation of the architectural heritage initiated in the 1970s — for instance, in the older parts of Montreal, Québec City and Toronto — and the increasing migration of suburban dwellers to downtown areas were the main motives driving the refurbishment of old buildings.

Very fashionable indeed was the loft-style kitchen where the cooking units and, sometimes, an eating space form an 'island' surrounded by wooden cabinets which may also conceal the stove and the refrigerator.[22] Consequently, Canadian General Electric — among other manufacturers — offered compact electric ranges with a width of 30 inches that became the standard from the 1960s. They were brightened by vivid turquoise or pink colours that subtly matched the cabinets, other appliances and the furniture in adjacent rooms.

Although the Kelvinator company introduced the first domestic refrigerators on the American market in 1918, some of the components — tubes, thermostat, compressor and motor — suffered many deficiencies. In addition to being noisy, the refrigerating and the freezing units were sold in parts at a very exorbitant cost for the average consumers. General Electric released their 'Monitor Top' in 1925 and many innovations in refrigerating units eventually resulted from work done in the company's laboratory.[23] The model manufactured by Canadian General Electric in 1935 was still in use in some homes until recently. The shape recalls a traditional wooden ice box transformed into an enamelled steel cabinet with a hermetically sealed round condenser on top. From the former ice box, the door retains the wooden moulding on the edges, heavy hinges and a rubber gasket, while nickel plated handles and aluminium wire shelving are innovations in the hardware.[24] As the main operating mechanism, the beehive-shaped rotor is used for oil cooling and to maintain a low pressure within the case. This type of compressor resulted from work done at the company's mechanical research laboratory in the early 1930s.[25]

It is likely that the first generation of 'baby boomers' provided sufficient incentive for the production from the mid-1950s of domestic refrigerators even larger than the ranges, since their capacity increased from an average of 6 to 14 cubic feet. With many mouths to feed, food storage required numerous shelves within the welded-steel enamelled cabinet. Polymers and metal alloys were used to lighten the weight of the unit. For instance the refrigerator offered by Canadian manufacturer Leonard in 1957 has polystyrene for trims, fittings and freezer; fibre glass as insulation; a balloon-shaped rubber ribbon door seal and aluminium hinges[26] although the exterior recalls the Sears Coldspot model designed by Raymond Lowry in the 1930s.[27] More imposing still is the 14 cubic feet model made by the Moffat Company with two vertical doors, the left one being the freezer compartment. Adjustable metal shelves, temperature control for the meat compartment, and the self-defrost freezer are the major innovations while the variety of the colour palette — beige, copper, avocado green — also available for the ranges, harmonised the appearance of the kitchen.[28] One may suggest that the bulky design of the refrigerators made by Leonard and Moffat was also influenced by the automobile industry.

'You Wished, You Dreamed'

First exhibited in 1893 at the Columbian World's Fair in Chicago, the electric kitchen became, in the following decades, an important marketing tool for home electrification. Sir Adam Beck, the first Chairman of HEPC, gave public demonstrations of electrically powered farming and household appliances placed aboard a vehicle — the famous Beck Circus — that circulated in the Ontario countryside between 1910–20. A similar incentive led the SWP to set up a 'cuisine électrique ambulante' within a caravan travelling in Québec's rural areas during the 1930s (Figure 2).[29] Demonstrations at provincial trade shows, for instance in Québec City and in Toronto, and show rooms and windows of utility companies such as MLHP emphasised the qualities of the electrical appliances for sale.

To make available 'power for the people', HEPC launched promotion campaigns, in 1936 and 1937, to increase the number of electric ranges in the municipalities linked to their supply system. For this purpose, HEPC worked jointly with the municipal authorities to ensure adequate domestic wiring, and organised displays of ranges; it also distributed brochures and subsidised sales of ranges and wiring costs. At the Canadian National Exhibition grounds in Toronto, manufacturers of electric ranges and refrigerators sponsored cooking classes given by nutritionists; apparently they attracted about 40,000 participants.[30]

