Hick Hargreaves & Co.: The History of an Engineering Firm c.1833-1939. A Study with Special Reference to Technological Change and Markets.

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Abstract

Philip William Pilling. Hick Hargreaves & Co.: The History of an Engineering Firm c.1833-1939. A Study with Special Reference to Technological Change and Markets.

A case study of an engineering enterprise dating from the early-Victorian period might place in perspective arguments concerned with British economic performance by examining the performance of entrepreneurs in a long-standing family business. If the response of industrialists to a changing market environment accounts for Britain's inability to retain her industrial leadership, an enterprise representative of the engineering industry would exhibit those features associated with entrepreneurial failure: a laggardly response to the productivity gains offered by innovatory techniques; an indifference to the possibilities offered by standardised production; a reluctance to adopt new products and develop new markets.

Throughout the life of Hick Hargreaves, the decision-takers - who evolved from the founding entrepreneur to the directors of a private company - were alert to the profitability of the enterprise and ensured that its competitiveness was upheld. In the early years of the enterprise engineering expertise and excellence of build rewarded the business, allowing a wide range of products to be turned out. When prices subsequently reflected the growth in suppliers this underscored the attractions posed by specialisation, which stressed the technical aspects of the business.

By the close of the 19th century, the price of the chosen speciality mattered just as much as the fit and finish of the product, as the international market for industrial power lay in the hands of several domestic suppliers. The financing of a costly capital programme to enhance the firm's position in the market was achieved internally, although it depended upon the support of the firm's bank. No weakness of entrepreneurship was evident at Hick Hargreaves at the time when entrepreneurial weakness is alleged to lie at the heart of the shortcomings in British industry. A business strategy appropriate to the time was arrived at and successfully carried through.

Less reassuring was the response of the directors after 1918, when the market was experiencing fundamental changes that undermined traditional certainties. Then the firm persisted with the marketing of accustomed products and developed a technically efficient successor for a waning market in industrial power. The adoption of completely new products was forced upon the company in the depths of the Slump. But even in the period between the wars there was an over-riding desire on the part of the directors to ensure the firm's survival.

The purpose behind the study of Hick Hargreaves was to illustrate the entrepreneurial performance of those guiding the firm. The results reveal that the decision-takers did not shrink from the challenge of business at any point. As an engine of reward, the organisation of the business demanded and received the attention of entrepreneurs, who were rarely complacent about the rate of return on capital and strove to realise the opportunity for profit.

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Contents

Statistical Appendices:

Preface

It would be correct to say that this study was inspired by Professor Saul's examination of the British engineering industry. This industry was a product of the Industrial Revolution, with a role that was fundamental to the structure of the British economy and the growth of national product throughout the 19th century. Yet the evidence available on engineering concerns themselves appeared limited. The faltering performance of the economy evident after 1870 also seemed to be bound up with an industrial structure that continued to be dominated by the staple trades well into the 20th century. In the interwar period the engineering trades accounted for 6 per cent of manufacturing output and 9 per cent of employment, while the marked contribution of this old industry to the rapid rise in industrial productivity between 1920 and 1924 apparently stemmed from an attention to efficient production that was a legacy of wartime experience. Saul was unhappy with those explanations of Britain's industrial performance that advanced generalisations in the absence of specific secondary evidence drawn from industry. Saul himself sought to provide a remedy by throwing light on the several engineering trades and the technology that they employed within the distinctive setting of their markets.

The environment in which the engineering firm operated was crucial, Saul contended, to an understanding of performance and the circumstances that shaped the response of entrepreneurs to such developments as the advent of specialised machine tools that extended the opportunity for standardised manufacture. Indeed, Saul referred to Hick Hargreaves of Bolton as a builder of standardised stationary engines from the 1860s and it was evident from other sources that the origins of this firm lay with the appearance of a mechanised cotton industry.

The likelihood that Hick Hargreaves might offer the opportunity of writing a case-history or business biography appeared strong, because the company enjoyed an unbroken sequence of production on the original site. An approach to the firm eventually met with an encouraging response from Electrical & Industrial Securities Ltd., the holding company. At the outset the chairman of FIS attempted to establish whether the remaining historical data at the firm merited the attention of an economic historian. Circumstances prevented the chairman from searching the firm and I was invited to 'start from scratch'. In the meantime, I had agreed to list certain records held at the Public Record Office and a year elapsed before I was able to begin a search of the firm's premises. At that time a large collection of business records was stored in the basement of a branch library, pending their removal to the damp free environment of the central library. These records had been relinquished by Hick Hargreaves and preserved through the efforts of a local industrial history society. I elected to include these papers in my search, because they had originated from the firm. However, the large quantity of material and the haphazard manner in which it was stored discouraged a thorough search, while the limited time I had available encouraged a selective search of several piles of records. Nevertheless, the limited inventory of the Hick Hargreaves collection stored at the branch library was to prove of value some years later, when the time came for the documents to be removed to the central library.

Access to the records at the temporary depository helped to crystalise ideas on the shape of the study. I had explained in detail to the firm that I wished to examine the technology of engineering, namely the methods of production employed over time in producing those products for which Hick Hargreaves became renowned. I wished to

discover whether there were any enduring trends in production methods that a subsequent generation of entrepreneurs had expressed through major capital projects. Mention of the entrepreneurs behind the enterprise raised the question of the ownership and control of the firm. Over what length of time had the firm remained a family business and at what point, if at all, had anonymous managerial expertise taken the place of family direction of the business. I also wished to explore the markets in which the firm had operated, the extent to which the firm's products ranged and how the decline of traditional markets found a response in the direction of the company.

The essence of the study as originally envisaged involved three complementary areas of study: technology; markets and entrepreneurship. I did not envisage that the case study should become a social history by embracing labour relations within the firm. This is not to deny the relevance of labour to an understanding of an engineering enterprise, particularly one which participated in the two major engineering disputes of the 19th century. Notwithstanding the importance of labour as a subject pertinent to a business biography, I excluded labour from the areas I intended to examine because I doubted - rightly as it turned out - that this aspect of micro-economic history would be adequately reflected in the available company papers. Indeed, the only documents relevant to disputes that came to hand (from the office of the Managing Director) were copies of the firm's notice to workmen at the time of the 1852 lockout and a memorandum sent to all engineering employers in Bolton at the time of a local dispute in 1887. I freely admit that this protracted dispute offered an opportunity for examining the traditional basis of relations between masters and men, and the causes of a local stoppage in an industry where craft attitudes and policies were deeply rooted. However, given the paucity of material on labour relations

within the firm by comparison with the great weight of records relating to the other aspects of the business, I concluded that labour management did not constitute a practical line of enquiry. Had the search for records yielded the opportunity for understanding relations between masters and men at Hick Hargreaves, labour management would have become an appropriate theme to explore.

If labour was a dark area the same could not be said of the firm's products and markets, as the random search of the documents in the branch library quickly revealed. It was understandable why the company had regarded as valueless the material found heaped together on the library floor. Here lay numerous Copy Books that spanned the years 1892-1920 and which listed alphabetically the firm's customers and contained sketches of the work undertaken for them. A number of sacks held bundles of drawing sheets that dated from the eve of the Great War, presenting in detail the component parts of mill engines built by the firm and the arrangements of complete steam-engine installations. Supported by a library book trolley lay a pile of large paper drawings on linen, a number of which dated from the 1850s. They were not the earliest drawings to have survived, because there were plans of the manufactures of Benjamin Hick, Engineer, Bolton, dating from the 1840s. At the time of the random search many of the early large drawings, lying in piles upon the floor, were so badly ravaged by damp as to be unrecognisable. But one untitled drawing was a plan of Hick & Son's twelve exhibits at the Great Exhibition that included 'Hicks Improved Mandrills'.

The titles of the drawings and sketches reflected the nature of the work undertaken by a firm of engineers, millwrights and boilermakers, whose specialisms were derived from the power needs of industry. A striking feature of the jobs undertaken by Hick Hargreaves was the work

attributable to the requirements of overseas customers. The foreign business of the enterprise appeared to have developed within a short time of the firm's foundation in 1833. Although the evidence offered by the titles was impressionistic it pointed to the importance of world markets to the success of the undertaking for over a century. At various times markets in Europe, Asia and South America stimulated power engineering in Bolton, but the most remarkable foreign market for the firm's machinery was that in Spain. For over half a century engineering enterprise in Bolton was promoting the development of the Andalucian economy by supplying the technology of steam and iron. The titles found in the branch library revealed that in the mid-19th century Benjamin Hick & Son designed and manufactured the engines and millgearing required of mills and ironworks built in the 'English Style' by Spanish entrepreneurs. Entrepreneurial activity in southern Spain afforded Hick & Son with one of its first export markets and this connection with an export market was treated in Chapter 3, based on some of the earliest surviving letters of the firm.

At the outset, however, it was necessary to place an enterprise in engineering within the setting of an early industrial town and discuss the profitable opportunities that moved Benjamin Hick to trade on his own account. Equipped with a checklist of the ideal business records upon which to base a business biography, I searched the recesses of the company and approached the staff for the records of Hick & Son. Chapters 1 and 2 were partly based on the surviving business letters, but new source material came to hand some time after the search was completed, when a start had already been made to give shape to the case study. The collection of letters directed to the firm in the initial years 1833-34 are a case in point, and the same is true of the old deeds and documents relating to the lands upon which Benjamin Hick erected his

ironworks. These papers arrived from the London office of the parent company and comprised the indentures drawn up at the time that the partnership of Hick and Hargreaves was evolving in the late 1840s, revealing in detail the lands and fixtures of the partnership at the Soho Foundry and the values placed upon the business. The financial structure of the partnership considered in Chapter 4 was the outcome of my search of the indentures.

The search for source material at Hick Hargreaves began in the brick and stone basement of the Victorian premises and continued through the upper storeys of the firm's offices. The search also extended to the middle floor of a brick building lying across the works yard, where redundant material was thought to be stored. Here, arranged in the boxes of some heavy deal shelving, were a number of large taps and dies, while two sets of governor weights lay on the floor. A number of discarded files, desks and chairs had been deposited in the storage room, as had some office equipment and the 'Surgery' weighing machine. At the back of the room stood several cupboards, with piles of office papers lying against them. One cabinet was marked 'Not To Be Emptied' and contained numerous envelopes that held Indicator Cards recording the behaviour of steam in engine cylinders. In another cabinet lay half a dozen photograph albums, including 'Sundry Plates' of Hick Hargreaves dating from the turn of the century. Amongst the plates were photographs of newly built textile mills in India, where the firm's power plant had been installed. A find such as this on a wet Friday in November was a uniquely memorable event that distinguished the search for records.

A day typical of most throughout the search witnessed the painstaking examination of those records that had accumulated in the many recesses of the office premises. After a short time a footstool

and boiler suit became as indispensable as a clipboard and a pencil for enumerating the records. A search of the basement yielded a number of framed photographs of the firm's steam engines and the contents of a metal cabinet which included the correspondence files of the company for the interwar period. Amongst the papers on file were the memoranda of the Managing Director. These and other papers permitted the firm's experience of the 1920s and '30s to be studied in detail. Other documents retained in the cabinet, of value to an understanding of the direction of the private company, were the inventories and valuations of the ironworks compiled in 1900 and 1920. The inventory for 1900, together with a valuation dated 1890, proved useful following an examination of the Minutes of the Board of Directors from 1892. These minutes - made available through the company secretary - revealed that the private company had embarked on a remodelling of productive capacity soon after incorporation. Indeed, the incorporation of the firm was a necessary change in the legal basis of the enterprise, if the later generation of proprietors were to secure the improvements to capacity. Chapters 6 and 7 attempted to place the firm's incorporation and subsequent remodelling in the context of the commercial strategy or outlook of the sons of William Hargreaves, who directed the firm after the death of the sole proprietor in 1889.

As the search progressed and the inventory of the company's papers took shape, the chronological basis of the study and the lines of enquiry envisaged at the outset assumed a definite form. One topic fundamental to an understanding of the entrepreneurial decisions reached at the firm was the earnings performance of the business. No records had survived that disclosed how the enterprise had been financed in the 1830s and I was compelled to rely on the assumption that the accumulated savings of Benjamin Hick, derived from his participation in a separate

engineering partnership, had provided the capital for his venture. The second generation of proprietors could be expected to be particularly attentive to profit and interest on capital, as their expertise and ability had been introduced into the enterprise by means of ownership. The terms of Benjamin Hick's will ensured that even his eldest son had to acquire a capital holding in the firm, because the partnership system was synonymous with the assiduous management of business. In Chapters 6 and 7 the importance of profit to the financing of the firm and the financial performance of the firm itself were considered from two financial statements derived from the firm's books of account that were no longer in existence. By courtesy of the company secretary, I received a statement of 'Particulars of Profit & Loss Account' for the period 1869-1891 and an untitled financial statement of the incorporated firm for the period 1892-1920. The values in this document bore interesting comparison with those values presented annually to the shareholders and preserved in the Minutes of the Board of Directors. The directors of Hick Hargreaves, who had so recently been proprietors of a family business, felt ill at ease in their new role as shareholders' managers and Chapter 7 also attempted to reveal the lengths they were prepared to go in order to conceal the self-financing of fixed-capital investment. At a time when the company's earnings did not allow both retentions and dividends, the directors felt compelled to maintain secret capital funds and pass doctored accounts before shareholders.

At the close of the 20th century, it is apparent that enterprise in engineering, initiated in response to innovations in cotton textiles, has declined to a shadow of the industry's former self. In the interwar decades, the long-standing firms of engine-builders already gave the appearance of a relict industry, whose future lay as a source of

resources for new growth sectors rather than as a focus for further investment and reward. The Lancashire cotton industry had stimulated the transformation of millwrighting from a craft into a mechanised industry and the formation of such engineering firms as John Musgrave & Sons, George Saxon and Scott & Hodgson. The Manchester firm of W. & J. Galloway began as a millwrighting partnership in 1790 and at Knott Mill the enterprise developed into a major supplier of stationary engines and boilers from the 1840s. Galloway and the above mentioned mill-engine builders had gone into liquidation by the early 1930s; their patterns, drawings and goodwill purchased by Hick Hargreaves. The Soho Foundry survived the difficult interwar years largely through a combination of retrenchment and good fortune. A forceful Managing Director, appointed shortly after the Great War and drawn from outside the family circle, ensured that the business was run as economically as possible in response to a difficult trading environment. The importance of new product lines was recognised in the early Thirties, but strong demand for an existing product line, developed after the Great War, pulled the company through the slump.

A readiness to adapt in response to changing demands has proved crucial to Hick Hargreaves continued trading in the postwar period. In the Second World War new machinery was purchased and the works layout modified as the company planned to meet the needs of peacetime. At the close of the 1950s, the firm was organised to supply plant for central power stations. A decade later, Hick Hargreaves was a notable supplier of vacuum equipment to the chemical and petrochemical industries. Today, Hick Hargreaves are manufacturers of vacuum and pressure producing equipment that enjoy a wide range of industrial applications from alcohol distillation to yeast concentration. Both the site and the work force may have shrunk over recent years, with other enterprises

occupying new structures and the subdivided spaces of old shops and bays, but Hick Hargreaves are still providing employment, generating incomes and refuting the belief that engineering has no role to fulfil in the post-industrial society. The scale of operations at the Soho Foundry may have diminished, but one cannot overlook that this enterprise is still trading and by responding as it has to present-day circumstances has allowed smaller enterprises to settle within Bolton, offering opportunities for a new generation of entrepreneurs to seize. The parallels with the past are unmistakeable.

It is impossible to know whether Peter Rothwell, a timber merchant, ever comprehended the significance of his venture in iron founding at the close of the 18th century. Out of his enterprises in iron emerged Benjamin Hick's Soho Foundry, John Musgrave's Globe Ironworks and the firm of Dobson & Barlow. At the close of the 19th century Bolton was the site for several other substantial engineering firms, such as the works of John and Edward Wood and the Ryder family. The town's earliest engineering establishment, the Wharf Foundry, set up in the 1790s below the parish church in anticipation of the canal to Manchester, also flourished to the eve of the Great War. Few of these engineers, millwrights and boilermakers survived into the 20th century, but Hick Hargreaves was one that did.

The Soho Foundry entered the interwar period firmly committed to such traditional 'specialities' as Corliss mill engines, millgearing and boiler plant and was forced to find success with condensing plant and auxiliaries for power stations. What had been good for the Victorian economy proved profitless in a later period. Benjamin Hick and his contemporary entrepreneurs survived the perils and grasped the opportunities presented by Britain's industrialisation. This is a study

of Benjamin Hick & Son's Soho Foundry. It will attempt to provide an insight into the makeup of an engineering enterprise and address those questions that determine a judgement of a firm's performance: its flexibility to changing technology both in methods of manufacture and final products, and the entrepreneurship or response of those directing the firm in the chosen market. Just how efficient was this Victorian firm in satisfying the demands of its customers? How wide were its activities in mechanical engineering, that most heterogeneous of industries? Did Hick & Son, or Hick Hargreaves as it became known from 1868, possess some advantage over its rivals in the 'specialities' it adopted? Did the later generation of proprietors match the vigour of the early Masters? Is there proof that the second or third generation of entrepreneurs were alive to the wider challenge of the era in which they performed? By addressing these questions a judgement may be possible on a business that flourished in the 19th century and survived into the 20th by adapting itself out of traditional markets and into new areas of profit. Hick Hargreaves still occupy the original site chosen by Benjamin Hick and have maintained a continuity of production extending through four generations over a century and a half. It is in those four generations of skilled labour and managerial expertise that the reason for Hick Hargreaves continuity lies.

Chapter 1 Introduction

Engineering in Bolton and district before 1833

I

It is convenient to date Bolton's recent history from 1792 when an improvement Act was passed enclosing Bolton Moor and authorising the election of governing Trustees. The year before there had been another tangible sign of change with Parliamentary approval for the Manchester, Bolton and Bury canal.[1] Both events marked a breaking down of the town's dismal isolation. The canal in particular conferred 'considerable advantage' to Bolton, because it allowed a 'large proportion' of Bolton's cotton fabrics to be sold to Manchester merchants.[2] Nevertheless, Bolton's depressing aspect does not appear to have barred it from achievement. 'The barreness of its situation', Aikin remarked, 'has probably aided its progress in wealth and population by operating as a stimulus to the industry and ingenuity of the people'.[3] Another stimulus to industry and ingenuity appeared in Bolton at this time, through the use of steam engines in cotton spinning. Not long before, in 1780, Samuel Crompton's 'rare invention', the spinning mule, had been made public, with the result that the Hall i' th' Wood wheel was quickly adopted for fine spinning 'throughout the manufacturing districts' of Britain.[4] Crompton's invention coincided with the appearance of small-scale spinning factories in Bolton, while the excellent yarn produced by the mule influenced the decision to set aside Arkwright's patents and throw open his machinery rights to the public. For many years Arkwright had successfully resisted the agitation of Manchester textile merchants and manufacturers to end his monopoly of water-frame manufacture and its use for spinning cotton

yarn. From 1785 this factory machine was available for the 'free and general use' of all. The overthrow of first the technological and then the legal limitations to the increased output of an all-cotton cloth, led to a 'new system of production', one based on 'large-scale factory industry'.[5]

At the start of the nineteenth century Bolton was 'noted for its medicinal waters, but more for being the staple of divers sorts of fustians'.[6] Baines, two decades later, had a firm impression of the town:

> Bolton has grown into great importance within the last 50 years and in its degree keeps pace with Manchester. A variety of causes have combined to produce this effect but the two principal ones are its vicinity to the metropolis of the cotton trade and the abundant supply of excellent coal with which it is surrounded.[7]

Bolton already possessed a long history as a textile centre before the appearance of the new cotton manufacture at the close of the eighteenth century. Baines wrote of the appointment of an aulneger 'as early as the reign of Richard I' and that 'it is probable that the woollen cloth trade existed here as early as the 12th century'.[8] Thomas Fuller, the seventeenth century clergyman and antiquarian, believed 'that in 1337 the Flemish clothiers settled in this place, and brought over their craft intending to make their fortunes'. Leland, in his Itinerary of 1558, wrote: 'Bolton-upon-Moor standeth most by cotton and coarse yarn'. French refugees were attracted to Bolton's woollen trade following the Revocation of the Edict of Nantes and there was a further accession of people from the Palatinate of the Rhine during the reign of Queen Anne. They, according to one local historian, were 'remarkably clever for bleaching the goods manufactured in this part'.[9]

2

Three centuries after Leland's Itinerary, at the height of Britain's industrialisation, Bolton had grown into a 'great seat of the cotton trade', the site of numerous mills, finishing works and engineering establishments.[10] Cotton manufacturers turned out 'counterpanes, quilting and toilet cloths, on a large scale', and their output also embraced shoe linings, dimities, and sewing cotton, as well as sail cloth, canvas and bed sacking. The influence of the European immigrants on the town's cotton trade is shown by the French and Flemish origin of some of these terms.