Publicity in trade catalogues stressed the importance of easy-cleaning devices: General Electric's ranges were meant to be free of fumes, gases and smoke and did not have any damaging effects on the walls and furniture; Benjamin's table stove and hot plate were 'non-arcing, non-sticking and easily cleaned'. When invited by General Electric to co-operate in designing the 'Monitor Top' refrigerator, Norman Bel Geddes refused for he found it too difficult to clean.[31] Perhaps this preoccupation for cleanliness had its roots in the poor hygienic conditions in housing as a result of industrialisation; it may also have been influenced by Le Corbusier's recommendations to

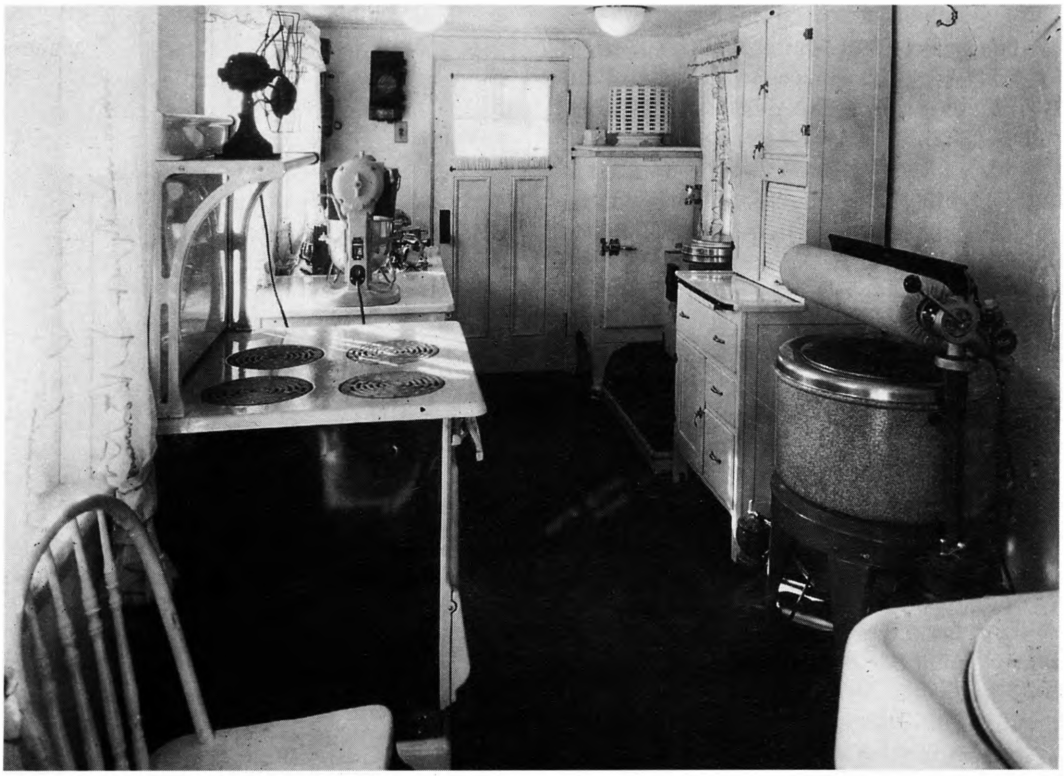

Figure 2. 'Cuisine ambulante' in Québec, c. *1933. Centre d'archives Hydro-Québec, Fonds Shawinigan Water and Power F1/700 864, #A-20.*

architects to 'put the kitchen at the top of the house to avoid smells'.[32]

Electric ranges were considered more economical to use, more reliable than highly waged servants and less of a burden for the housewife. Highly praised in wedding list publicity, the table stove and the perco-toaster allowed the hostess to enjoy the company of her family and guests at the table since they did not demand extensive culinary skills.[33] Advertisements also emphasised the 'joy of cooking' with an electric range for a better preservation of food values, and the prevention of bacteria; explosion or toxic fumes could result from the use of coal or gas ranges. For similar reasons, the electrical refrigerator was preferable to the ice box for conserving food properly.[34]

Health and safety measures became important in the design of the refrigerating units made by General Electric in the mid-1950s: the magnetic door catch allowed the opening of the door from the inside as well as from the outside and so prevented, for example, a child being locked inside. The door in the refrigerator made by the Leonard Company had a rubber ribbon seal to maintain the efficiency of the preset temperature and reduce the waste of energy.[35]