In addition to the cotton mills, Bolton also had 'iron and brass foundries, machine works, glass works, saw mills, bleaching and dye works, tanneries, distilleries, brick and tile works etc'. In 1861 it was noted that: 'Among the machine works, are the celebrated establishments of Benjamin Hick and Son, Rothwell & Co., John Musgrave and Sons, and Messrs Dobson & Barlow'. Bolton's engineering activities grew out of the town's importance as a seat of cotton. In 1814-15 Bolton had four iron foundries and five machine works, while a decade later Baines enumerated ten iron and brass foundries and nine machine makers.[11] Dobson and Barlow, the textile machinery makers, provide an obvious example of engineering growth stimulated by the cotton industry. Founded in 1790 as Dobson and Rothwell this partnership produced its first spinning-jenny in 1796 and was employing eleven men a year later. For some time Dobson's few lathes, drilling machinery and other plant were driven by a horse gin. By 1908 Dobson & Barlow was giving employment to 4,000 people and ultimately extended over three extensive works, becoming one of several British firms that made up the textile engineering trade, an 'overwhelmingly dominant force in world trade'. What is significant is the close social and business ties that bound the early entrepreneurs together. Benjamin Hick was a partner in Rothwell & Co. before trading on his own account from 1833. Peter Rothwell, the

founder of Rothwell's Union Foundry, was also Isaac Dobson's partner. John Musgrave, who arrived from Yorkshire in 1805 to become the foundryman for Rothwell & Co., was later a manager for Hick & Son before buying the Globe Ironworks, with his son Joseph, in 1839 and establishing John Musgrave & Son. Musgrave, like Hick, lived in Blackhorse Street, during his association with the Union Foundry, which was established in Blackhorse Street, along with Dobson & Rothwell, machine makers.[12] Rothwell, Hick and Dobson shared the same society, met entrepreneurs from other trades, who shared a common outlook and promoted the same ideas.

II

Before the improvement Act of 1792 Bolton was 'truly and literally in the Moors, being merely surrounded by wet, sterile and gloomy wastes of barren land'. Except for the market day the town 'must have been comparatively speaking a dull and dreary place'. But it was growing. Aikin estimated Bolton's population at little more than 5,300 in 1773 and this had more than doubled to 11,739 by 1789. Aikin, writing after the enclosure of the moor, wrote of the building of houses 'in the skirts of the town'. He also noted that: 'Fustians were manufactured about Bolton, Leigh, and the places adjacent' from the middle of the seventeenth century, with Bolton the 'principal market for them'. The concentration of fustian manufacturers in Bolton was, by 1772, far greater than at any other place around Manchester. Aikin also remarks that among the Manchester chapmen who bought the cloth Humphrey Cheetham was the 'principal buyer at Bolton'. Cheetham was more than simply a merchant 'engaged in the Manchester trade', dealing 'chiefly in Fustians purchased in the Bolton market'. Cheetham was a manufacturer, who employed people over an extensive area in spinning, weaving and finishing cloth. He provided materials and credit to nominally

independent producers who were dependent on him for the provision of raw materials and disposal of the product. According to one local historian 'Humphrey Cheetham, and Bros., had warehouses and works in Bolton and its neighbourhood'.[13] This suggests that from an early date the cottage-based textile producer was not a completely free manufacturer, though it remained possible to acquire materials and credit from 'foreign' dealers at the market place, and sell finished goods to wandering dealers. With capitalists such as Humphrey Cheetham active in the seventeenth century, it is possible to question the existence of 'semi-independent producers in the rising cotton industry'. Daniels doubted 'whether they should be regarded as the typical workpeople'.

With the appearance of the spinning-jenny from the 1760s the 'giving out of work' by Manchester chapmen in Bolton and other markets continued, with the weaver 'made responsible for the spinning as well as for the weaving'. At first technological change reinforced existing connections between merchant capitalist and workpeople. Daniels concluded

> that even if it be true that before the first part of the eighteenth century the greater proportion of fustian weavers were semi-independent producers, who themselves bought their raw materials, and sold their product to traders, by the middle of the century they were certainly the workpeople of capitalist employers, as probably many of them were long before that time.

Fustian manufacturers in Manchester became prominent in the first half of the seventeenth century, but in 1772 the country manufacturers 'formed an outer semi-circle of Manchester, with three outstanding points at Leigh, Bolton and Oldham'.[14] Bolton was by far the most important of these centres, possessing almost a third of the total

number of fustian producers. According to Whittle, the town's 'cotton business was introduced here about 1756, by Mr. Jeremiah Clarke', providing the cotton weft for the Irish, Hamburg or Bremen linen-yarn-warp of fustian cloth. In 1782, Samuel Oldknow 'commenced at Anderton the manufacture of British muslins' at the same time as Arkwright's cotton 'yarn, and other roller-drawn yarns, were becoming plentiful'. As late as 1773 immigrant weavers from the 'vicinity of the Rhine' settled in Bolton, giving 'an impulse to the working of woollen cloth, and that was a fabric composed of linen yarn (chiefly procured from Germany) and partly of cotton... first originated in Bolton in 1756'.[15]

It is possible to evoke a picture of Bolton as a market place before its rapid transformation into an archetypal manufacturing centre of the industrial age. During the weekly Monday market Bolton became a 'bustling, busy town'. Farmers arrived with fustians, herring-bones, dimities and other fabrics 'in wallets balanced over one shoulder, while on the other arm there was often hung a basket of fresh butter'. In addition to these 'small manufacturers' there were Irish yarn dealers selling linen-yarn for local use as warp. Merchants from London and Manchester were drawn to Bolton 'to purchase the heavy fabrics for which Bolton was then the principal mart'. Many of the goods they purchased were finished by local bleachers and dyers, who also attended the market. Much of the bleaching was done in the open air at the surrounding crofts. Business was transacted at 'warehouses and market halls', but some fabrics, 'rough from the loom were pitched in the open street, or under rude piazzas erected in front of the shops'. The town 'had many considerable inns, most of them having large yards behind with ample stabling for the long strings of packhorses required for the conveyance of the raw materials and the manufactured goods'. To store the heavy fustians and other piece goods made in the neighbourhood there were 'many considerable warehouses'. Bolton's inhabitants

'depended for employment almost entirely on the Monday market'. On other days the inns and shops were 'comparatively idle' and the streets 'all but deserted'. This meant that the 'better class' of inhabitants had 'so much leisure time to dispose of, that habits of social intercourse were established, and a consequent courtesy of manners acquired which, unfortunately, has not been maintained'.[16]

Fustians were no match for the finer Indian calicoes or muslins. What was required was an all cotton cloth and this was made possible through Arkwright's roller spinning water-frame of 1769 and Crompton's mule of 1779. The latter spun a smoother yarn than that produced hitherto and allowed the home manufacturer to excel the quality of Indian muslins. Samuel Crompton was a 'Bolton worthy' rescued from oblivion by G. J. French in the mid-nineteenth century. Crompton's life apparently demonstrated 'that natural ability of the highest order, even when supported by education, industry, sobriety and frugality, does not exonerate any man from the duty of acquiring a knowledge of his fellow-men, and of learning how to deal with them in the business of life'.[17] Crompton has recently been perceived 'as an important but by no means a lone or exceptional figure in the process of textile invention'.[18] To French, Crompton was an inventive genius who made public the secret of his spinning machine on the broken promise of a subscription from some of the 'principal tradesmen in Manchester, Bolton etc'. After discovering 'the utter impossibility of retaining his secret' and trusting to the generosity of a subscription, Crompton was met with 'deceitful ingratitude',[19] becoming an embittered and disillusioned man. Nevertheless, Crompton's inventive genius continued to be exercised despite what Daniels calls the 'despicable' treatment he experienced in 1780. Rose found 'bills dated 1826 ... for metal castings supplied by Hick and Rothwell'.[20] Crompton had firm friends in Benjamin Hick, Peter Rothwell, Isaac Dobson and others, who met and shared each others

society. In 1824 Crompton's friends, 'Messrs. Hick & Rothwell'[21] and John Kennedy among them, raised an annuity for Crompton's benefit. John Kennedy and George Lee, both prominent Manchester manufacturers, had promoted an earlier scheme in 1802. From 1801 a Prosecution Club met at the Blackhorse Inn to support financially the apprehension and prosecution of those pilferring materials from the businesses of the members. Isaac Dobson was the club's first treasurer and Crompton belonged to it from 1810, sitting on its Committee of Management in 1819. Isaac Dobson's nephew, Benjamin, later partner in the machine making business, was also a member, and so, too, were Hick and Rothwell. In addition to the Prosecution Club there is evidence of another group, the Blackhorse Club, whose 'prominent' members included Isaac and Benjamin Dobson, Rothwell and Hick. Samuel Crompton was a guest of this company, who met at the Blackhorse Inn 'to discuss not only business matters but the most interesting topics affecting that period'. The 'most prominent members of the club' - Hick among them - promoted the railway from Bolton to Leigh in cooperation with other commercial interests.[22]

III

Great Bolton's rate books mention 'factory' for the first time in 1792, a year that also saw the appearance of two, perhaps three, atmospheric steam engines for cotton spinning. Their role was a 'secondary one', pumping the water of the Croal to a higher level so that it would give 'motion to the water wheels'. At this time the rateable value of Bolton's public houses and inns exceeded that of the 'new factory' and fire engines, a reflection of what were then considered the 'most important business buildings in the town'. In 1793 the hand-loom weavers of Bolton enjoyed 'unexampled prosperity', but within a few years the price of woven muslin began to decline,

initiating this handicrafts long decline. As late as the 1850s Whittle noted hand-loom weavings 'great and lasting repute here', but also added that it 'has been gradually diminishing' before the power loom. Arkwright's 'contrivances and combinations', French tells us, 'more directly and immediately induced' the factory system, because the water-frame 'demanded the investment of large capital' and required buildings 'adapted for the purpose'. By contrast, the mule's 'comparatively small cost made it accessible to persons of very moderate capital', while its 'compact form' meant that for many years it was a 'domestic implement than a portion of the great modern factory system'. The mule's impact was nevertheless profound. 'Many industrious men commenced business with a single mule worked by their own hands, who as their means increased, added to their machines and progressively extended their business until they rose to honourable eminence as the most useful and extensive manufacturers in the Kingdom'.[23]

Whittle believed that: 'Spinning factories on a small scale began in 1778 or 1780 soon after the introduction of machinery into the manufacture of cotton... and worked by water, although water was not so very plentiful in the immediate locality of the town'.[24] But coal was, as Leland had noted three centuries before. The early cotton factory proprietors were favoured by being able to draw on a supply of local people skilled in weaving and spinning. Coal dug in the neighbourhood was available for energy and the canal to Manchester facilitated the movement of both raw and finished materials. The early proprietors did not, however, require a purpose-built factory. Existing premises could be converted from previous uses and entrepreneurs could rent the power generated by water wheel or steam engine. Many of the big concerns of the nineteenth century, such as McConnel and Kennedy and the Ashworth's of Turton, began in a small way. What was crucial to success was

working capital and bank credit. Indeed, one of the first cotton houses, the proprietors James Ormrod and Thomas Hardcastle, were bankers as well as cotton spinners.

The appearance of 'fire engines' in the manufacture of cotton textiles proved significant for machine and engine making. 'The steam engine was crucial to the growth of engineering, not only because it provided the main driving force for industrial mechanisation - thus greatly expanding the market for "machine-making" - but also because of the central role of "engine-making" itself'. In each Lancashire town touched by the growth of the cotton industry, the needs of cotton manufacture, and the use of steam power brought into being a 'multitude of obscure textile machine-makers, engine-makers, millwrights etc'. Manchester was the heart and centre of the 'revolution in the cotton industry' and 'that in engineering associated with it'.[25] But elsewhere in the county one could find outstanding firms and among these was the Union Foundry of Rothwell, Hick and Rothwell. Joshua Field believed the Union Foundry dated from c.1801. It was certainly established through the enterprise of Peter Rothwell (1755-1824), a wealthy timber merchant and contractor, and one of the original Trustees for Great Bolton. Since 1790 Rothwell had been in partnership with Isaac Dobson (1767-1833), the 'youngest son of a Westmorland yeoman family, who had migrated to Bolton in 1789'. According to one source Dobson intended to become a book-keeper to a local cabinet-maker, but adopted the craft of cabinet-making instead. Dobson & Rothwell's sale of textile machinery was assisted by Rothwell's position in the community. He was 'known commercially throughout Lancashire and was related to many of the early cotton spinners'. The foundry business, too, was stimulated by the demand for textile machines. Field noted in 1821 that the Union Foundry 'cast a good deal of work for the spinning machine makers'.[26]

10

Rothwell's enterprise in machine making and iron founding proved of lasting significance to Bolton. Dobson & Rothwell survived the demise of the original partners and attracted new proprietors, becoming known as Dobson & Barlow from 1851, with the arrival of Edward Barlow. By 1888 this firm of spinning machinists had grown into a 'veritable collossus'[27], with a potential output of between 600 to 650 mules, sufficient for twelve first-class spinning mills. Edward Barlow's father, Robert, was until 1824 a wine and spirit merchant. He retired from this trade and became a partner in the banking firm of Hardcastle, Cross & Co., his eldest son later becoming managing partner. Rothwell's influence as the head of an iron foundry induced both Benjamin Hick (1790-1842) and John Musgrave to cross the Pennines and join the Union Foundry. They subsequently extended and developed iron founding for their own benefit and with others made Bolton a major engineering centre in the nineteenth century. Hick came to Bolton in 1810, five years after Musgrave, and may originally have been 'engaged with Mr Rothwell' as a draughtsman.[28] By 1814 Hick was one of several partners in the foundry and by 1821 he was described as the 'managing partner'.[29] In 1814, the Union Foundry of Smalley, Thwaites & Co., became Thwaites, Cockrane, Hick & Co., with the retirement of Edward Smalley from the partnership. Hick's fellow partners were Peter Rothwell, timber merchant and builder, James Cockrane, Thomas Crompton, possibly a paper maker and joint proprietor with John Crompton of the Farnworth mills, Isaac Dobson and William Crompton, uncle to Rothwell's son, Peter Rothwell Jnr.(1792-1849). It is possible that Rothwell only became a partner in 1814, following Hick's arrival, but what is certain is that they became the most enduring partners in the business. Another change in proprietorship soon followed that of 1814, with the Union Foundry styled as Thwaites, Hick & Rothwells from 1816-17.[30] Field commented on the role of these proprietors in 1821 when he noted that: 'Mr. Thwaite

seems retiring and Mr Rothwell is a genteel young man perhaps a capitalist'.[31] The next year Thomas Thwaites withdrew leaving Hick, Rothwell and Peter Rothwell Jnr. as iron founders, engineers and millwrights.

We have already noted Hick's membership of the Prosecution and Blackhorse Clubs, both of which were centred on the Blackhorse Inn. Hick's home for many years was close to the Union Foundry gates in Blackhorse Street, so it is unlikely that he was oblivious to the commercial society of the town, particularly as Isaac Dobson worked close by. It is even suggested that Dobson was the proprietor of the Blackhorse public house. There is, however, firm evidence that Hick moved among Bolton's manufacturing entrepreneurs and professional men from an early date after his arrival. In 1810, the year Hick came to Bolton, a branch of the Pitt Club was formed. This was a 'political organisation composed of the admirers of William Pitt', whose members included 'leading gentlemen of the town and neighbourhood'. These 'admirers' included cotton manufacturers, bleachers, clergymen, solicitors, attorneys and tradesmen in general, including John Hargreaves of Hart Common, Westhoughton, the father of William Hargreaves, who became the sole proprietor of Hick Hargreaves. It is also apparent that an entrepreneur, such as Peter Rothwell, did not require to move far in order to meet and know the town's manufacturers. Rothwell was an original Trustee for Great Bolton, but by 1808 he was a member of the congregation of St. George's Church, serving a district of Little Bolton. This church had been erected and consecrated in 1796 and among its congregation were Thomas Ainsworth of Thomas Ainsworth & Co., cotton spinners, Johnathan Hitchin, muslin manufacturer, Peter Ainsworth, counterpane manufacturer and several other textile manufacturers.[32]

12

IV

Aikin noted that coal was 'met with all round' Bolton and its vigorous exploitation was a compelling motive behind the Manchester, Bolton and Bury canal. This and other canal links 'speedily' provided a 'complete system of water communication' that extended 'into the neighbouring counties and to remoter places'. Although the promoters of the Bolton canal aspired to greater things, with projected extensions and links to Liverpool and some of the other cotton centres in Lancashire, the Bolton canal became simply a 'ten mile local link'.[33] Nonetheless, this waterway and the other canal schemes belonging to the 'second phase' of canal building, authorised during the 1790s, 'were not cut into an empty map', but represented the culmination of river improvement and canal construction extending over a century. Coal lying beneath the Irwell valley and the swelling market for it in Manchester, from manufacturers and domestic users, was the attraction behind the Bolton canal scheme. It was known 'that there were considerable coal reserves in the Irwell Valley to the north of Manchester and in the district between Bolton and Bury which were poorly exploited, largely because of the difficulties of carriage to markets'. The Bolton canal was specifically promoted with the aim of affording a 'useful, short, and easy Communication' between the three towns and the 'adjacent Country', while also opening 'an Introduction to many valuable and extensive Mines of Coal'. Coal 'alone', Aikin wrote, 'can repay the expence of such an undertaking'.

The presence of 'an excellent water communication both for the conveyance of merchandise and passengers' proved a stimulus to further economic activity and presented a demand for engineering work. The canal's traffic was 'related to the existing activities of the district,

but much more originated from the industrial development fostered by the waterway'. The appearance of wharfage and marketing facilities at the terminals led to 'many new pits' being sunk along the canal route. In the 1790s, when the canal was barely begun, Aikin had noted of Bolton's pits that: 'Steam engines are much used, not only for draining the mines, but on a smaller scale for drawing up the coals. But few of them are on the plan of Messrs Bolton and Watt'. Tomlinson believes 'that the adoption of improved winding techniques was related to the canal's ability to dispose of an increased tonnage of coal'. Steam technology had already been adopted by mining entrepreneurs before the appearance of the Bolton canal, but with its arrival there was a greater incentive to produce coal for the town markets. To begin with, new canal-side pits were sunk that could benefit from direct loading between the pit head and narrow boats. Branch docks serving adjacent pits became a familiar feature of the canal except on the hillside sections of the route. Here, there were opportunities for gravity assisted tramways. These had existed from an early date in the canal's life, but tramways assumed a greater importance as pits were established 'further afield', with the working out of canal-side pits and the continued profitability of coal mining.

The Bolton branch of the canal adopted the valley of the River Croal from Damside to a terminus lying below the parish church and adjacent to the Bury-Bolton road. The valley was 'already lined with bleach, dye and chemical works', while the provision of a warehouse, available free to carriers from 1804, in addition to a quay and service road, proved attractive to the passage of traffic. The choice of location for several activities was determined by the canal's presence and the ease with which it could move goods. In Bury, a corn mill was built to grind canal-borne grain. In Bolton, the Wharf Foundry of Thompson & Butler was sited in 1792 with the canal terminus in mind, by

14

being placed across the road from it. The site of the town's second gas works may also have been influenced by the canal. Private gasworks, too, required convenient supplies of coal and water and turned to the canal for supply, as had the mining entrepreneurs at an earlier time when installing steam engines. Of several paper and textile mills and finishing works producing gas by 1840 all 'were sited alongside the canal'. Nevertheless, the Bolton canal 'differed from most other Lancashire canals in its relatively slight long-term influence on the siting of cotton factories. There are scarcely any examples of it affecting water-powered mills, many instances of its attraction for builders of early steam-driven factories in the first four decades of the nineteenth century, and few cases where it influenced builders in the late nineteenth century'. The canal proved beneficial to existing water-driven spinning mills, bleachworks and printworks by easing the supply of materials and finished goods, and subsequently supporting steam engines as they were adopted. There was 'little development' of steam-powered mills along the Bolton branch of the canal, but this was not the case at Bury, Manchester end and certain settlements between Bury and Pendleton. Aikin's prediction that the Bolton canal would 'afford much carriage' had been realised by the 1830s as the waterway dealt with an expanded volume of traffic. This was reflected in the increased number of carriers working the canal in the 1840s, among whom was John Hargreaves Jnr., the brother of William Hargreaves, and an operator with 'extensive land carriage connections'.

V

As the demand for textile machines increased and the use of steam engines became widespread, the long-established skills of wheelwrights, millwrights, brassfounders and blacksmiths grew increasingly in demand and it was from these distinct trades that that of mechanical

engineering emerged as the nineteenth century unfolded. Musson points out that:

> The most important market for Watt engines in addition to the S.W. tin and copper mines was in Lancashire, where powered mule spinning was being rapidly developed from the 1790s onward and numerous other makers of steam engine, notably Bateman and Sherratt of Salford, were doing a roaring trade with a great deal of pirating.

Steam power was also being applied to ancillary trades, such as 'calico printing and calendering machines, to washing and squeezing (mangling) machines in bleachworks and to grinding logwood, fustic, etc., in dye works'[34]. The early engines of Newcomen and Watt involved the work of local millwrights, blacksmiths, iron and brass founders etc., who fabricated the engine on site under the supervision of an erector, with special parts brought in from outside. It is not a surprise to learn that in Newcomen's engine of 1712 'the boiler with its setting was little more than a large brewer's copper'[35]. Boulton & Watt only established the Soho Foundry in the 1790s having hitherto relied on the work of others, such as John Wilkinson whose boring mill provided cylinders. By the close of the eighteenth century 'many rival "engine-makers" had sprung up either making the older-type engines or "pirating" Watt's inventions'[36]. His 'master patent for the separate condenser'[37] had endowed Watt with control over stationary engine design, which proved frustrating to the inventive efforts of others. But in 1800 Watt's 'master patent' expired and the field was thrown open to further experiment and construction. Of the two activities - engine and machine making - engine making played a more crucial role in the development of mechanical engineering. To quote Musson again:

> The steam engine was particularly important in the evolution of engineering being a more complex industrial machine than any

previously in use and requiring more precise methods of construction for pistons, cylinders, valves, condensers, air pumps, etc., as well as stronger and more efficient boilers.[38]

Matthew Murray (1765-1826) was the 'first serious competitor' of Boulton & Watt after 1800, and a 'pioneer of the commercially built self-contained steam engine'. Murray's influence as an engine and machine tool builder on his pupils was 'far-reaching' and Benjamin Hick was among those influenced. But during Hick's lifetime the beam engine developed by Watt underwent little 'noticeable change' until it was compounded by McNaught in the 1840s. It was improved - iron replaced wooden beams and connecting rods 'flitched with iron plates' - but essentially the beam engine remained as Watt arranged it, a low pressure double-acting engine using steam expansively. The persistence of this type stemmed from the limitations imposed by the available machine tool technology, while in its rotative form it met the requirements of mill and factory owners who were provided with a durable engine. The easier access to coal enjoyed by Lancashire power users reinforced the beam engines retention. In Cornwall the market for power was more demanding. Here, coal was dear and the Cornish metalliferrous mines sought economical engines, encouraging the work of Trevithick in the development of high pressure steam engines and attracting Woolf's compound engine. Trevithick's heretical advocacy and use of high pressure steam led in 1812 to the appearance of the high pressure 'Cornish' beam engine. Woolf had already developed a compound beam engine in London in collaboration with Humphrey Edwards, a millwright, and exploited the design in Cornwall from 1811, where a competitive spirit was engendered by the publication of engine performances. Of the two engine types Trevithick's 'Cornish' beam engine ultimately emerged triumphant. 'Woolf built no more of his compound engines after 1824

17

because, in spite of their efficiency, their greater cost and complexity made them unable to compete with the high-pressure Cornish engine of Trevithick, which held the field for heavy pumping-work without serious rivalry, until nearly the end of the century'. What we should note here is Woolf's long collaboration, begun in 1818, with John Taylor, the 'major mining adventurer' and engineer. Taylor's success 'was founded on heavy investments in the most up-to-date mining and dressing technology combined with astute financial management'. It was said of him that he 'was at his best when collaborating with the professional and truly talented engineer, providing informed advice and intellectual encouragement and, more particularly, the immense financial resources and opportunities which his business empire placed at his command'.[39]

Woolf's abandonment of the compound engine arose from the inadequate steam pressures available to this engine type. The additional expense and complication of a second cylinder was not justified by steam pressure of 40lbs., which rendered Woolf's compound engine uncompetitive with Trevithick's high pressure single cylinder 'Cornish' engine. Only when pressures had risen to 100lbs. or more did the compound engine come 'into its own in Britain' and this was achieved by McNaught in 1845, working within the manufacturing environment of Lancashire. Mill and factory power users were now demanding more power from their beam engines and McNaught answered the need by adding a second high pressure cylinder to the beam. The practice of 'McNaughting' was soon followed by the appearance of the slow-running horizontal engine, which replaced the beam engine for use in mills in the second half of the century. Hick Hargreaves was one of several 'well known companies' who became identified with the horizontal steam engine, particularly the horizontal Corliss engine. It was Hick Hargreaves who introduced the Corliss valve-gear into common use in Britain from the 1860s. Nevertheless, they were still building single

cylinder and 'McNaught Compound' beam engines well into the 1870s - de Jersey & Co. ordered two McNaught Compound beam engines for one of their mills in 1875. The changes in engine design reflected the advances made in machine tool technology achieved from 1815 when machine tool making was stimulated into rapid growth. Hitherto, machine and engine makers had been dependent on what metal cutting tools were available from such fine trades as instrument making, allied to the slow costly manual labour of skilled millwrights. Further progress in engine making beyond Watt's consummate engine, the double acting rotative engine of 1787, called for machine tools that allowed their replication without resorting to expensive hand work. These were soon forthcoming through the work of Maudslay, Clement and the pupils of Maudslay - Roberts, Nasmyth and Whitworth. These disciples of Maudslay not only equipped there own workshops with machine tools, but found a market for them. Benjamin Hick was himself a capable designer and builder of machine tools, one of the contributors to Buchanan's Practical Essays on Millwork, while it is equally significant that B. Hick & Son were a customer of Nasmyth for machine tools fron 1836. In 1838 Nasmyth Gaskell & Co., supplied two planing machines to Benjamin Hick and James Nasmyth wrote as follows to one J. Bramah, London, a potential buyer:

> We are in hand with two such machines for Mr Hick of Bolton who has had a turnout of his millwrights and in consequence came to us for our assistance as he is determined to supply their place entirely with machinery which will be fully attained by a few planing machines.

By 1841 it was recognised that the manufacture of self-acting machine tools had became a 'distinct branch of mechanics and a very important trade'. Two other branches of 'mechanics', in an industry increasingly characterised by the use of power driven machine tools, were also

noticeable: the manufacture of steam engines, millgearing, hydraulic presses and other heavy work; and the manufacture of textile machinery. Firms specialising in one of these engineering trades had now begun to appear, but such specialisation 'was never clear-cut, most firms remaining general engineers'.[40] This was certainly true of Hick & Son, who in the 1850s were building steam locomotives in addition to the stationary engines that established their reputation. Soon, the manufacture of locomotives was to form another distinct trade, possessing possibly greater opportunities than the other branches of engineering for standardised output with interchangeable parts.

VI

How distinguished an engineer was Benjamin Hick? Joshua Field, who spent a day in Hick's company, visiting the Union Foundry and other factories in Bolton, was impressed by his draughtsmanship. But Hick was more than simply an accomplished drawer. He was the designer and builder of radial drilling, planing, vertical boring and other tools employed in the manufacture of a variety of millwork and engines. The introduction of the radial drilling machine was the product of several engineers work, wrote Steeds. 'One of the earliest examples of this type of machine was made by B. Hick & Son at some time before 1840 and in some respects this design was in advance of its contemporaries'. The number of men engaged in tool building was 'increasing rapidly' by 1840, according to Roe, 'and it is impossible to consider many English tool builders who were well known and who did valuable work, such as Lewis of Manchester, B. Hick and Son of Bolton, and others'. Hick's Master, Matthew Murray, was a pioneer of mechanical engineering, at one time the sole 'engineer' in Leeds among so many millwrights, iron founders and blacksmiths. Murray 'was the first in Leeds to build flax spinning machinery; carding engines; pumping engines; stationary engines for

mills; air pumps; locomotives; planing machines; cylinder boring mills; hydraulic testing machines; pressure gauges; and gas making plant'. Murray's pioneering influence in the manufacture of this wide range of metal goods was carried by Hick to Bolton. Most important of all was the knowledge of machine tool use that Murray imparted to his pupil. Among other tools Murray built a 'machine for planing valves and similar work'. Consequently, Hick must have been alive to the contrast in time, effort and cost between hand methods of shaping metal and the use of machine tools. 'Murray's success was partly due to the able co-operation of men he gathered round him' and Hick was one of those 'clever assistants' Murray trained in engineering. That Hick learnt to value the use of machine tools in the manufacturing process is clearly shown by his circular of April 10th, 1833, soliciting business for his 'new works, Soho Foundry, Bolton, now erecting'. Hick's partnership with 'Messrs Rothwell' had 'this day expired' and Hick was about to begin the 'general business of Engineer, Millwright and Ironfounder'. To this end Hick would 'take every advantage of the most recent improvements in Machinery'. If Murray 'possessed in a high degree, that attribute of real genius, namely, a truly liberal mind', his pupil was similarly endowed. Hick's 'attention was devoted to almost all branches of mechanics and the ingenuity displayed in his inventions and improvements' was 'generally acknowledged'. 'His good taste, his integrity of character, the encouragement which he extended to talent of all kinds, and the assistance given by him to all public improvements, obtained for him considerable influence in the town of Bolton'.[41]

Benjamin Hick was born in Leeds in 1790 and was 'brought up as a practical engineer' by serving an apprenticeship at the Round Foundry of Fenton, Murray & Wood. Matthew Murray was in charge of the engine building department and Hick certainly witnessed and probably

21

participated in Murray's novel engineering work. We are told that 'Murray devoted almost all his active energies to making inprovements in the steam engine, which were afterwards the subject of several patents'. In a patent specification of 1801, embracing a number of constructional details meant to 'increase power and save fuel', Murray simplified Murdock's 'brilliant invention' of the slide valve, and gave rise to what later became the locomotive D-valve. Murray's patent was significant for showing a 'circular motion for operating steam drop valves by wipers or cams'. Unfortunately, 'that ingenious device,the eccentric' had already been devised at Soho and Boulton & Watt were able to set aside Murray's patent by means of writ Scire Facias. According to Dickinson, the 'combination of Murdock's eccentric and Murray's D-valve... received as wide exemplification as all other valve gears put together'. Not surprisingly, Benjamin Hick & Son adopted Murray's device for the valve gear in their larger engines. The bedplate, an important advance in the evolution of engine design, was introduced by Murray in 1802 and was soon widely adopted, proving particularly valuable for rotative engines. Released from the legal and other constraints imposed by Boulton & Watt, Murray developed some novel engine designs. One of the most durable was his self-contained or portable engine of 1805, out of which the marine side-lever engine was later developed by other makers. Hick's experience of Murray's 'portable' engine, 'something like the old beam engine turned upside down', was later put to profitable use as Hick & Son were 'responsible for a good deal of marine engine work' in the 1840s and 50s.[42]

Hick must have displayed some promise during his apprenticeship because 'at an early age he was intrusted with the superintendence and erection of several large engines, etc'., and 'was eventually offered a partnership' in the Round Foundry. He declined this 'and in 1810

22

engaged with Mr Rothwell in the Union Foundry at Bolton'. This manufactory was not the only iron foundry in the town, nor the first to be established, but it was certainly impressive. According to the Bolton Directory of 1818, the foundry belonging to Messrs Thwaites, Hick and Rothwell was 'on a very extensive scale', furnishing 'employment to a great number of hands'. The Union Foundry's extent was so great that its layout merited a description:

> In the west wing... is a spacious gallery or apartment of 195ft. in length, and 24ft. in breadth, entirely filled with an immense number of models, used in the manufacture of almost every kind of Mill-work and comprehending nearly 500 different kinds for wheels of various dimensions, complete sets of patterns for steam engines of all sizes from 1 to 100 horses power, and for Hydraulic-mechanical presses, a powerful machine now in general use, particularly amongst the Bleachers. Messrs Thwaites & Co., have lately constructed two of these presses, each of which weighs upwards of 27 tons, and has the power of pressure nearly equal to 3,000 tons.

By 1824 the partnership of Rothwell, Hick and Rothwell was manufacturing 'steam engines, hydraulic presses, weighing machines, gas light apparatus, mill machinery... sugar mills' and constructing 'fire proof buildings'. Field's detailed description of the manufactory also noted that it was 'both large and complete', with the 'large foundry... chiefly employed in casting engine work of which they do a great deal'. Murray's influence was evidently present in the use of machine tools for cutting and boring work, because a machine with a 'large horizontal chuck' was used 'very much' on anything requiring to be bored. The 'house of Thwaite, Hick and Rothwell' also possessed 'one very large and heavy lathe in which they turn heavy shafts, beams, etc., 2 or 3 other

rough heavy lathes turned by a multitude of wheels and a new lathe... very well made and finished, kept very clean'. Field described the 'new lathe' at length and concluded that it was 'so useful that now they have it could not do well without it'.

Grinding, too, had a role at the Union Foundry for shaping and finishing components. Field noted: 'In a small building they have a grinding mill where they grind all their bright work and we saw some round rods done so well that they seemed to have been turned'. Not everything Field saw met his approval: 'Above the lathes are vice shops with the motion carried upstairs and many small lathes by no means good ones'. A great deal of the Foundry's work was provided by the textile industry. Field found the works making a 'number' of the weigh bridges for two wheel carts that were 'very common about this country'. In the 'small foundry', with its 'small cupola', the business 'cast a great deal of work for the spinning machine makers', who presumably included the neighbouring partnership of Dobson & Rothwell. The quality of the 'small fine wheels' cast by the foundry was judged 'very excellent' by Field. However, the boiler department had 'nothing extraordinary in it' and built mainly 'waggon boilers', a common type that produced low pressure steam. One was being built at the time of Field's visit 'for a 42 Horse engine'. A small gasometer was also 'making here'. Field found the Foundry's 'counting house... very neat having a private office going out of it and on the other side a drawing office with one young man drawing'. He also noted that his guide, Benjamin Hick, 'draws very much and very well himself'. The pattern makers shop was 'very well arranged' and had produced a 'great many' wheels. The town's mills also provided a demand for engines in addition to millwork. On the day of Field's visit the Foundry had 'in hand a 42 horse engine for a cotton mill in the neighbourhood, several 20s & 10'. Hick 'took us to see 6 or 8 Engines close by of their make, one of which, a 20 H, I think is

the neatest machine I ever saw'. Murray had introduced the bedplate as a foundation for the engine twenty years before. Now, Field discovered that Hick had adopted this innovation as a standard feature of some of his engines. 'Up to 42 horse power he makes them upon 4 strutting columns, or rather pallisters, very wide, & standing on a plate upon which the cylinder, crank, plummer block, etc. were all fixed'. After dining with Hick at his 'very nice house adjoining the premises', Field was shown the mill of Ormerod & Hardcastle and the 'machine factory of Mr Dobson'.[43]

VII

By the time Hick established his Soho Foundry in 1833 the local market for engines and millwork had expanded to an extent greater than that which had supported the Union Foundry a decade before. It was noted in 1834 that:

> ...The bleachworks, foundries, machine makers and cotton factories (the latter of which have lately increased in number), employ numerous steam engines, and it is estimated that the labour performed by steam in the town and direct neighbourhood would require at least 1,500 horses. The iron foundries are on a very extensive scale, and an important addition to this number is now being made by Messrs. Hick & Co. adjoining the railway.

This railway from Bolton to Leigh, with an extension to the Liverpool and Manchester Railway at Kenyon Junction, had been promoted by prominent members of the Blackhorse Club - Hick, William Crompton, Isaac and Benjamin Dobson - while other participants in the town's railway scheme had included such 'well known local gents' as William Hulton, Peter Rothwell Jnr. and Robert Darbyshire, the engineer to the Manchester, Bolton and Bury canal. These were men known to each other

through the society of the Pitt Club and were representative of Bolton's manufacturing and commercial interests. The participation of local entrepreneurs in a scheme for a railway line points to the importance of the Bolton & Leigh Railway Co., as this project was from the beginning planned as a link between existing communication systems that would join Bolton to both Liverpool and Manchester. In 1819, following almost three decades of discussion, negotiation and agreement, it was finally apparent that within the machinations of canal promotion the Bolton canal had lost out to more influential interests and would not become Manchester's new link to the Mersey. It was to remedy Bolton's isolation from the regions commercial centres that a railway or tramroad was projected in 1824 as a link between two canals - the Manchester, Bolton and Bury and the Leeds and Liverpool canals - but the appearance of the Liverpool railway scheme dramatically enhanced the value and significance of the Bolton railway. To engineers, such as Hick and Rothwell, steam locomotion clearly presented a new and profitable dimension to their work. Hick chose to site his new works beside the Bolton and Leigh railway, which since 1831 had proved 'of great advantage to the town', following the start of a service to Liverpool. Hick became a railway promoter and shareholder in other local companies and this interest brought him into company with John Hargreaves Jnr., the carrier, who had developed a distinctly separate interest in railways by assuming responsibility for their working, as well as promoting them.[44] How Hick and Hargreaves came to recognise their mutal interest in engineering is treated in detail in the next chapter.