An advertisement of the International Harvester Company in the early 1950s used words appealing to women's dreams: literally compared to a gem, the refrigerator has 'sparkling gold interior trim, a jewelled shadowing and a colour-keyed door handle; for all those qualities, it is "femineered from top to bottom"'.[36] Commercial catalogues of the 1920s and the 1930s indicated that the stove or the refrigerator were 'as important as your husband'. Interior design magazines of the 1970s in Québec emphasised the renovation of a kitchen as the fulfilment of women's wishes: 'Ce que femme veut, [votre manufacturier] le peut.'[37] These marketing messages hinted at the influence of housewives in the purchase of appliances. However, from a quantitative point of view, it is difficult to determine if they were the main group of consumers. Canadian statistics follow a specific methodology that does not indicate either the percentage or the gender of appliance buyers. In view of the fragmentary data, we will provide only a few examples.[38]

The production of small cooking devices nearly doubled between 1926 and 1927 and it seems that they remained part of the kitchen equipment during the next two decades. From a survey conducted in 1948, there were 623,000 Canadian homes using electrical cooking devices, of which 42,000 were hot plates.[39] This suggests that the devices, once luxury goods for upper-class families, became objects of necessity for the less fortunate ones. A similar survey conducted in 30,000 Canadian households in 1953 estimated that of the 1,261 electric stoves being part of the cooking equipment, 696 were used in Ontario and 210 in Québec. 35,000 households were surveyed in May 1961, and the number of electric stoves had increased to 2,612 with 1,162 units being used in Québec and 1,601 in Ontario.[40]

By comparison, although they were manufactured in Canada from the early 1920s, electric refrigerators were only slowly adopted for domestic purposes. It seems that 496,000 refrigerators were found in Canadian homes before 1940. In 1948, only 29% of the Canadian households had a mechanical refrigerator. In 1953, 68% of Québec homes had an electric refrigerator, a number that increased to 94% in 1960; during the same period, Ontario households owning a refrigerator increased from 80.7% to 96.1%.[41]

Recent studies on gender roles have analysed publicity as a means of identifying women's concerns in the acquisition and use of electrical appliances in Ontario in the 1950s. In summary, these related to the authenticity of the advertisement and the need for adequate information on the qualities and functions of the apparatus.[42] Nevertheless, commercial literature did not always target women as potential consumers of electrical appliances. In a brochure about their Super De Luxe electric range, Canadian Westinghouse welcomed the 'ever-widening circle of homemakers who enjoy cooking'.[43] When advertising their Multi-function mixer produced in 1993, Kitchen-Aid Canada indicated that 'models are available for every consumer'. The attachments — sausage stuffer, pasta maker, vegetable slicers — used in the food preparation indicate the diversity of the consumer groups now part of the Canadian population. The mixer became a crossroad symbol integrating the influence of the various cultural communities in today's diets and eating customs with their preoccupation for hygiene and the aesthetic presentation of the food.[44]

Conclusion

This study has demonstrated that the electrification process that took off in Canada in the 1920s was, at first, more beneficial to industrial consumers. Companies like Canadian General Electric and Canadian Westinghouse quickly diversified their products by adding household devices to, for example, generating equipment. They were soon followed by numerous Canadian firms that took inspiration from American technologies to specialise in the fabrication of stoves and domestic refrigerators, and maintained a successful national industry until the mid-1960s.

The electrical appliances industry provides a good example of the evolution of the 'grappes industrielles'. Companies set up laboratories where scientists worked on new technologies and materials to enhance the quality and the performance of the devices. In order to make the appliances appealing for the consumers, industrial designers contributed to the creation of fashionable styles that aimed to harmonise the kitchen to the home decor. As a result, other industrial sectors — aluminium, plastics, steel, and metal alloys — sprang from these works, with new materials for the housing, the structures, the wiring, the lighting and other parts of the appliances, and for improving their function and performance.

Although electric ranges and refrigerators were available on the market and highly promoted from the 1930s, the major consumer 'boom' occurred after the Second World War, but more so in the 1950s, with the development of Canadian suburban areas, the increase of affluent families and the search for higher living standards. The marketing strategies, which seem at first to have targeted women, became eventually directed to various consumer groups.