Chapter 2

Hick and Hargreaves: Fntrepreneurs in New Ventures in the Railway Era

I

Benjamin Hick was already established as an influential entrepreneur when, in 1833, he took land and began to hire labour for his Soho Foundry. Hick's reputation as a locomotive builder already extended across the Atlantic. The locomotive work undertaken at the Union Foundry for American railroads explains his widespread reputation as a locomotive engineer, but how did this work begin? Where are the origins of Hick & Son's locomotive building that saw them turn out between 90 and 100 locomotives in the period 1833-1850? It is apparent that Hick was familiar with the pioneering work achieved in Orrell by Robert Daglish (1777-1865), who claimed to have built the earliest locomotive in Lancashire, because the Orrell locomotives were described by Hick in 1822 through The Kaleidoscope. The two men became firm friends and from 1824 collaborated together on the Bolton and Leigh railway, the first public railway in Lancashire, and the one that marked Hick's involvement in railway promotion. Shortly before the promotion of the Bolton & Leigh railway, Hick entered the political life of the town by becoming one of the Trustees of Great Bolton. This association with other manufacturers would have heightened Hick's awareness of the inadequacy of canal carriage for the supply of raw materials and movement of finished goods. Bolton's entrepreneurs were sympathetic toward the desire of Liverpool's merchants to improve communications and facilitate a growth in trade. Joseph Sanders complaint that the navigation companies were charging exorbitant tolls in return for a poor service found an echo among Bolton's manufacturers.
27

Like their counterparts in Manchester they were affected by delays in the movement of freight, because 'raw materials from Liverpool intended for Bolton had to be conveyed through Manchester'.[1] The solution to this problem common to both Liverpool and Bolton seemed to lie with the building of a railroad.

II

As a Trustee Hick sat with his partners and other manufacturers, who were cotton spinners, brewers, ironfounders and machine makers. As Trustees these wealthy entrepreneurs wielded considerable power in the township of Great Bolton, as they were entrusted with responsibility for its improvement. To fulfill their obligations the Trustees were empowered to place contracts, appoint watchmen, build offices for peace officers and make sewers and drains. Not surprisingly, the dividing line between the railway proprietors collective wish to benefit the commercial interests of Bolton and the Trustees public function of improving the town was hard to distinguish. Clearly, the outlook and guiding principles of the town's entrepreneurs also shaped the decisions taken by the same men when entrusted with its improvement. The inevitable result of this overlap between public and private responsibilities was the intrusion of politics into a commercial venture: the promotion of the Bolton railway.

James Hardcastle, a bleacher and son of a Trustee, was not impressed by the display of altruism shown by the railway's promoters. He 'acquainted' William Hulton of Hulton Park, a leading member of the railway project, 'with the Local Politics of Bolton'. Hardcastle's letter was prompted by notice of a forthcoming meeting 'of the subscribers only'. Hardcastle wrote:

Suppose the meeting held - Mr. Hulton is voted to the chair & then

28

his mouth is closed, it being the business of a president to hear not to speak - Resolved that proprietors holding 10 shares & upwards shall form a Committee in whom the entire management shall be intrusted - Now let me ask who could form the Committee? Boardman, Hick, Rothwell, Crompton (Pothwells Uncle), Dobson, Wm. Morris, Hulton Esq., & Scowcroft - On all public matters for many years past the first six have generally voted with each other. Suppose the Committee sat - Mr. Hulton chairman We have six on one side & one on the other - Query who will most probably make the Engines? It is well to observe that in all our business with Iron Founders we give Hick & Rothwell a preference, I would give no man any more, & that they may have in this instance, but by all means let the thing be open to competition.

Hardcastle's dislike of Ralph Boardman, a lawyer and Town Clerk, had arisen 'solely from my knowledge of his gross misconduct in public matters'.[2] This animosity may appear to be a reflection of the petty jealousies that would naturally have arisen from parochial politics. However, the expense of building the Bolton railway did escalate rapidly, proving beneficial to its contractors, while the politics of Bolton certainly had their seamy side. Hick may have been, as he appreared to be, a sober and upright manufacturer, but there were some people who found fault with those entrepreneurs and Trustees with whom Hick consorted. In the Bolton of 1825 the cry of impropriety was not an empty one.

It was inevitable that the railway's promotion would come before the Trustees and Hick's role as both Trustee and railway proprietor ensured that he occupied an influencial position. It was this powerful duality of roles possessed by Hick and his partners in the Union Foundry that gave rise to the animosity felt by Hardcastle. However, the strong

position of the railway party in Bolton almost guaranteed that the scheme's progress would be unobstructed. In 1825 Hick was one of seven Trustees 'appointed a Committee for widening and improving Moor Lane'. It was this committee, five of whose members were railway proprietors, which met the Bolton & Leigh Railway Co., 'for the purpose of laying out the Line of Road from Moor Lane to Deansgate'. In June, 1828, the Trustees were able to order the widening of Deansgate in a straight line, 'agreeably to a sketch shewn upon the Plan produced by the Clerk to the Rail Road Company', in addition to sanctioning the company's purchase of land and buildings based upon 'avarage cost'.[3]

III

Stretton and Dendy Marshall had good reasons for believing that the Bolton railway party collaborated with that in Liverpool to plan a junction of their schemes at Leigh. The engineer to both railway projects was George Stephenson and the Bolton-Leigh and Liverpool-Manchester Railway Bills entered the same session of Parliament. Moreover, promoters of the Liverpool scheme corresponded with William Hulton, a leading personality of the Bolton party, who had apparently invited Stephenson to construct a railway between Bolton and Leigh 'for the convenience of the Hulton collieries'. Eventually, the Bolton and Liverpool lines were joined at Kenyon Junction, but this connection only arose after the successful promotion of both railways. Winning approval for the Liverpool scheme was strenuously resisted by vested interest, such as the canal companies, whose role the railway promoters aspired to supplant. By contrast the Bolton railway met markedly little opposition and was smoothly authorised largely because its promoters astutely balanced the possibility of a link with the Liverpool railway against the reality of a canal terminus at Leigh. This cautious approach frustrated Stephenson

and the Liverpool party, but it resulted in the building of the first public railway in Lancashire, with an opening ceremony that included an exhibition of steam locomotion over a year in advance of the Rainhill Trials. Hick, who had been involved in the planning of the railway, was a witness to the display of steam locomotion that Stephenson performed in Bolton in 1828.

At an early date Hick was found 'going over' the proposed railway's route in the company of the surveyor. Robert Stephenson the elder, brother of George, was the 'resident engineer' to the project, while Robert Daglish supervised construction. Hugh Steele, an assistant to George Stephenson, was assigned the task of surveying the line and later became the Surveyor to the Bolton Company once the railway was authorised. Steele had the onerous duty of fulfilling George Stephenson's concept of the line's course, while also placating the scheme's promoters. Basnett's study of the Hulton Papers reveals that Stephenson planned to build a railway that would be admirably placed for an extension south of the Leigh terminus to the Liverpool line. In October, 1824, Stephenson was completing his survey of the Liverpool railway which passed two miles south of Leigh, and he was alert to the possibility of a junction between the two schemes. The section on the Bolton railway plan, deposited at the same time as that for the Liverpool scheme, 'shows the line finishing some feet above the canal and not on the banks as one might reasonably expect'. However, the Liverpool railway Bill was defeated in May, 1825, two months after the Bolton Bill received the royal assent and Stephenson was dismissed from both projects, with the result that the Bolton railway became subject to other considerations.[4]

Basnett notes that the 'close association between the railway companies was a reflection of the equally close trade relationship

between Bolton on the one hand and Liverpool and Manchester on the other'. She refers to a 'group of Bolton gentlemen' - Rothwell, Hick and others - who met at the Black Horse Inn and suggests that the Bolton scheme stemmed from this group's awareness of the Liverpool railway project. The motives of manufacturers, such as Hick, were similar to those held by merchants in Liverpool. Bolton's goods traffic was predominantly canal-borne and had to pass through Manchester via the Mersey & Irwell Navigation or the Bridgewater Canal, which meant that the supply of raw materials - wrought iron, cotton and whitegoods for bleaching - was subject to a costly duopoly. The canal companies control over the market rewarded investors with handsome dividends, while Liverpool's merchants complained of heavy charges and a poor service. The Liverpool railway scheme naturally provoked the hostility of the canal interests, but this was not the case with the Bolton railway party, who were authorised to provide either a railway or tram road 'from or from near the Manchester, Bolton and Bury Canal in ... Bolton-le-Moors, to or near the Leeds and Liverpool Canal, in the Parish of Leigh ...'[5] Thus, the Bolton railway was perceived by the canal companies as an improvement to the existing system of canal transport.

The Bolton & Leigh Railway Co., was empowered to make a railway 'from the Westerly side of the Manchester, Bury and Bolton canal ... Haulgh, to the Leeds and Liverpool Canal ... Westleigh ... with Two collateral Branches', both commencing 'from or near' Lecturers Closes and terminating near Great Moor Street and Deansgate. William Hulton's aspirations were realised because he established a coal depot in Great Bolton, an interest that the promoters of the Bolton and Preston railway were obliged to protect in 1837. By then Hick had sited his foundry at Lecturers Closes, beside one of the collateral branches, but in 1825 the projected branch to Great Moor Street conveniently entered a corner of

Rothwell, Hick and Co's. Union Foundry. The marketing of Hulton's coal was an important consideration to both the Bolton and Liverpool railway parties, while the search for a junction between the two schemes was not confined to Stephenson alone. John Moss, Liverpool banker and staunch supporter of the Liverpool project, wrote as follows to Hulton in September, 1825:

> By our Rail Road I am confident we shall carry your Coals much under 5£ p ton I should think for about 3£ p ton and the same quality is now sold for 16£ p ton here. I do hope that we may come nearer to Leigh if not quite to it, than the line which I left with you. Our surveyor will be at Liverpool on Monday when we intend to call his attention to the Junction, we have generally determined our line as far as Newton beyond that we cannot decide until Mr. Trafford has been seen.

Moss hoped to see Hulton 'supply both Liverpool & Ireland' with his coal, particularly as he had been told that within 10 years 'all the Orrell coal will be out'. What Moss did not disclose was that Vignoles preliminary survey for the second Liverpool Bill was complete and envisaged a line running south of that planned by the now discredited and discharged Stephenson, passing through Newton, Chatt Moss and Eccles. Like Stephenson, the Rennie brothers did not plan on deviating the Liverpool railway north to Leigh, whereas the Bolton party had been careful to project a scheme that did not cross the canal, because of their anxiety to secure the consent of the canal interests. By the Autumn of 1825, with the Bolton railway authorised to be built, the Bolton party was in a position to promote a project for a junction. According to Rasnett a plan of a 'junction line from Leigh, surveyed by George Piggot', was deposited at the same time as the Liverpool

company's third and successful plan in November 1825. The following May the Liverpool railway was sanctioned by Parliament, 'but nothing further was heard of the Bolton company's proposed extension'.[6]

Basnett shows that the promoters of the Bolton railway were influenced by the strength of the canal interests, who apparently frustrated the planned crossing of the Bolton canal into Haulgh. At the same time, the railway party's desire for a terminus at Leigh and a junction with a canal raised the suspicion in Liverpool that the Bolton party was really a 'cloak' for canal interests. In fact, the promoters astute approach to the realisation of their railway project stemmed from the need to improve Bolton's communications, a desire tempered by their percepton of the power of the canal companies. A railway junction that led to Liverpool and Manchester was the ideal solution to Bolton's carriage problems, but an imperfect canal link appeared to be the only scheme most likely to succeed. As Stephenson's plans for the Liverpool railway were deposited and the time approached for this scheme's consideration by Parliament, the promoters of the Bolton railway were content to play a cautious hand. The certain and immediate benefits of a canal junction had to be weighed with the doubtful circumstances surrounding the Liverpool railway project. Basnett believes that the shrewd course taken by the railway committee was known to the Liverpool party through Hulton, who wrote to Lister Ellis at the close of 1824, disclosing that the committee was

> unwilling that Bolton should forego the advantages to be derived from a scheme to which there is no opposition, for the sake of one which appears to them to be attended with considerable difficulty. Bolton and its neighbourhood have been so long shut out from the benefits desirable from an outlet at Liverpool, that its inhabitants can no

longer endure that prohibition, and it is this acute feeling which has induced them to prosecute this measure now in progress. At present I incline to think the necessities of this neighbourhood are too great not to demand the junction with the Leeds and Liverpool Canal as a temporary convenience.

The subsequent failure of the Liverpool railway Bill vindicated the Bolton Committee's carefully measured approach, based ostensibly on the 'acute feeling' of the town's inhabitants. In reality, the promoters were fearful of provoking the hostility of the canal companies and wished to be identified with that interest. The price for the Bolton Bill's successful passage was an undertaking that the railway would go into and not over the canal at Leigh, which closed one of the earlier notions entertained by the Bolton party. Unfortunately, this commitment weakened Stephenson's concept of where the line should run and lie, creating an awkward complication for the future when he was reinstated as engineer to the Bolton and Liverpool railway schemes.[7]

IV

The building of a 'cheap and expeditious *Communication between* Liverpool, Manchester and Bolton' came with the authorisation of the predominantly Liverpool financed Kenyon & Leigh Junction Railway in 1829. From January, 1831, the advanced state of this line permitted the passage of goods traffic, with the result that the 'Bolton and Leigh Company commenced to run its own goods and mineral trains, not only over the ... Junction Railway ... but also over the Liverpool and Manchester Railway through to the Edge Hill station ...' Hick's Soho Foundry was therefore brought into being at a propitious time as the movement of raw materials became less restricted and free to rise in volume under the stimulus of growing manufacturing activity in Bolton.

The railway connection to Liverpool permitted the carriage up to Bolton of several thousand tons of cotton and 'goods for bleaching, printing etc', while railway carriage down to Liverpool allowed the movement of 'white goods' and 'Printed Goods etc. from Bury and its neighbourhood'. Over the 28 miles of railway between Liverpool and Bolton, it was anticipated that 10,000 tons of 'iron and other metals' would be moved annually to Bolton, along with larger quantities of grain, timber and slate etc., plus groceries, oil, spirits and vegetables. 'Sundries' down to Liverpool, which presumably included finished metal goods, would amount to 1,000 tons per annum.

Hick's awareness of the value of railway carriage led him to locate his foundry on a site adjacent to the Bolton railway, with a siding into his works. Nothing can better illustrate the meaning behind Hick's choice of location than a letter, dated December, 1833, addressed to 'Mr. Hick, New Foundery, Rail Road Fnd, Bolton'. The convenience of railway carriage from within the works was an important consideration in Hick's mind, that determined Hick & Son's location. As an engineer Hick benefited directly from the building of the Bolton & Leigh railway. The first train to make a round trip to and from Liverpool was hauled by 'Union', a locomotive built by Rothwell, Hick & Rothwell. Valuable experience of locomotive design and construction was learnt from meeting the requirements of the Bolton railway, while the escalating cost of construction provided a more tangible benefit to contractors, such as the Union Foundry, who may have been responsible for the two permanent engines installed on the line. Stephenson estimated that three locomotives would be necessary for the Bolton railway, with two engines 'going continually & 1 for a reserve'. But by the summer of 1831 five locomotives were in use, three of which had been built by local foundries. The opportunity for substancial financial gain certainly existed for Hick as expenditure on the project was eventually double

Stephenson's estimate, while as a member of the Railway Committee Hick was in a strong position to direct contracts. James Hardcastle's letter to Hulton confirms that Rothwell and Hick received a 'preference' for foundry, or engineering work, and from the start the making of the railway involved large sums of money.[8]

The company of proprietors authorised share subscription of £44,000 was based on Stephenson's estimate of the project's cost and construction was permitted once the capital had been subscribed. However, once work had begun the company was compelled to seek additional powers, including the authority to raise a 'further' sum of £25,000. This power was conferred in the spring of 1828 when the original sum of £44,000 was completely subscribed for, but not wholly raised, and not 'sufficient to finish and complete' the railway. Stephenson's railway estimates became notorious for their inexactness and detachment from reality, and that of the Bolton and Leigh railway appears to be no different. By July, 1826, eighteen months after Stephenson's estimate of the railway's cost, the 'Probable expense of Completing' the project stood at £56,564. A figure of £14,231 had originally been arrived at by Stephenson for the cost of 'Excavation and embankments'; by 1826 a further sum of over £11,000 was required to complete these works. 'Rails', previously estimated to cost £8,360 now required £16,200, while expenditure on some items of rolling stock exhibited a spectacular increase. Stephenson had ascribed a figure of £600 to the cost of 'Waggons', but the later estimate reads: 'To 80 waggons, c. £30 each, £2,400'. The cost of the three locomotive engines showed no change and remained at £600 each, whereas the two fixed engines judged necessary by Stephenson, costing £1,500 each, had multiplied by the Summer of 1826 'To 3 Stationary Engines Complete £7,020'.[9] The escalating cost of the project was a major reason behind the aquisition of additional powers from Parliament.

By 1831, a sum of £66,000 had been raised from subscribers by the creaton of 120 new shares of £100 each, with a further £3,000 raised by mortgage. However, not only was the railway 'not yet completely finished', but the monies already raised had been expended, together with an unauthorised sum of £20,354. The subscribers had raised 'themselves, by a Contribution of £25 for ... every share of £100 .., the sum of £16,500', and it was deemed 'expedient' to add this sum to the company's capital by means of 660 shares of £25 each. At the same time the company was 'authorized to borrow on the Credit of the ... Undertaking the Remainder of the said Sum of £20,354, and also a further additional sum or sums ... completely to finish and perfect ... said Railway'. In 1836, when the Bolton and Leigh company sought the power to connect with the Manchester, Bolton and Bury railway, it had actually raised £66,025 through the 'Creation of 641 new shares of £25' and a sum of £21,100 secured through mortgage. The additional powers, allowing the Bolton railway to effect a connection with the railway from Manchester, authorised the raising of £60,000, 'over and above the Sums ... heretofore raised or authorized'. Eventually, in 1845, the Bolton and Leigh company was consolidated into the Grand Junction Railway Company when its share capital amounted to the sum of £82,025, divided into 660 shares, while loans through mortgage debt totalled £24,100.[10]

The evidence presented by the Acts suggests that the Bolton and Leigh railway incurred one of Stephenson's notional estimates, because in 1831 the railway, though open to the public, was still incomplete despite the expenditure of £89,354. However, Stephenson himself was critical of the railway's line and cost following his reinstatement as engineer early in 1827. This was itself a significant event. Hitherto, Stephenson had been so preoccupied with the Liverpool scheme, that his

grip on the Bolton railway had been weak. Two surveys of the line had originally been prepared, one by Robert Daglish and the other 'under Stephenson's instruction' by Hugh Steele. The latter was adopted and Daglish, a pioneer railway engineer, supervised construction.

V

Daglish had hoped to complete the Bolton railway by June, 1828, but for the opening ceremony, held on August 1st, 1828, only the length from Lecturer's Closes to Hulton's collieries at Chequerbent was completed. The railway's opening was marked by an impressive display of rejoicing. Music played, coal was distributed to the poor, the locomotive christened with a garland and a crowd of 'upwards of 40,000 persons' cheered the ceremonial procession into Bolton. For the inhabitants, whose feelings Hulton and the other promoters claimed to represent, the opening of the town's railway offered as good a reason as any for celebration. But it was also an occasion exploited by Stephenson, who was anxious for the adoption of steam locomotion on the Liverpool railway. Stephenson's display of the capabilities of one of his locomotives explains why the ceremonial opening was different from that planned.[11]

On the opening day Stephenson was given the 'entire management on the line' and seized the opportunity to show off his engine, the 'Lancashire Witch', whose appearance in Bolton came at a crucial moment for steam locomotion. The Stockton & Darlington railway had been open for almost three years and was failing to vindicate Stephenson's faith in engines and rails. Traffic and profits were scant. Horses hauled the passenger traffic and it was rumoured that they were to replace the expensive locomotives for moving goods. More alarming was the financial state of the Liverpool railway company, which in 1827 had secured the power to borrow £100,000 from the Exchequer Loan Commissioners in order

to continue construction. The company's difficulties led to Telford, the commissioners engineer, being instructed to report on the railway's workings and estimate the cost of completing them. His critical and unflattering report, carried out at the close of 1828, confronted the Directors with the problem of railway traction and they resolved, in April, 1829, to hold the Rainhill Locomotive Trials. The Trials were also the outcome of the inconclusive debate on railway propulsion among engineers that was becoming intense from the Autumn of 1828. By the Spring of 1829 the Directors of the Liverpool railway had, in the space of six months, 'received six reports and a volume of correspondence ... on mechanical traction'. Stephenson was determined that locomotives should work the Liverpool line, but 'travelling engines had their detractors, who favoured propulsion by rope and fixed engine'. At the time of the Bolton railway's opening Stephenson's case was weak because 'it did not appear that any spectacular improvement had been made in the locomotive since it first went into regular service in 1812'. By contrast, the stationary steam engine 'was a comparatively efficient and reliable machine', and when, in December 1828, Walker and Rastrick were commissioned by the Liverpool company to examine existing railways, the Bolton railway was one of the few lines where both travelling and stationary engines could be examined together. Both engineers visited this and other railways in January, 1829. Exactly a year before, the Liverpool Directors had authorised the building of the 'Liverpool Travelling Fngine' for £550. In detail this was 'in many respects ... a prototype for the Rocket' and as the 'Lancashire Witch' of the Bolton company she would have been seen by Walker and Rastrick. Their reports did not present 'any definite conclusion as to the best method of operating the railway'. But Walker did suggest the holding of a locomotive trial and in April the Directors 'decided that no system would be adopted that might inhibit the Company from benefiting from any

future development in mechanical transport, and the locomotive was the machine where more improvements were likely to be made'.[12]

Set within the context of an indeterminate debate between the adherents of railway propulsion by either fixed or travelling engines, the opening of the Bolton railway was possibly a key moment, that could vindicate Stephenson's case for the locomotive. At the very least, the ceremonial opening of the line presented an opportunity to impress the several influential gentlemen present, with a display of locomotive power. The ceremony was meant to begin at noon, with the departure of the locomotive, hauling twelve wagons, with a party of guests and musicians, to the summit of the inclined plane. The instructions requested the party of ticket holders to assemble 'soon after eleven o'clock' and noted that in each of the ten waggons 'four seats' were reserved by the directors 'for the other proprietors present:- It being calculated that not more than 10 Directors will be present'. However, 'as the visitors were making their way to the starting point' they found three wagons loaded with 'about 40 people' and thought that an unplanned treat was in the offing. Hurrying 'with all speed to headquarters' the visitors discovered Hulton's steward, Hopper, 'loading six waggons with coal. Each contained two tons and some of the lumps weighed at least 12 cwts each'. Also present was the as yet unchristened 'Lancashire Witch', 'driven' by Robert Stephenson, the elder,

> and a coach capable of holding 40 passengers, but it contained upwards of 60, to which were attached six waggons in front and seven behind for passengers. Besides this were the coal waggons previously mentioned, on the front one of which was Mr. Hopper and his son, Mr George Stephenson, the engineer .., and Mr. Spooner, manager of the Bolton Gas works.[41]

The train ascended the Daubhill incline to the stationary engine where the locomotive was christened, before a 'series of trial runs' were given. According to another account: 'Several experiments were made of the capabilities of the locomotive engine and on one occasion it travelled, but unladen, at the rate of twelve miles an hour'. The locomotive then returned to Bolton, passing lines of people, drawn to the occasion, while 'upwards of 40,000 were assembled' in the town, who cheered the procession's arrival.[13]

The instructions for the opening ceremony called for two ascents of the incline by the locomotive, with the party of guests preceding a train of eight coal wagons. On the day, Stephenson dispatched both the guests and the coal in one train to the summit of Daubhill. His confidence that the 'trial runs' would favourably impress the guests was not misplaced. The appearance of the 'Lancashire Witch' produced a glowing tribute in the Bolton Chronicle, that reported on its 'remarkably steady and silent' movement, 'which elicited from all who saw it the most unqualified testimony and approbation to its construction and operation'. Among the guests present at the ceremony, whom Stephenson wished to influence, were 'many of those inhabitants of Manchester, Liverpool and Bolton who have been long eminent ... for varied knowledge, mechanical genius and commercial enterprise'. Charles Lawrence, chairman of the Liverpool railway company, was present, as were 'Mr. Robert Gladstone, Mr. Hick, Mr. Moss, Mr. Sandars and others'. Stephenson was intent on proving that steam locomotion was not a dangerous aberration and that the doubts entertained by respected engineers, such as Telford, who could not conceive how the Liverpool railway was to be worked, were without foundation. Among the Liverpool Board only Henry Booth and Joseph Sandars shared Stephenson's faith in steam locomotion at this time, so it was essential to win other minds to his side. The ceremonial events on the Bolton railway in[42]

August, 1828, foreshadowed those held fourteen months later at Rainhill, and represents an important test of locomotive traction at a time when the Liverpool railway was incomplete and the debate over the method of propulsion was reaching its height. Hick witnessed the performance of the 'Lancashire Witch' and may have been persuaded by Stephenson's display that the future for steam locomotion was more rewarding than he had first imagined.

VI

In April, 1831, John Hargreaves Jnr. (1800-1874) was introduced to the Directors of the Liverpool company as the lessee who planned to operate the railway between Bolton and Liverpool. Exactly a year before it had been arranged for the Bolton company 'to work their trains between Bolton, Liverpool and Manchester on payment of toll and on condition they found their own locomotives, waggons and carriages'. The Bolton company found it congenial to reach an agreement with Hargreaves Jnr., whose carrying expertise seemed appropriate to running a railway. The arrangement proved successful and 'he was soon in charge of the entire traffic, operating both locomotives and rolling stock', moving freight and passengers. Hargreaves' trains became a familiar sight on the tracks of the Liverpool company and when, in 1836, the Bolton company acquired the power to lease the Kenyon Junction line Hargreaves contracted with the company to work both lines, paying rent to the Directors. Hargreaves father, John Hargreaves (1778-1860), had built up the carrying business begun by his father in the eighteenth century and the new 'Rail-Way Conveyance' of the nineteenth presented fresh opportunities to this long established family business. Marshall says Hargreaves Snr. was a Bolton carrier, but the business he operated was not parochial in scale. A Bolton directory of 1814-15 lists Hargreaves as one of three carriers, operating 'to Preston and the North', and in

3

1818 Hargreaves' wagons were travelling daily from his Warehouse, Deansgate, to, for example, London, Edinburgh and Glasgow, including 'all the intermediate places', with a twice weekly service to towns on both sides of the Pennines. But the appearance of railways threatened to efface the whole business of medium and long-distance land carriage by horse wagon and canal barge.[14]

The railway companies 'principal aim was to supply improved transport facilities for existing customers' and traffic data reveals that both freight and passenger traffic 'grew steadily' from the time reliable data were collected in the 1840s. The Trunk lines in particular 'established themselves' by meeting the needs of 'high-fare-paying passengers from the stage coaches', and manufacturers and traders, anxious 'to relieve the burden of high inventory costs' that were involved with road and canal carriage. Railways 'encouraged a widespread reduction in costs' before becoming 'substantial movers of freight', while the impact of the Bolton railway, an early local scheme, certainly demonstrated to Hargreaves Snr. how irresistible this new form of competition was. At the close of the 1820s Hargreaves was firmly committed to canal carriage, with a warehouse at the Salford terminus of the Bolton canal and boats to 'Bolton, Blackburn, Preston, Lancaster, Kendal etc'. The opening of the Bolton & Leigh railway immediately reduced the cost of coal by 2/- per ton in Bolton, evidence that railways presented an explicit threat to existing methods of distribution. Early railways, such as the Stockton & Darlington were leased to contractors, who undertook to work the lines and this practice presented an opportunity to Hargreaves and his son. The activities of Hargreaves Jnr. on the Bolton railway were matched by those of his father on the Wigan Branch railway. This had been promoted by Wigan coal proprietors and worked from its opening in September, 1832, by the Liverpool company. Hargreaves Snr. quickly 'offered to take over the

Wigan traffic between Liverpool and Parkside' and was allowed to lease the Wigan line once the Liverpool company's returns vis-a-vis those of the Wigan company proved embarrassingly large. By 1834 an agreement had been reached 'whereby the traffic between the railway and Chorley, Burnley and other places on the Leeds and Liverpool canal was transferred from Leigh to Wigan'. Railway traffic at Leigh was, of course, worked by Hargreaves' son, which no doubt assisted Hargreaves Snr.'s purpose. The Liverpool company continued to work trains over the Wigan railway, but from the close of 1835 'all goods were carried in Hargreaves' waggons'.[15] Hargreaves Snr., who already operated out of Wigan on the Leeds-Liverpool canal, had correctly perceived the implication of railway goods traffic on existing systems of transport and showed no hesitation in gathering traffic to the newly arrived railway, once he had control of its freight service.

The success of the Liverpool railway encouraged the promotion of other schemes, with the result that the 'gradual extension of railways in Lancashire made the Liverpool and Manchester the hub of an extensive local network'. Benjamin Hick played a minor role in the creation of this network, but it brought him into company with John Hargreaves Jnr., who went beyond leasing railways and actively promoted them in order to work his wagons over greater distances. After promoting the Bolton & Leigh railway Hick became one of the proprietors of the Bolton & Preston railway. John Hargreaves Snr. and his son were also proprietors and sat with Hick as members of the first Board of Directors of the company. The railway to Preston was projected to connect with the Bolton end of the Manchester, Bolton & Bury railway and in 1838 it was authorised to effect a junction with the North Union Railway at Euxton, allowing a termination to be made with the Lancaster canal at Preston. Here branch lines were permitted to be built 'in order the more conveniently to

45

bring the Canal Traffic upon and from' the North Union. In 1844, the Bolton & Preston railway was incorporated into the North Union and John Hargreaves became one of the first Directors of the larger company. The North Union Railway had been created in 1834 through the consolidation of the Wigan Branch and Preston & Wigan railway companies, creating a 'continuous' line from Preston through Wigan and terminating with the Liverpool railway at Parkside. Hargreaves Snr. was already involved as lessee of the Wigan line and as a proprietor of the Preston & Wigan railway from its authorisation in 1831, while from 1839 'a Mr. Hargreaves of Bolton' was sole carrier on the North Union line, providing locomotives for the goods trains. Further north, the Lancaster & Preston Junction railway, authorised in 1837, was built to 'communicate' with the North Union in Preston, while its Lancaster terminus was placed close to the canal that ran to Kendal. The Hargreaves, father and son, were among the proprietors of this railway scheme and from February, 1841, seven months after its opening, Hargreaves Jnr. 'began a daily service of goods trains between Preston and Lancaster, paying tolls for the use of the line and rents for warehouses'. The Bolton & Preston railway was open from February, 1841, following the completion of a length of line 9 1/2 miles long from the end-on junction with the Manchester, Bolton & Bury railway.[16] At first the Manchester company worked the Bolton & Preston railway and also arranged to work the Lancaster line, alert to the possibility of working through from Manchester to Lancaster. However, Hargreaves Jnr. had similar ideas in mind and was in position to put them into practice. In 1840, he had become Chairman of the Bolton & Preston company and from February, 1841, he was carrier on this line, working his wagons between Bolton and Lancaster on the rails of the Bolton & Preston, North Union and Lancaster & Preston Junction railways. The Bolton & Preston railway was not open throughout until the Summer of 1843, but Hargreaves would

have been able to reach Preston and Lancaster via Leigh, Kenyon Junction and Parkside.

From December, 1831, Hargreaves Jnr. was hiring locomotives from the Liverpool company for use on the Bolton & Leigh railway and a month later he was buying engines from this source. 'By 1840 he had 14 locomotives of a variety of designs and supplied by eight different makers', including the Vulcan Foundry, Tayleur & Co., and Edward Bury among others. Hick & Son's very first locomotive, the 'Soho' of 1834, was built for Hargreaves, while Bolton also supplied the six First Class carriages used in operating a 'regular passenger service between Bolton and Liverpool'. There were also some 300 goods wagons 'used for coal one way and merchandise the other'. The coal traffic to Liverpool was a major reason for the agreement between the Bolton and Liverpool companies.

Hargreaves 'had six engines working his goods trains' on the North Union Railway, but he also promoted special passenger trains. The North Union was a strategically important line whose rails reached out to Birmingham, Liverpool and Manchester. Hargreaves, alive to the implications of this for passenger travel, became a pioneer of passenger excursions from Bolton to Liverpool and London, with delayed return from the capital available through the provision of lodgings. Hargreaves role as a railway contractor proved an agreeable one, particularly at a time when the Lancaster & Preston Junction railway was in dispute with the North Union, who in turn fought one of the earliest rate-cutting wars against the Bolton & Preston company. But with the absorption of several railways by the Grand Junction Railway Company in 1845 Hargreaves ceased to be a carrier.

Hargreaves and his father had successfully adapted to the arrival of the railways, exploiting them in order to continue the family

4-7

carrying business. From the early 1830s Hargreaves Snr. was despatching goods daily to Blackburn, Lancaster, Kendal and into Scotland from the 'Bolton and Leigh Rail-way warehouse', while his son was sending goods to Liverpool and Manchester 'per the railway'. Within a few years their extensive carrying service was carried out from the 'Bolton railway office'. By 1845 Hargreaves had warehouses in Crook Street and Deansgate and was the dominant carrier operating in the town, offering a service to a list of places recently made accessible by railways, while the conveyance of goods by water occupied a minor role. Since 1834 Hargreaves had been a Trustee of Great Bolton and from 1845 Hargreaves was a magistrate. But after 1845 there is no trace of the Hargreaves as carriers, not one indication that the family business continued beyond the creation of the Grand Junction Railway. In that year, according to Marshall, Hargreaves Jnr. 'joined his younger brother William and John Hick' at the Soho Foundry and established Hick Hargreaves, while also developing colliery and textile interests. Benjamin Hick had died in 1842 and was quickly followed to the grave by two of his three sons. Hick and Hargreaves had collaborated together on railway matters. Hick was a manufacturer of locomotives, while Hargreaves employed them. There are enough similarities of interest between the two men to explain Hargreaves involvement in engineering. But the most convincing of attachments was the supreme tie of consanguinity created by the marriage of Hick's eldest daughter, Mary, to John Hargreaves Jnr. in 1836.[17]

VII

The dissolution of Hick's partnership with Peter Rothwell was the prelude to the creation of an extensive concern equipped with machine tools adapted for slotting, cutting and planing the workpiece. Robert Daglish, writing soon after Hick's departure, remarked that it would 'require a considerable time to get the large establishment you

intend to go (?) upon, ready for action'.[18] Hick's aim was that machinery and not skilled hands alone should satisfy his obligations and those tools that Hick could not provide himself were bought from Nasmyth, Gaskell & Co.[19] Hick was a notable designer and builder of machine tools, an engineer who appreciated their importance for manufacturing metal goods, and an entrepreneur who was anxious to set a high and exacting standard. His works embodied the ideas of a keen mind brought to familiar problems. The solution to the problem of coping with heavy articles in the process of assembly was a branch railway throughout the whole works linked to the adjoining Bolton and Leigh railway.

The manufacture of locomotives had attracted Hick's attention before 1833 and the Soho Foundry was well adapted to undertake this class of work because of the fixtures built up by Hick. Yet craft skills remained crucial to the operations of Hick's venture and during the first year of Hick & Son's life 179 skilled and unskilled men were hired, representing a variety of trades. Appendix One illustrates the number of men and their trades engaged by the proprietor before the close of April, 1834, and those remaining in Hick's employ at the end of the firm's first year.

Hick & Son's commitment to locomotive engineering was reflected in the creation of a distinct locomotive shop. But in 1841 this department comprised one 'Forman of Loco' Shop' and five fitters. The number of locomotive hands employed at the Soho Foundry never rose above 13 and declined from this size in 1849 until just one locomotive fitter remained in 1858. This reflected the place of locomotive building within an enterprise whose classes of work embraced stationary engines, boilers, millgearing, hydraulic presses, weighing machines, gas light apparatus and, indeed, any article fashioned from metal. The

manufacture of such a wide range of articles was rational to an establishment that embodied costly machine tools, while the severe depression of the late 1830s emphasised the value of each job. By 1842 Bolton's engineering firms were 'working on an average only four or five days a week', whereas six years before overtime had allowed 'some departments' to work 'from 9 to 12 days a week'. Over the period 1836-42 795 men employed by the engineering Masters had been discharged from a total figure of 2,110 employed in 1836. It was noted that a 'considerable number' of the unemployed had 'left the country, some for the continent, others to America, carrying away their skills and our experience to aid our rivals'.[20] Under these circumstances locomotive work could not have been ignored by such firms as Rothwell & Co. and Hick & Son. Any class of work that assisted the Masters by covering fixed costs and allowing the retention of skilled hands was valuable.

However attractve locomotive building was to engineering in the 1830s, it was attended with difficulties that eventually compelled some firms to choose between outright specialisation in locomotive work or one of the other classes of engineering. Hick & Son faced this choice at some point in the 1850s, when locomotive work ceased at the Soho Foundry. According to Lowe the last engines built by Hick & Son were manufactured for stock in 1849-50 and delivered in 1851, while Ahrons' believed that two more locomotives 'were supplied to the Stockton & Darlington Railway in 1855, after which date no record appears to exist ... of further locomotives constructed by the firm'. Nonetheless, a striker and a smith were taken on for work 'in the Loco Shop' as late as December 1863. The dwindling size of the locomotive department from 1849, together with the known output of this shop, would suggest that locomotive building at the Soho Foundry ceased in the mid-1850s. The basic reason behind this decision can be found in the nature of the market for locomotives. But a contributory influence was

an awareness of the difficulties inherent in this line of engineering, which were apparent when locomotives seemed an appropriate article for Hick & Son to produce.[21]

The design of Benjamin Hick's engines was strongly influenced by Edward Bury, the exponent of a school of locomotive engineers, whose four-wheeled engines appealed to both manufacturers and users alike. Hick was undoubtedly influenced by a proven design that would sell. Indeed, the volume of orders to Edward Bury & Co. was so great in the 1830s that many orders were subcontracted to several other firms that included the Soho Foundry. It made commercial sense to follow Bury's practice and build 2-2-0 and 0-4-0 Bury-type engines, particularly as sales were promoted by Bury's management of the London & Birmingham Railway's locomotive department from 1837, which allowed Bury's firm to secure a 'virtual monopoly of the supply of locomotives to the first of the great trunk lines'. Such control over purchases inevitably led other builders to copy Bury's design and in 1837-38 Hick supplied seven four-wheeled passenger engines for the London & Birmingham Railway. Moreover, Bury's influence over locomotive policy extended to other lines, who adopted the Bury type almost exclusively. Ahrons' comment on Hick & Son as locomotive builders was that 'Much of the earliest locomotive work of the firm was devoted to Bury's type ... and most of them were built to Bury's orders and designs, and had the standard dimensions then adopted by the engineer'. But the emulation of an accepted design did not offer the certainty of a successful contract.[22]

Nine Bury-type engines were built by the Soho Foundry for the Midland Counties Railway in 1840-41. A decade earlier the Bury type had represented an advance in locomotive engineering. By the 1840s the limitations of a small unit of power that was incapable of improvement were becoming increasingly evident. Nonetheless, the Bury engine was a

simple design that was dependable in use, provided the workmanship was thorough. Hick had set himself the challenge of creating an enterprise capable of turning out articles whose build exhibited a high standard of finish, a standard founded on machine-shop practices. But the evidence offered by the correspondence of Josiah Kearsley, the Locomotive Superintendent of the Midland Counties Railway, suggests that Hick's model enterprise failed to meet the demands of a new branch of engineering. Not only were Hick & Son slow in fulfilling orders for engines in 1841, but they also failed to heed Kearsley's pleas to avoid certain technical pitfalls. Benjamin Hick's eldest son, John, had charge of locomotive affairs and was personally responsible for taking the dimensions of the Bury design, the standard engine of the Midland Counties Railway. Hick & Son was ultimately responsible for the supply of a quarter of this line's passenger locomotives in the shape of Bury 0-2-0 singles. Yet the engines the firm supplied in 1841 hardly exemplified the best practices in engineering. Early in the year, Kearsley had expressed his disappointment that the engines were 'in such a backward state' and he requested John Hick to 'pay particular attention to the case hardening, as all your other engines have been very poorly done one & all'. Kearsley more than once asked 'that very great care is taken in the case hardening', because this was the 'most essential point to ensure the accurate & pleasant wear which the gearing of a locomotive requires to work well; and if not done well; the engine very soon deteriorates and loses her character'.[23]

Several months passed before the three engines contracted for were delivered to Derby. They had only been in use for a short time when several deficiencies in build came to light. The metallic piston rings fitted to Hick's engines required alteration 'in <u>every trip</u>' and prompted Kearsley to remark that 'Those at present in the engines will I

52

feel very sure do us no service, & you no credit'.[24] The boiler tubes of Hick's earlier engines had failed 'after doing the least work and before any others' and a similar problem affected one of the three later engines. Her tubes leaked so badly that they constantly required re-ferrulling. Kearsley ascribed this problem 'to the tubes having not been properly drifted previous to driving in the ferrules'.[25] Some time later Kearsley despatched the following to the Soho Foundry:

> Specimen of Ferrules taken out of No 34 engine - after running 9 days - every tube leaked & on taking out the ferrules - the tubes were found very slack - not half drifted very unlike Hick's work in general[26] and not likely to gain credit.