Among the issues that could be explored in further investigations, are, first, the interaction between manufacturers, particularly their work on the materials used in the making of the appliances. A study of the research undertaken in corporate laboratories would certainly reveal more data on the 'life-cycle' of the materials, for example measures taken to prevent metal fatigue. One may wonder if the new directions in plastics manufacture will allow it to replace traditional materials like sheathed metal. The impact of new technologies either in the design of appliances, or in food conservation and preparation, would be well worth exploring.[45] Secondly, concerns affecting consumer patterns deserve to be explored, such as motivations behind the acquisition of kitchen appliances, frequency of acquisition, levels of performance sought and the use of 'energy-saving' devices.

Nowadays, old models of stoves and refrigerators have become collectibles, not only for museums curators, but also for consumers seeking 'old designs and technologies' for their home or work environment. It is 'cool' to have a 'Monitor Top' in a movie set-up or as a piece of furniture in a flower shop, while a Super Deluxe Westinghouse range can easily decorate a yuppie's loft with a 1950s design. As a matter of fact, the appliances have become as important in our today's consumer society as were the steam engine in the industrial revolution, the discovery of petroleum or even the invention of electricity itself. With this perspective in mind, kitchen appliances deserve to be studied not only as consumer goods or aesthetical conversation pieces, but also as industrial objects whose creation is the result of a series of manufacturing processes. Indeed, the topic certainly offers a privileged field of investigation in industrial archaeology.

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TICCIH2000 delegates visited the Kew Bridge Steam Museum and saw this 90-inch cylinder Cornish beam pumping engine in operation. This engine was manufactured by Sandys, Carne and Vivian of Hayle, Cornwall for the Grand Junction Water Works Company at Kew in 1846. It is one of several engines under the care of the Kew Bridge Engines Trust at their Museum of Water in west London. Photograph by Dick Fillery, supplied by John Porter, © Kew Bridge Engines Trust.

THE ASSOCIATION FOR INDUSTRIAL ARCHAEOLOGY (AIA)

AIA is the national forum for industrial archaeology and industrial heritage in Great Britain. A volunteer organisation, it provides seminars, conferences and field visits for its members; supports local groups; makes annual awards for field recording and the conservation of industrial sites; and publishes a quarterly newsletter, *IANews*.

AIA defines industrial archaeology as a period study embracing the tangible evidence of social, economic and technological development in the period since industrialisation, generally from the early 18th century onwards. Its house journal, *Industrial Archaeology Review*, is published twice a year. The focal point and common theme of its contents is the surviving evidence of industrial activity. Emphasis is placed on the practical aspects of a subject in which fieldwork plays an essential part, including recording, surveying, excavation, interpretation, conservation and protective legislation. While deriving most of its material from within the British Isles, the journal aims to be international in its coverage of the subject, presenting material of relevance and value to those concerned with industrial archaeology throughout the world.

For details of membership and subscriptions, contact the AIA Liaison Officer, School of Archaeology and Ancient History, The University, Leicester LE1 7RH. Email: AIA@le.ac.uk. Visit our web site at http://www.industrial-archaeology.org.uk

ENGLISH HERITAGE

English Heritage is an independent body sponsored by the Department for Culture, Media and Sport. It is the government's principal advisor on all matters relating to the historic environment in England and its aim is to increase the understanding, awareness and protection of the country's architectural and archaeological heritage for the benefit and enjoyment of present and future generations. With over 400 of England's important historic houses and monuments in its care and open to the public, it develops and promotes specialist technical and scientific skills and advises local authorities and others on conservation issues. It gives millions of pounds in grants each year for, amongst other activities, archaeological projects, cathedrals and churches, repairs to historic buildings and decaying inner cities. It is also heavily involved in education, promoting, through direct contact and by publication, the study of the heritage at school, college and post-graduate levels.

English Heritage is particularly concerned with the conservation of the nation's industrial heritage and believes that full evaluation and understanding of what survives (and what has gone) is a prerequisite for sound management of the resource. English Heritage and the Royal Commission on the Historical Monuments of England, which merged with English Heritage in 1999, have long fostered research on industrial archaeology and have an impressive track-record of industrial publications stretching back more than two decades. During that period both bodies have maintained a close relationship with the Association for Industrial Archaeology and indeed have collaborated with the Association in the past to publish numerous articles on their industrial work including a thematic issue of *Industrial Archaeology Review* devoted to textiles mills.

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