Hick & Son's experience with the Birmingham & Gloucester Railway in the same year reveals that the firm could turn out well finished locomotives; that the combination of craft skills and precision tools was technically rewarding. Unfortunately, the commercial rewards of the locomotive market proved illusory where the supplier was dealing with a financially weak company, as in the case of the Birmingham and Gloucester. This railway adopted the American 4-2-0 bogie engine built by Norris of Philadelphia, a design familiar to Hick because of the strong influence exerted by Edward Bury upon American locomotive builders. The Norris engine also exhibited American manufacturing practice that in the opinion of British commentators compared poorly with British practice in locomotive construction. The appeal of the Norris engine arose from its well publicised adaptation to American conditions, which the Birmingham and Gloucester Railway had reproduced in the Lickey Hills by building the daunting Lickey Incline. American railroads were built on the up-and-over principle that Capt W.S. Moorsom adopted for the Birmingham-Gloucester route. Moorsom believed that the Norris engine could overcome the strenuous two-mile incline he had

5

constructed at a gradient of 1 in 37.7, the most demanding railway ascent in Britain in the era of steam locomotion. To overcome this steep gradient the Birmingham company imported 17 Norris engines from Philadelphia between 1839 and 1842 and purchased another 9 on this pattern from Nasmyth, Gaskell & Co. and Hick & Son in 1840-41, who also supplied Norris locomotives to Continental railway companies in 1841. In April, 1840, John Hick had visited Birmingham to copy the dimensions of the 'Victoria', a heavy class Norris engine. He copied the sample engine in such detail that engines produced at the Soho Foundry 'differed little in constructional details from the Philadelphia productions'. At the same time the Hick engines acquired features that reflected 'current English practice of the period'.

Moorsom described the American engines as 'very simple and the work plain', but a potentially 'durable and economical machine'. David Joy commented of one of them: 'The little thing could pull, but she was odd, plenty of cast iron in her, even the cross-head pins were cast iron'. Although the Norris engine compared poorly in some minds with British practice, Moorsom was content with their fit and finish.[27] When the Patricroft firm departed from the sample engine by substituting wrought iron, steel and brass for cast iron, Nasmyth was compelled to defend these improvements against Moorsom's censure. Hick's engines also differed structurally from those imported into Britain, the most noticeable difference lay with the bogie and its 'centrally placed pivot'. Once delivered to Birmingham, the home-built engines proved subject to failure and Hick & Son were prompted to send their Locomotive Shop Foreman to report on and rectify the three engines built by the Soho Foundry. The foreman's appearance followed the trials of two of the engines at which John Hick was present. The performance of the locomotives supplied by the different builders was the cause of much

54

interest and speculation by the separate parties on the line. At the close of 1840, Nasmyth instructed his representative at Cheltenham 'to take particular notice of the various parts wherein the American engines have failed ... how Hicks engine is and what is the matter with it'.[28] News of the state of Hick & Son's engines and those built by Nasmyth was given to the firm by a customer of the Soho Foundry in Birmingham, while comparisons with the performance of other engines was a feature of the foreman's reports to Hick.

The foreman reported on the repairs necessary to make good the wear and tear on the engines as they were tried on the line. The result of the experimental trials was encouraging, reported the foreman, who in time noted that the engines were 'certified', so that any further defects would be at the railway company's expense. Here was the point of conflict between Hick & Son and the purchaser, because failures continued to afflict the engines well after their delivery. In one of his later letters, the foreman disclosed that new defects had appeared in one engine that included cracks in the rims of 'two of the small wheels'. The foreman confided that only he and the driver knew of the deficiencies and the Master's reply was that the foreman should return to the firm 'if he could do so'. Hick & Son 'would prepare a new pump' for the one damaged, while the wheels were 'as good as can be made on that plan with the best Iron we can procure & we cannot be responsible for them'.[29]

The acceptance of Hick & Son's engines by the Birmingham & Gloucester Railway was followed by an acrimonious correspondence between the parties that revolved on who was liable for certain charges. The Soho Foundry included a 'Bill for Sundries' that the Directors refused to 'admit particularly as they observe a great portion of it is for wages while your men were attending on the Engines'. Burgess, the

company secretary, wrote:

> now it is obvious that if the Engines had been what they ought to have been this attendance would not have been required & that if the Compy intended to make the repairs etc themselves - there would have been no occasion to have had your men.

Burgess went further and cited certain charges for repairs, saying that until these items had been replaced 'your Engines scarcely ran a journey' without failure. The secretary's defence of the company's interests developed into an attack of the engines supplied by Hick & Son. Burgess wrote:

> in fact without wishing to irritate your feelings I must say the Compy & all connected with it have been chagrined & dis appointed with your Engines - I was one who always opposed the American purchases & I did expect that when you recd the orders of the Directors we should have had something of a superior kind - but up to the present time not one of your engines has run a week without breaking - The bogie wheels professing to be equal to the Americans are all worn out & several of them broken the Americans have run 9 months not one is broken or had to be changed & they are very little worn.

Hick & Son clearly defended themselves against Burgess's criticism, because in one of his later letters Burgess wrote: 'My remarks on the quality of you Engines are founded (unfortunately) on facts'. By early June, 1841, the Directors had reached a decision on the firm's account. Burgess wrote:

> Referring to your a/c against this Company & to the claim which you have made for the repairs of the Engines - the same has been

referred to Capt Moorsom & he conceives you can have no claim whatever for such charges - The Directors do not however wish to keep the matter open nor to dispute upon trifles they have therefore authorized me to say that they will meet the matter by accepting your Draft for the amount say £2470.18.6. at 4 months - this offer is of course made without prejudice - & is I think under all the circumstances attended on the Engines a liberal one.[30]

The criticism levelled at Hick & Son by Burgess, together with the condemnation voiced by Josiah Kearsley, appears to question the value of Benjamin Hick's engineering practices. The remarks suggest that just as there was a rational reason for adopting locomotive building in the first place, there was also a compelling commercial reason for abandoning this class of work, as it proved too demanding an activity in its own right for the firm to pursue amongst a number of other activities. In truth, the defects in build that Kearsley mentioned stemmed from poor boilermaking and fitting skills that in turn reflected upon the management exercised within the shops of the Soho Foundry. In November, 1841, for example, Kearsley sent the following to John Hick:

I hope the enclosed blocks are a <u>very raw</u> specimen of Bolton fitting. Pray apply a square to them & then give the fitter who got them up, what he deserves - Best respects to your Father.

The best endeavours of a machine-tool pioneer and engineering entrepreneur were to little avail when factory management and supervision failed to match the fixtures of a model enterprise. Hick sought steady workmen in the engineers, fitters and millwrights that he hired to fulfil contracts in his novel establishment. That this innovator was frustrated in his ambition is clear from the number of men Hick discharged for neglect, loss of time and insobriety. The remark[57]

'discharged for drinking' appears time after time in the early Names Books of the firm.

The realisation of Hick's aim of superseding craft methods of manufacture through an innovative use of machine tools relied upon craftsmen, whose attitudes and customs were in conflict with the Master's conception of labour-saving mechanisation. Disputes over the finish of Hick & Son's locomotives cannot explain the firm's retirement from this activity. The products of the Soho Foundry were probably no worse than the average pattern of British locomotive builders and instances could be given to illustrate the point that Hick's engines were no worse than other builds. For example, the Philadelphia-built engines praised by Burgess did not prove durable in use, because the iron fireboxes required replacement with copper ones, while there were a number of breakages of bogie wheels.[31] The basic reason behind the termination of locomotive building at the Soho Foundry was the changed structure of the market for motive power by the 1850s, with the close of the railway booms and the appearance of railway company workshops.

Locomotives were regarded as a fitting article for Hick's machine-shop practice well before the promotional activity initiated by the success of the Liverpool & Manchester Railway. By the 1850s locomotive engineering at Hick & Son had extended over a quarter of a century. It had occupied Hick's attention while he was a partner at the Union Foundry, but it never became a paramount activity of the Soho Foundry. The impinging demands imposed by locomotive work upon design activity and labour deployment in the shops meant that this activity could not remain as simply one of several lines of business. By dispensing with this class of work the Masters - John Hick and William Hargreaves - made a statement of the engineering trades that Hick & Son

was best adapted for. Until the middle 1850s locomotive builders enjoyed a 'golden time', playing a 'leading part' in the supply of engines. But by 1853 the railway companies were meeting their own demands, with the result that the market structure was fundamentally changed. Private builders were compelled to find customers abroad as the home market contracted before the appearance of railway company workshops, with long-term consequences for locomotive engineering in Britain. More immediately several 'celebrated' locomotive firms, that included Rothwell & Co., retired from the engine market. Hick & Son, who had never identified themselves strongly with locomotive building, responded to a changing market by specialising in other fields. Saul cites Rothwell & Co. and Hick Hargreaves as two of the several 'more important makers' who left the market during the 1850s.[32] Heightened competition for a shrinking home market seems to have been instrumental in killing the Union Foundry, while Hick & Son possessed the resources and the will to orientate themselves successfully to more rewarding markets.

Chapter 3

Andalucia: An Early Emulator of British Manufacturing Industry

I

In Andalucia, a remote region of Europe, far removed from the manufacturing activity of Lancashire, an attempt was made to create several modern enterprises that promised to raise the province of Malaga into the leading rank of industrial centres. Prominent among several Spanish entrepreneurs was Manuel Agustin Heredia, who in the 1830s emerged as the Peninsula's most outstanding entrepreneur. Heredia's entrepreneurial activity in collaboration with other wealthy individuals, such as Paul and Martin Larios, had transformed Malaga province by the middle of the 19th century. The achievement, at the time of Heredia's death in 1846, was that Malaga had become Spain's second industrial province after Barcelona, possessing iron and lead works and equally modern chemical and textile factories, while the demands of these industrial undertakings had stimulated the promotion of a bank and steamship company through Heredia's vigour. Following the death of His Excellency, Senor Don Manuel Agustin Heredia, the most outstanding member of the so-called 'Alameda oligarchy', an inventory of his estate revealed assets to the immense value of 78.6m reals. Capital net of liabilities was an impressive 60.5m reals and took the form of ships, premises, real estate and goods, credits and cash.

The manufacturing premises owned by Heredia included the 'San Andres' lead factory at Adra, while at Malaga, the provincial capital, lay the three soap producing works that gave Heredia a dominant

place in the region's soap industry. Two new ventures begun shortly before Heredia's death involved a chemical factory and 'Industria Malaguena', a textile enterprise initiated in co-operation with Paul and Martin Larios, both of which adjoined the 'La Constancia' ironworks. This enterprise and the 'La Concepcion' ironworks at Marbella were major undertakings that came to be largely owned and managed by Heredia.[1]

Benjamin Hick's involvement in the industrialisation of Andalucia antedates the Soho Foundry; in 1827 the Adra lead works received from Rothwell, Hick & Rothwell a 14 h.p. engine and blowing cylinders. Half a century later the tie with Bolton still existed as Hick Hargreaves & Co. Ltd. were supplying Larios Bros. & Co., Malaga, with millgearing. In 1833, while Hick was beginning his enterprise, the 'La Constancia' ironworks was taking shape in Malaga. The plant's tall chimney and top-knot of black smoke seemed more appropriate to Manchester than the Mediterranean coast. This expression of progress came as a surprise to foreign visitors, who, Spanish historians argue, arrived with a very distorted image of a poor Andalucia, backward and blind to the discoveries made in science and technology. Richard Ford's Handbook for Travellers in Spain described Andalucia at a time of industrial prosperity, as 'this pleasure-loving, work-abhoring province', populated by 'gay, good-humoured, light-hearted children of a genial atmosphere', who displayed indifference and procrastination, 'tempered by a religious resignation to providence'. The iron industry of Malaga province was a model of its kind, based on plant adopted from the leading industrial nations, but Ford was impressed more by the sight of a region half 'abandoned to a state of nature'.[2]

The 19th century had, however, witnessed a spectacular bid to transform the region's economy away from a dependence on primary produce and for a time the modern industries of the north were rivalled by the

iron and cotton ventures of Heredia and Larios in Malaga. Here, the firms 'Industria Malaguena' and 'La Aurora', the 'cotton-producing nucleus' of Malaga, consistently absorbed a rising volume of raw cotton that for over two decades exceeded 5 per cent of Spain's total import of this raw material. In 1844 the iron firms of Heredia and that of his 'servile' imitator, Juan Giro, accounted for 72 per cent of total Spanish pig-iron output and caused the 'dominance of the Andalusian iron industry' to prevail for several years. But the glittering promise held out by up-to-date ventures in iron, textiles and chemicals, ventures that reached out to Britain's manufacturers of capital goods, was rapidly burnt out. 'Malaga, which was, after Barcelona, the second industrial province of Spain between 1850 and 1860, was half century later completely disindustrialised'. Prosperity and success had stemmed from one mind alone, whose enterprising talent could not be matched by his successors.[3]

II

Manuel Agustin Heredia was undoubtedly the most dynamic figure among the local magnates of the south. His enterprise gave rise to an immense fortune, one of the largest in mid-nineteenth century Spain. Profits arising out of trade between Andalucia and the Spanish speaking territories of America financed modern manufacturing ventures, that in turn gave rise to new trading links. However, the inherent nature of Heredia's wealth, where the value of fixed assets was five times less than circulating capital, required decisive entreprenuerial control by his heirs to ensure the continuity of a vibrant dynamic business, where considerable risk was always present. Cristobal Garcia Montoro, the student of Heredia's wealth, has asked what became of this entreprenuer's fortune, which ranged across several branches of commerce, industry and finance, once it was in the hands of his

heirs? What attitude, he wonders, was adopted by 'la segunda generacion?' Montoro's entry into the study of Spanish entrepreneurship inspires the same fundamental questions familiar to British students of economic development at home. The founding entrepreneur was distinguished, according to Montoro, by intelligence, effort and an iron will to succeed. If these qualities of control and leadership were absent after 1846 this may explain Andalucia's decline into desuetude that became apparent from the 1860s.

Manuel Agustin Heredia arrived in the south in 1804 and launched his fortune through the extraction of graphite during the turbulent period 1808-14. His wife, Isabel Livermore, was half English and sister to the wives of Serafin Calderon, the writer, and Jose de Salamanca, the notable financier and willing protege of Heredia. He was not a mere opportunist whose aim was to create wealth and comfort by ventures in the traditional enterprises of the south. Heredia's mind aspired to achieve greater ends for which the profit acquired through commerce would be the means. Andalucia was, despite appearances to the foreign traveller, a fertile ground for the activities of a widespread commercial and manufacturing house, managed under one head.[4]

III

Andalucia had flourished in the eighteenth century. The early part of the century 'was the golden age of... latifundist agriculture, with fabulous profits for the owners of rural properties' that were a 'source of capital accumulation'. By the close of the century 'high-grade wine was being fostered' along the Andalucian littoral to satisfy new markets in northern Europe. Capital from foreign wine markets flowed into the region, giving rise to 'mixed companies... which in the course of time became consolidated through matrimonial connections'. In the 19th

century, the severe economic misfortune attributable to the loss of Spain's American colonies underlined the importance of viticulture to the economy, along with the extraction of minerals. In a country wasted by war and excluded from traditional foreign markets, the rich land of Andalucia offered an attraction to entrepreneurs alert to novel ventures and it was as a result of this attraction that Malaga became the 'commercial and industrial fief of the Heredia and Larios families'.[5]

Manuel Agustin Heredia's wealth may have been 'launched' by exploiting graphite deposits in the Serrania de Ronda, but at his death the House of Heredia had developed extensive commercial ties with the rest of Europe and the former colonial territories in America. Overseas commerce had long been one of Heredia's activities. During the wars of independence Heredia astutely traded with the Indies through neutral ships, principally British and American vessels. Subsequently, he was a pioneer in the creation of cordial business relations with the new republics, dealing in wine, cocoa and soap, as well as the fruits of the Americas.[6]

IV

The commercial success of the House of Heredia provided the basis for bold manufacturing enterprises that drew upon the latest industrial technology. Andalucia was rich in lead ores and from 1823 free working and exploitation was confirmed having hitherto languished under the dead hand of the State. Heredia did not initiate the lead smelting and processing works at Adra, but acquired a venture that possessed the potential for profit if managed well. In 1822 Casa Rein y Compania had erected a plant near the port of Adra to exploit the ore deposits in the Sierra de Gador. In the face of very low yields the company was

4

encouraged to install English furnaces that required the skills of British fitters and operatives. Production improved and additional machinery was imported, including a blowing engine built by the Union Foundry, Bolton, in 1827. When Heredia purchased the 'San Andres' foundry in 1837 it had become the property of Collman, Lambert & Co., London, and embodied many British features. Once Heredia assumed control the output of sheet and tube lead rose and in his 'Reforms in Customs Legislation' (1841) Heredia confidently claimed that his plant was supplying Spain's foreign markets and was in a position to compete with other free-trade nations in America. He later remarked that improved technology in the shape of British machinery would open up new horizons and offer far-reaching prospects. Unfortunately, there was a major problem to the operations of the lead works that also blighted Heredia's iron venture.[7]

By 1841 a major enterprise of Heredia's was the smelting and wroughting of iron at Marbella and Malaga. He was not alone as the demand for iron was 'unleashed' in Spain after 1830 at a time when the Basque Region, the traditional centre of iron production, was technically backward, 'even by the reigning Spanish standards', and in decline because of the loss of colonial markets and the decay of the Spanish navy. Entrepreneurs in the south of Spain were also favoured by the First Carlist War (1833-40), which disrupted production in the north and directed demand to the Andalucian works. Heredia was one of a group of promoters who, from 1826, attempted to exploit magnetic iron ore deposits at Ojen, near Marbella, with charcoal-fired blast furnaces erected besides the Rio Verde. But it was Heredia alone who persevered with the project and, inspired by the British example, adopted coal-fired furnaces in a new works at Malaga. Eventually the 'La Concepcion' (Marbella) and 'La Constancia' (Malaga) plants became an

integrated iron founding and forging concern that dominated iron production in Spain. Circumstances could not have been more favourable to the exploitation of the rich iron-ore deposits in the south. The commercial policy of the State from 1825 favoured an extension of the iron industry, while 'La Concepcion' could draw on the expertise of Francisco Antonio de Florza, a notable figure in the extraction and refining of Spain's mineral deposits, who had studied at close hand northern European methods of ironmaking. Elorza was a founder member of 'La Concepcion' whose works were established under Elorza's guidance.[8]

However, the actual mining operations, begun in 1825, were characterised by a haphazard approach that contrasted sharply with the company's carefully thoughtout organisation. The District Engineer, Francisco Sales Garcia, was critical of the open-cast method of extraction that was adopted because of the ore's abundance. By the late 1830s the area available for new diggings was close to exhaustion and covered in debris. Further mining required conventional excavations and these, the District Engineer reported, would 'be more costly now to set up than they would have been if this had been done at the outset'.

The location of the smelting plant was determined by the availability of ore and charcoal and the water power of the Rio Verde. Ore was carried from the diggings on horseback over a distance of 1 1/2 leagues, while fuel was obtained from the adjoining hills and motive power derived from the river. Florza directed the erection of the smelting plant and it was his wide experience of ironmaking methods, in conjunction with Heredia's drive, that saved the venture from ruin. The Catalan method adopted for smelting the ore simply failed to produce satisfactory iron and against a background of futile tests, delays and difficulties expenditure on the project began to exceed that envisaged at the outset. According to Heredia's subsequent account of events,

the majority of the partners, with two or three exceptions, saw the enterprise in 'a "self-destructive" light' and were afraid for the safety of their fortunes. Heredia was already the owner of the greater part of the share capital when he willingly accepted additional shares from his wavering partners, in order to avoid, as he explained it, the ruin of the company. Advised by Florza, Heredia implemented a thorough revision of iron making at Rio Verde. The Catalan forges were replaced by charcoal-fired Belgian (Walloon) forges in 1830 and two years later English puddling furnaces were in use. It was only from 1832 that the supply of charcoal-blast iron was assured for refining at 'La Concepcion'. In Britain coke smelting had developed first, calling forth a technological response in forging, whereby pig iron was refined into wrought iron. Continental countries learned to refine charcoal-blast iron first using coal, because the economies that could be secured were greater than those attainable through coke smelting. Originally at 'La Concepcion' ore was first smelted by the Catalan method and the iron made ductile using the Catalan forge, 'a descendant of the antique oven that antedated the blast furnace'.[9] This technology was proven while outmoded by comparison with innovations being made elsewhere in Europe; its failure to produce satisfactory results at Marbella moved Heredia to adopt new processes and create a quite different ironworks - 'La Constancia' - at the seaside resort of Playas del Carmen close to the centre of Malaga.

The Marbella works had from the beginning presented a costly fuel problem. Shrubs and pines from Ronda's sierra fired the blast furnaces and Belgian forges, but puddling required coal imported from Britain or Asturias. Shipping rates were expensive and became even more prohibitive in the case of ports which did not offer 'drawback' facilities: refunds on the duty paid. The port of Marbella, with little

67

export traffic, belonged to this category. Moreover, transportation inland, using packhorse, was a costly burden to the enterprise. Heredia was therefore induced to remove refining to the provincial capital because of the need to lower freight and haulage costs. Another influence was the desire to exercise a firm grip over the business and draw on the cheaper labour of Malaga. Consequently, iron processing was divided between two sites. At Rio Verde, the ore was smelted and the pig iron despatched for refining at the Malaga works, where wrought iron was produced by puddling and rolling. Here, too, foundry work was undertaken by casting iron into moulds.

In 1844 the 'Boletin Oficial de Minas' reported that the Malaga ironworks had been built to match the 'most advanced plants' of its kind abroad. According to other contemporary descriptions, the imported equipment represented the latest and most sophisticated innovations in iron refining, which was constantly improved due to the restless spirit of the entrepreneurs, who made frequent visits abroad to maintain a high technological standard. Skilled labour was also imported, but local workers quickly acquired the skills necessary to take their place. The appearance of 'La Constancia's' tall, plain chimney from 1833 seemed to place the seal of modernity upon Malaga, marking the onset of a period of manufacturing prosperity.

V

After 1833 Heredia moved to the forefront of industrial enterprise in Spain, becoming, in Nadal's opinion, the 'Peninsula's most outstanding entrepreneur', because of the complexity of his affairs, the output of his factories, the number of employees under him and Heredia's presence and success in all quarters. 'La Constancia' prospered greatly once its initial problems had been overcome, taking full advantage of

the shutdown of Basque ironworks due to the First Carlist War. Output from Malaga rose and southern iron supplanted that from the north in the national market. 'La Concepcion' and 'La Constancia' together employed 2,000 hands in the early 1840s, growing to 2,500 by the decade's close, and there were more hands retained at Adra, the soap factories and the commercial house of Heredia. The ironworks at Marbella had had a particularly arduous development, extending over four dismal years of experiment and a further three of low output, before intense activity in 1834 rewarded the technological innovations. Heredia's influence in policy-making circles helped procure favourable adjustments to the duties levied on iron goods, such as a reduction in the duty on iron gates secured in 1833. It is this personal influence that Heredia exercised to his advantage as ironmaster, which suggests that the civil war and closure of Vizcayan ironworks were simply contributory causes of 'La Concepcion's' prosperity and control over the national market.

The success of the Pio Verde works was reflected in the purchase of adjoining land for the expansion of operations, while the supply of fuel seemed secure because of a contract with the Count of Luque, that gave 'La Concepcion' the lease to the pine-tree forest of Benaharis for a period of ten years. An adequate supply of wood fuel was crucial to the two charcoal-fired blast furnaces that were in use in 1837. These were built of refractory bricks imported from England, with a blast derived from water-powered bellows. From 'La Concepcion' pig iron was carried by horse to Marbella and shipped to Malaga for refining. Contemporaries, such as the District Engineer, recognised that the separation of the two processes involved onerous haulage, supervisory and accountancy costs, and on occasion outright losses due to storms at sea. Nevertheless, it was at 'La Constancia' that iron from the blast

furnaces was made into wrought iron. If the smelting technology present at Rio Verde was characteristic of that in Britain half a century before, the refining techniques at Malaga represented an emulation of the latest British practice. At 'La Constancia' Cort's puddling and rolling process was adopted that allowed for the production of wrought iron in 'those standardized crude shapes - beams, bars, rails and the like - that... constitute the framework of industry, construction, and transport'.[11] Refining pig iron at Malaga in 1841 was achieved as follows:

> ...The first operation - reduction - takes place at seven fining stations, or reverberating furnaces, using fibrous anthracite coal (or, fossil fuel). Two skilled men and four apprentices man each station. The iron produced by them is forged by means of a drop-hammer attended by six operatives. It is then delivered to the forging rolls, manned by five operatives. All of these operatives are employed throughout each twenty-four hour period, being relieved in four six-hour shifts, i.e. six hours on, six hours off, .. The wrought iron re-heating operation is carried out in three air furnaces, also fed by fibrous anthracite coal, and manned by six skilled men and six apprentices; alternatively, two of the former and two of the latter in any twenty-four hour period. Once the iron is adequately hot, it is delivered to the rolls, which give it the desired shape, be it square or circular section, or sheet billet; nine operatives are employed at this rolling station over a twenty-four hour period ...

Power for the plant's rolls, drop hammer and a large shearing unit was provided by a 30 h.p. steam engine, while the blast to some furnaces subsequently installed was derived from a huge cast iron 'rueda hidraulica', or box water wheel.

Contemporary Spanish opinion was divided on the quality of Heredia's iron, but there was no disagreement over the superb plant of 'Ferreria de la Constancia de Malaga'. The entrepreneurs behind the project had devoted themselves to creating one of the finest ironworks that could be found and Heredia was keen to impress the Government with its outstanding iron-making technology. In 1841, 'La Constancia' already possessed 19 puddling furnaces, six annealing furnaces, a cupola furnace and three reverberatory furnaces for foundry work. Three steam engines with a combined power of 100 h.p. had been installed along with a ventilation plant for the cupola furnace. There was also a wide range of equipment present for processing the many types of iron demanded by the market. Buoyant demand for Heredia's iron, assisted by the disruption caused by the Carlist War, stimulated a rise in output that continued into the 1840s. Moreover, the efficient running of the works called for the erection of two blast furnaces at Malaga in 1843, that made 'La Constancia' a truly integrated enterprise; one that exercised a predominant role in Spain's iron industry for a further two decades.

Heredia was only too well aware of the vulnerability of his iron venture to low-cost producers elsewhere, but Heredia's influence allowed him to exploit Spain's protectionist tariff legislation to his advantage.[12] In 1836 Heredia secured a personal reduction on the punitive duties levied on coal - extended the following year to all industrialists - because of the needs of his ironworks.[13] Heredia perceived liberal ideas of unrestricted trade as a threat to the prosperity of his iron enterprise, while the idea of tariff reform served to rekindle the controversy between adherents of protectionism and free trade. The ironmasters of Malaga expressed their desire for a protectionist policy in two papers published in 1840 and '41. One was penned by Heredia himself and its title reflected his attitude: 'Reforms in Customs Legislation, with a view to increasing the import and export

tariffs demanded for the greater progress of national industry, the development of the navy and the protection of trade'.

Andalucia's lack of anthracite and its costly transport to the region was the greatest challenge facing the south's iron industry. Heredia realised that the future of the industry depended on a solution to this problem and he strove to admit foreign coal into Spain at a low tariff. A second approach towards raising 'La Constancia's' competitiveness lay with the improvements to the technology of iron making and here, too, Heredia was active. He personally travelled to Britain in 1840 and visited Butterly & Co. where anthracite was in use, ordering equipment from them that offered a saving in fuel. But 'La Constancia' remained dependent on foreign coal, subject to a burdensome duty, and despite trials and tests of new equipment and processes Heredia failed to reduce the high-cost structures of the southern ironworks.

VI

The prosperity and confidence created by Heredia's commercial, financial and manufacturing ventures encouraged further enterprises.[14] There were unsuccessful schemes involving a steamship company and a bank, the Banco de Malaga. Other enterprises proved more rewarding. Since 1830 Heredia had been the proprietor of a soapworks and this interest may have encouraged him to establish a chemical works, producing stearine, a commodity used in soap and candle manufacture, and artificial barilla, a form of sodium carbonate and another ingredient of soap. The chemical works, begun in the last months of Heredia's life and sited beside 'La Constancia', was also a source of sulphuric acid, a liquid used in the manufacture of dyes. In truth, the venture into chemicals was bound up with Heredia's final initiative as an industrial

capitalist: the manufacture of textiles. 'Industria Malaguena', a mill also adjoining 'La Constancia', was the expression of a grandiose scheme, undertaken in cooperation with Paul and Martin Larios, for the spinning and weaving of cotton and the processing of flax and hemp. Registered in May, 1847, Industria Malaguena S.A. was the second limited liability company in the Spanish cotton industry, but the low number of high value shares kept within three families - Heredia's, and the two Larios families - ensured that it was a 'family' business, with family control of the company assured for the future through clauses in the charter of incorporation.[15] The nominal capital of 4.8m reals was raised to create a mill in the 'English style', with automatic bobbins, mechanical looms, gas lighting and steam power. By 1851 39,000 bobbins and 774 looms were in use in a mill requiring the employment of 1400 workpeople in 1852. 'Industria Malaguena's' success encouraged Carlos Larios to establish another textile firm, 'La Aurora', which proved equally successful.

Malaga's industrial renaissance was brief. Until the 1860s both the iron and textile concerns prospered, but from this time the lower cost structure of the Asturian iron industry began to tell against the iron firms. While the iron producers of Asturias and then Vizcaya became the foremost providers of Spanish iron, the primacy of the Andalucian industry fell away. In 1861, the contribution of the region's ironworks 'to the basic product of the industry' was 55.1 per cent, but by 1868 it was a mere 4.7 per cent. 'La Constancia' continued to operate until 1890-91. Malaga's textile firms thrived until Spain's agricultural sector, whose incomes determined demand for the whole industry, became depressed in the 1880s. As a consequence the Catalan cotton industry experienced deceleration of growth, while Malaga experienced absolute decline. 'La Aurora' closed in 1905. The 667 tons

of raw cotton shipped to 'Industria Malaguena' in 1913 represented a fifth of that imported in the record year of 1883. There was a fundamental reason for the collapse of Malaga's manufacturing ventures that stemmed from the inherent weakness of a fragile base. Viticulture remained an important source of employment and incomes in the region. In the late 1850s Spanish exports of wine accounted for almost a third of the value of goods sent abroad and despite the presence of model factories the Andalucian economy was essentially an agrarian one, vulnerable to the vagarious shifts of natural phenomena.[16] In 1876, phylloxera, a parasitic insect, reached Malaga having already blighted French vinyards. As Phylloxera spread throughout the grapevines of the Malaga area in the 1880s, the agricultural and commercial economy of the region broke down, toppling the uncompetitive manufacturing concerns. It is significant that in 1861, a time of prosperity for Malaga's factories, the output of sulphuric acid, stearine and barilla from Heredia's chemical works was well below capacity, because, a contemporary noted, of the limited consumption of these products.

VII

The scale of Hick & Son's work for Manuel Agustin Heredia is graphically illustrated by the firm's engineering drawings.[17] The 'La Constancia' iron works was built in 1836 and for this Hick & Son drew a 'Plan of [the] Engine House Foundations for a High and Low Pressure Steam Engine with blowing cylinders', and another of the '... proposed situation for a Condensing Steam Engine of 20 Horse Power for M. Heredia Esq., Malaga'. A decade later, the firm was involved with arrangements for the 'Water Balance, Blast Furnaces [and] Landing Stages Constancia Ironworks Co.', and was subsequently occupied by a 'Driving, Gearing and Rolling Mill', driven by a 120h.p. engine installed earlier. Moreover, the cotton enterprise

of the Larios family, 'Industria Malaguena' and 'La Aurora', also provided lucrative contracts for Hick & Son. A 'Ground Plan', dated 'July 1850', shows the layout of the 'Cotton Mill and Linen Weaving Shed with Engine and Boiler Houses, Bleaching Establishment and Gas Works'. Other drawings, dating from the early 1850s and 1870s, showing general plans and giving details of fixtures points to a substantial involvement by Hick & Son in Andalucian industrial enterprises during the middle decades of the 19th century. Nevertheless, the Soho Foundry's impressive manufacturing role was possibly surpassed by Hick & Son's function as a channel of knowledge on British best-practice techniques to Spain. Heredia's avowed purpose was to compete with Britain in the markets of the world and he appears to have drawn on Hick & Son's engineering knowledge, as well as its skills, in order to appraise methods of manufacture adopted in Britain.

For most of 1841 Manuel de Heredia was touring England and Wales, maintaining a regular correspondence with Benjamin Hick, and acting for his father, who had placed orders with Hick & Son. Manuel's correspondence shows clearly that in addition to their iron and sugar interests, the Herediias were active in lead and copper smelting and wished to improve the efficiency of their soap-manufacturing plant, by seeking out improved processing methods. When 1841 opened, the Soho Foundry were building a 25 h.p.engine for the Adra lead works and Manuel Agustin Heredia was anxious that Hick would 'make every effort to have it completed as soon as ever it be possible'.[18] By late May Heredia's son, Manuel de Heredia, had arrived in Britain and from Bristol he discussed the estimate placed with Hick for a blowing engine. Manuel wrote:

> I have to acknowledge receipt of your favor of the 27th inst. enclosing an estimate for a blowing engine of 80 horse power without boilers for £2200 to work with low pressure steam, with an

aggregate sum of £300 if made on the high & low pressure principle with 2 cylinders - In the specification of the several parts of the engine, you make no mention of the fly wheel, connecting rod crank etc, to regulate the motion, which I consider necessary for the good working of the engine, and the amount of which, would, I suppose, be included in your estimate - I shall thank you to inform me how much coal p horse power you would guarantee the engine to work at, with one of the other systems of cylinders, - as also what discount you would allow, as I am afraid they may find the prices in Malaga rather high - 19

It was the dissension that arose over this engine's cost, which was to prove irritating to the relationship between Manuel de Heredia and Benjamin Hick.

Manuel wrote from Swansea in June seeking Hick's opinion on the power plant required for a blast furnace and a stamp mill. Manuel's correspondence reveals that he was constantly claiming Hick's advice on technical matters. At the same time as he welcomed Hick's counsel, Manuel was not reluctant to defend his father's interests. In late June he wrote to Hick:

The increase on your estimate of £480, - for a crank, connecting [rod] & fly wheel, I find excessive - I have orders from my father to determine as soon as possible the ordering of said engine, of course from the parties who may offer more advantages - I should have great pleasure in settling the matter with you, because I have the honor of knowing you, and that you have already made a good [deal] of machinery for us - But I am altogether unable to accept your terms, and follow up my father's orders, having before me 3 other estimates from some of the most renowned & respectable

engineers of the kingdom, at much lower rates - Your engine (with high & low pressure) and fly wheel, would come up to £2,980, whereas for £300 above that sum I have an offer from Hayle for the blowing engine of the very best description, to consume about the same quantity of coal as yours, with flywheel etc, 3 larger boilers, & with a globe regulator, & pipes etc, all complete! I have other offers perhaps still cheaper, which I suppose needless to mention - When I perceive that there is such a great distance between your price and that of other engineers, I fear that the difference would continue as great or greater for the considerable number of appendices we shall require for our new blast furnaces, heatening pipes, Stamp mill, boilers, regulators etc -

I am much afraid that owing to your high evaluation, we may not be able to come to an arrangement - for I cannot feel myself justified to offer you above from 2500 to £2600, for the engine as stated, with fly wheel etc - Please let me known <u>inmediately</u> whether you could or not accept said terms, and as I fear that your answer may not reach me here, I beg you will forward it to Messrs Chs S. Middleton & Co of Liverpool - As your answer will decide me on the subject you will please render it as explicit as possible, and should it be favorable, I should pop over to see you - Did you not decide to come down even to £2600, you may still tell me your lowest terms for my own satisfaction -

Trusting you will do all in your power to meet my father's views, and to ensure to yourselves the making of all the other machinery we shall require.

20

At Hick's suggestion the two men met in Liverpool in July, when they were reconciled over the estimate for the engine. From this time on, and throughout the remainder of 1841, no other problem arose that

77

threatened to disturb the working relationship between the Heredias and Hick & Son. Manuel's next letter was written from Holywell, Flintshire, on August 18th. He told Hick that he had 'ordered a box containing a model of a Scotch blast furnace, and another of a hot-air stove, to be sent to you, from Liverpool, I hope you have received it, and that it may add a little information for our plans'. At this period Scottish ironmasters were at the forefront of iron production and smelting techniques. Hick was apparently preparing 'general plans and details' for Heredia, who wrote that he would be 'glad to know of any remarks' Hick 'may have to make on the subject'. In the same letter, Heredia wrote:

> I trust you will not forget to write as soon as you can to my friend Mr. Larios, with the required information for a complete establishment of spinning, weaving and bleaching cotton -
>
> I beg to remind you my fathers request to see if it would be possible to procure a proper situation for one of my cousins. (19 years old; understands mechanics etc & speaks English) in some cotton works, where there might be a probability of his profiting well his time -[21]

Manuel remained in Holywell until late August, providing Hick with a deluge of requests for information on the work in progress and the new methods of manufacture that had come before him. The idea for a light iron roof for the foundry was one idea that emerged from Manuel's tour of the industrial districts, while the Heredias interest in innovations extended to soap manufacture. Manuel Agustin Heredia's role as a soap producer prompted his son's desire for 'good information' on new soap pans, that led to a preferential contract with Hick & Son for the supply of soda tanks. Although Manuel was careful to stress his 'good connexions' with other and more competitive enterprises, the compact

reached between himself and Benjamin Hick in Liverpool a month before had conferred a unique commission upon the Soho Foundry as the major source of engineering goods required by the House of Heredia.[22] Just how strong this bond was is clear from a letter of Manuel's written in September:

> I have already advised you that my father wishes to set up also a Copper mill which is to be placed on one side of our old iron mill - As I should be very happy to leave this to your care in preference to any other, since, I believe you have not yet made any, I have thought it best to send you at once the estimate of all what would be required as specified by the Neath Abbey Co., who have made the mill of Messrs Vivian & all the others in Wales, and who appeared very anxious to make me one.

The copper mill was intended to supply copper plates to shipbuilders and was one of a range of activities envisaged by Manuel's father, who had taken steps to install blast furnaces based on the practices evident in Germany and France, as well as Britain, and had schemes in mind for a lead works and a cotton factory. In one of his letters Manuel disclosed that a relative of his was considering a glass works at Malaga, so Manuel was correct to 'forsee between us a long correspondence in future'.[23]

Manuel's visits to Wales and reading of technical journals is clear evidence that his tour of Britain was aimed at acquiring knowledge of the best-practice techniques to be found in iron foundries, soap works and any other enterprise where the Heredias had an interest. There is no doubt that they wished to adopt in Andalucia what was the latest and best in whatever field of enterprise they chose to enter. At one point, Manuel even referred Hick to articles in a recent mining journal on Cornish stamp-mill engines and the employment of blast furnace gases.[24]

The Soho Foundry was extensively involved in the modern schemes of the Heredias and Manuel's correspondence also reveals how Benjamin Hick was perceived by his Spanish clients. Hick, the 'renowned engineer', was essentially the capable translator and implementor of the high-flown ideas emanating from Malaga. When the Andalucian entrepreneurs required fire engines for use on the streets of Malaga Manuel turned to Hick for advice,[25] who also advised his clients on the purchase of machine tools. Hick's opinion and guidance on the 'best plan' for the foundations to the new furnaces and engines was also sought by Manuel. The engineering expertise possessed by Hick was indispensable to the Heredias and the enterprises they planned to emulate by adopting British technology and employing the skilled labour of British puddlers and moulders. By relying to the extent that they did upon Hick, the Heredias were acknowledging his standing as an exemplar of all that was modern and progressive in manufacturing industry. At the end of 1841, Manuel provided a letter of introduction for his cousin and Mr. Larios and trusted that Hick would be 'kind enough to show them through your beautiful establishment'.[26] Manuel's impressions of the Soho Foundry point to the size and organisation of this concern and more besides. In the next chapter, the firm itself is discussed, for an understanding of a business apparently at the forefront of enterprise in engineering in terms of metal-working techniques.

Chapter 4

The Anatomy Of An Engineering Firm

I

The manufacture of efficient and reliable stationary steam engines, particularly for mill driving purposes, earned Hick Hargreaves a long-lasting reputation as reliable suppliers of industrial power. When advances in the construction of engines were made that raised performance, or when major departures in engine design occurred, superseding existing lay-outs, the Soho Foundry proved adaptable and innovative. The arrangement of valves, for example, was a 'most important detail in the design of an engine' and here Hick & Son introduced the Corliss valve gear into widespread use in Britain by adopting this American invention in order to overcome the problems created by increased steam pressures. Half a century later, the realisation of known principles in the Uniflow engine, a distinct reciprocating stationary steam engine, which offered to the power user several advantages over existing compound and triple-expansion engines, led Hick Hargreaves to adopt this engine. The Uniflow engine was possibly the most economical of all forms of steam engine and this may explain why it was added to the several steam raising and power generating specialities of Hick Hargreaves. This attentiveness to changing forms and improvements in detail is a theme running throughout the life of the Soho Foundry. In the later period this theme can be perceived in the company minutes, while details of the changing size and type of the Soho Foundry's engines are available from 1871. But for the opening decades of the firm's existence, when control of the business was in the hands of, first, Benjamin Hick and then John Hick and William

Hargreaves, there are no records of the annual output of engines, their type or destination. Moreover, it cannot be said how important engine making alone was to the firm out of the range of activities embraced. In 1874, the Soho Foundry was still a source of stationary engines, sugar mills, hydraulic presses, gas apparatus and boilers.[1] If clear evidence of the weight ascribed to Hick & Son's engineering goods is elusive this is certainly not the case with the size and organisation of the firm. Knowledge of the finished technology may be slight, but proof of the human skills employed in its manufacture and the structure of the Soho Foundry are known in detail. Consequently, the movement in engineering away from a craft-based industry to one with pronounced fixed-capital investment ought to be reflected in the production practices found at the Soho Foundry.

II

On September 9, 1842, Benjamin Hick died. He was 52. Matthew Murray's promising apprentice had accomplished a great deal as a Respected Master in Bolton and his interests and influence reflected the acquisition of wealth. The sometime managing partner of the Union Foundry, with a home adjoining the business, was at the close of his life living at Highfield, beyond the insalubrious streets of the iron and cotton town he had partly shaped. Hick became a member of the Institution of Civil Fngineers at the age of 34 'and although the distance of his residence precluded his frequent attendance at the meetings, he was a liberal contributor to the collection of models, etc'. In the 1841 session of the institution, Hick donated a 'List of Wheel Patterns' employed by his firm, a model 'of an Fxpanding Mandrill' and contributed a paper on 'An improved Plank Frame, for sawing Deal Planks of various thickness into any number of boards'. The Annual

Report of the 1842 session noted, 'Mr. Hick has contributed several useful models of his Compound Hydraulic Press, Patent Governors, Drilling Machine, etc'. If London proved inaccessible this was not the case with Manchester and its societies. Hick was a 'proprietor' of the recently created Royal Victoria Gallery for the Encouragement of Practical Science, which in January 1841, held a conversazione 'On the Improvement of the Rivers Mersey and Irwell for Sea-going vessels to Manchester'. Alas, by July the subscribers were discussing whether the institution itself had a future because of its financial 'embarrassment'. Membership of the Manchester Geological Society also presented an attraction to Hick, affording an opportunity to hear a paper 'on the Salt Mines of Bavaria' read by William Fairbairn. Benjamin Hick was also numbered among the Trustees of the Manchester Royal Infirmary, upon whose patronage the appointment of such office-holders as that of surgeon depended. In the course of 1841, for example, John S. Newbold M.D. solicited the Trustees support for a vacancy 'in the Office of Physician to your highly valuable Institutions', an appointment 'which it is my highest ambition to obtain'.[2]

It was John Hick, the eldest of Benjamin's three sons, who inherited the Soho Foundry. He was, before his father's death, exercising managerial control over such work as locomotive building, while the majority of William Hick's letters from Leeds, where an important mill-engine job was undertaken, were addressed to John Hick. However, when William received two gentlemen interested in purchasing an engine it was to his father that he wrote for 'your prices'. This suggests not an absolute division of responsibility within the firm, but a clear ranking in which Benjamin Hick, the sole proprietor, retained control over such important entrepreneurial matters as pricing, while

his eldest son was groomed for the all embracing role he would one day assume. This was achieved by allowing John to manage the execution of certain contracts in order that he might become familiar with the business of engineering. By the time he was in his late twenties John was learning how to match the capacity of the firm to the demands of its customers. This business role was dependent on and subject to the strategic policy decisions taken by Benjamin Hick, who had taught John to become an engineer in keeping with established practice found within the art and science of mechanical engineering. Just as Benjamin Hick had been trained as a practical engineer at the Round Foundry, so his sons were schooled in engineering skills under their father's tutorage. Dependable execution of the Masters' commands was assured through the redoubtable authority of foremen such as George Bell, the Foreman of Millwrights, who ensured obedience to the work discipline of the factory shop for over thirty years. Trades' Foremen had a vital part to play in this enterprise where production was divided into several distinct departments. Hick & Son also possessed a Cashier and a Draughtsman who, judging by their long tenure, proved good and reliable subordinates. Experienced lesser managers, such as the Temperleys, could be called upon by the Master to fulfil managerial tasks, once these had been identified and explained by the proprietor. Hick was an admirable designer, but it was impossible and undesirable for him as the head of a business enterprise to be responsible for the firm's general and working drawings.

Pollard concludes that rising managerial rewards stemmed in part from a 'real increase in the economic value of industrial managers'. This arose from either a growth in the size of firms, or possibly an increase in the complexity of the managerial role, or 'because second-generation owners left more responsibility to their managers or gave

84

them less chance of a partnership'.[3] In the case of the Soho Foundry John Hick acquired partners within a short time of his father's death drawn from the family rather than the firm. The business John succeeded to had proved sound under his father's hand and there was every likelihood that it would remain as a source of profit under John's control. Yet he was soon in copartnership with John and William Hargreaves, who certainly commanded no comparable engineering ability among the gifts they possessed, which suggests that John sought either finance or partners capable of sharing the entrepreneurial role. Wherever the exact explanation behind the arrival of the Hargreaves lies, it clearly derived from Benjamin Hick's death and the possibility that John Hick was unable to bear the load of entrepreneurship alone. Lacking intimate knowledge of what sort of man John Hick was, whether rational to the point of being strong-willed, or with a more prudent temperament than his father, that was eager to preserve what had been achieved rather than enlarge upon it, we have to interpret the surviving records for the appeal of a partnership at the Soho Foundry.

The evidence of the legal documents clearly identifies the financial motive behind the partnership between Hick and the Hargreaves. This stemmed from the provisions of Benjamin Hick's will, which required the sale of his estate. Without the finance to buy the business alone, John Hick was compelled to seek out a man with sufficient capital and ability to become a sound partner. In the search for a trustworthy partner the Executors - Robert Sharpe Barlow, Thomas Lever Rushton and John Hick - did not venture far beyond the family circle, finding him in the person of John Hargreaves Jnr., the husband of Mary Hick and John Hick's brother-in-law. Under the terms of Benjamin Hick's will his wife, Hannah Elizabeth, was to benefit from a life annuity of £300 per annum, purchased from the sale of Hick's 'property real leasehold and[5]

personal'. The Executors were entrusted with receiving the 'purchase money' and 'investing sufficient to yield' the annuity. Moreover, they were charged with dividing 'the proceeds into several equal shares and pay one of such shares to each of my sons John Benjamin and William for his own use and to stand possessed of the remaining four seventh parts in trust for my daughters'. The bequests made to the daughters were 'for their several separate uses' and subject to the 'limitation' and 'benefits' that were 'set forth with respect to the share bequeath in favour of' Mary Hargreaves. The 'dividends' received by the Executors from her 'Trust' were to be paid into Mary's hands 'free from the debts and control of her present or any future husband' and on her death the money was to be held in trust for the benefit of her children. At the close of clauses concerned with the bestowal of the purchase money created by the sale of his estate, Hick declared:

> that my son John may notwithstanding his appointment as one of my Executors have full power to purchase all or any part of my Estate as fully as a stranger he in all such cases agreeing with the other Executor or Executors acting under this my will for such purchase or purchases in the same manner as if they or he were or was not the only executors or executor of this my will.

As the Testator left a 'personal estate and effects ... under the value of 70,000£' it is understandable that John Hick needed to enter into partnership with his monied relation. Four months elapsed from the Testator's death before the will was proved, but it was several years before the administration of the estate by the Trustees was concluded. Not that it was necessary for them to act with haste, as Hick had provided for his wife's 'immediate occasions' by a gift of £200 'to be paid within 28 days' of his decease. While the business was managed by the Trustees, John Hick's finances were strengthened by further family

misfortune. In November, 1844, William Hick died and bequeathed his 'share estate and interest under the will of may late father' and his 'real and personal estate' to his brothers John and Benjamin Hick Jnr., with 'two third parts ... for the absolute use and benefit' of John and the remainder bestowed upon the younger Benjamin. William's brothers were the sole executors and beneficiaries of the estate, but Benjamin Hick Jnr. died intestate before William's will was proved and his estate of 'under the value of nine thousand pounds' administered. One of the witnesses to William Hick's will was Thomas Lever Rushton, an executor of his father's estate.[4]

In 1842 Rushton was both a solicitor and a partner in the local banking firm of Hardcastle, Cross & Co. This was managed by Robert Barlow and when he died in 1849 his son, Robert Sharpe Barlow, assumed the management of the banking business. At this time Rushton and Barlow were still fulfilling their role as trustees of Benjamin Hick's estate, because in the execution of this duty they had advanced large sums to finance the partnership between John Hick and John Hargreaves Jnr. in Hick & Son. It was the new partnership's indebtedness to the executors that accounts for Rushton and Barlow's lengthy involvement with the Soho Foundry, for it was in 1851 when they were released from their trust. Yet even then an enormous sum was still owing to these bankers.

III

Rushton and John Hick were prominent local Tories with a common political outlook. Even as a boy at Bolton Grammar School Rushton was jostling with future factory owners and magistrates such as John Hick. Rushton's father, Thomas, was a solicitor in the partnership of Cross & Rushton and Thomas Lever was articled to him, before becoming a partner

of his father in a new partnership. Indeed, it was through his father's enterprise that Thomas Lever began to attain that 'prominent position' in life, which allowed Alderman Thomas Lever Rushton, as he became, to be described as 'one of the "Men of the Time" in the history of his native town'.[5]

It was as a result of the success of 'his professional and other avocations' that Rushton was able to immerse himself in 'manifold public capacities', embracing the charitable and administrative duties required of the Victorian middle-class. Before embarking upon his distinguished role as a member of the Town Council, Rushton was elected as a Guardian of the Poor in 1840 at the age of 30, along with Peter Rothwell and John Bolling. Thirty years later Rushton became chairman of the first School Board for Bolton. Rushton's 'abundant' efforts for the 'advancement of the church' led him to take a major role in the formation of the Church of England Educational Institution. Subscribers to what ultimately became a day and evening teaching institution included John Hick and John Hargreaves Jnr., who saw value in the 'technological evening classes', a 'special feature' of the institute, that were eventually initiated. At a more secular level Rushton was a Local Commissioner for the Great Exhibition, the treasurer of the Bolton Bank for Savings, a honorary treasurer of Bolton Infirmary and Dispensary and a member of the committee behind the New Infirmary. Rushton was also involved in the management of several charities and schools, that included a Governorship of Rivington and Blackrod New Grammar School, 'to which he was nominated by the Justices of the Peace of the Bolton and Chorley petty sessional divisions of the county'. Rushton was himself an 'administrator of the law' as first a borough and then a county magistrate. Politics, too, were a feature of Rushton's life and throughout he 'was ardently attached to the cause of Conservatism'.

88

Over 'nearly forty years' he rendered services of 'inestimable' value to the Conservative party. 'By his purse and personal exertions, he contributed materially to further the cause of Conservatism, and took a prominent part at the various elections, Parliamentary and Municipal, after his attaining manhood. He frequently presided over electioneering meetings, and nominated or seconded one of the Conservative candidates at each contest for Parliamentary honours'. At his death a spokesman for the Liberal party felt compelled to speak of Rushton as the community's 'greatest citizen', while a clergyman could eulogise his memory by saying here 'was a man who never said what he did not mean, and who never acted contrary to what he had honestly made up his mind was the right thing'.[6]

If altruism was the guiding influence behind Rushton's concern for the welfare of the community, then the spirit of self-help was arguably the animating force behind his varied 'avocations'. It was Rushton's successful business role that underpinned his numerous public duties, while the ethos of both his professional and political affairs was inspired by the commercial reforms of Pitt and Peel. In his lifetime Rushton discharged the roles of solicitor, banker and iron manufacturer, displaying the same 'energy, perspicuity, care and thoughtfulness' that distinguished his political activities. Rushton followed his father into the legal profession, becoming a partner of his once he was admitted upon the roll of solicitors at the age of 21. With the death of Thomas Rushton, he 'became allied in business with Mr. Robert Armitstead' in the legal partnership of Rushton & Armitstead, among whose clients was certainly Benjamin Hick. In England at this time the law 'was the nearest approach to the career open to talents' and it offered an avenue to rewards at all levels, from a career in parliament to a 'humble country existence'. On the death of his father Rushton

89

also became partner in the town's first private bank and it was banking affairs that eventually led Rushton 'to take a less active share in law pursuits'. The details of Rushton's part in iron and steel making - Bolton was an early site of the Bessemer process - are discussed in a later chapter, but it may be mentioned here that fellow entrepreneurs of his included John Hick, William Hargreaves and Henry Sharp, Rushton's brother-in-law, and son of John Sharp, proprietor of Sharp Brothers & Co., Atlas Works, Manchester. Examination of the personalities behind the 'eminent' banking partnership of Hardcastle, Cross & Co. would suggest that this enterprise was the bank to the proprietors of Hick & Son.[7]

Robert Barlow, wine merchant and agent to the Corporation of the Royal Exchange Assurance, was instrumental in founding this bank in 1818, in order to satisfy the commercial needs generated by the cotton industry, whose business was flowing to Liverpool and Manchester because Bolton had no bank. Barlow was confident that he had the ability to act as a banker as he was familiar with book-keeping and could conduct business from his premises. All that was required for the project's flotation was support from Barlow's 'more substantial friends to ensure the degree of confidence' called for in such an enterprise as private banking. Barlow approached James Cross and Thomas Rushton, attornies in partnership as Cross & Rushton, who agreed to become subscribers. Two other partners were found in the bleacher Thomas Hardcastle, and his colleague James Ormrod, the founder of the cotton manufacturing partnership of Ormrod & Hardcastle. 'It was arranged that four of the partners should ... provide £1,000 each as capital, on which they were to receive 5% interest, and Ormrod and Hardcastle an extra £2,000, on which they were to be paid 3%'. The business was 'first conducted in apartments connected with the residence' of Barlow and based on the

policy of retaining profits. Earnings arose from discounts and the deposit of surplus moneys 'with the Manchester banking firm of Jones Loyd & Company'. Note issuing from 1821 proved to be an unrewarding and short-lived experiment, which served to strengthen Barlow's belief that gain should accrue 'from the judicious use of sums lodged by customers'. This sound outlook had its reward because on his death in 1849 the 'balance of accumulated profits was £75,000, while the partners had received certain capital repayments and for a good number of years interest at 4% on their share'.[8]

It was Barlow's wish that his son should succeed him and Robert Sharpe Barlow did rise from clerk to managing partner of the bank. But his temperament was not equal to the demands of the business and in January, 1858, he committed suicide having involved himself in personal debts and the bank in a loss. Thomas Lever Rushton then became managing partner. On the eve of this tragedy the bank's capital had grown to £125,000 and after it the capital exceeded £100,000 once provision had been made for bad and doubtful debts. During Robert Sharpe Barlow's tenure as manager, 1849-58, the 'five partners had lived well ... drawing out of the business their 4% interest each year and also other sums totalling £35,000'. The younger Barlow seems to have felt himself inferior to the enterprise and strength of his father. Yet he did fulfil an important role at the time of the joint-stock banking boom of 1833-36 when the idea of converting the bank into a joint-stock company was seriously contemplated. Robert Sharpe Barlow spent a month in London during 1836 gathering information 'relative to banking affairs, the purchasing of Stock, etc' and the feeling in the City on joint-stock banks. That year witnessed a 'climax' in the formation of joint-stock banks in Manchester and surrounding districts. In Manchester itself there were 8 bank promotions - four of them failures - while beyond the

town 5 other banks were founded, that included the Bank of Bolton. It was this which proposed a 'junction between the two Banks' of the town. The growth in Manchester banking arose from the rising volumes and values of cotton manufacture and trade, which 'created enormous demands for remittance facilities and discounts'. Once the Bank of England's monopoly of joint-stock banking ended in the aftermath of the crisis of 1825-26 Manchester merchants and manufacturers began the 'quest for profits' that the town's private bankers seemed to have achieved with swift ease. The activities of the joint-stock bank promoters proved crucial for the 'development of a permanent institutionalized local market' as their creations became a major investment. By the second quarter of the century Manchester had become a 'vast capital creating centre' as well as a 'consuming centre' and joint-stock banks drew the surplus profits of entrepreneurs, the savings of the middle class and inherited fortunes. The paid-up capital at par in 1837 of the 8 joint-stock banks founded between 1826-36, amounted to £3.3m. So great was this absorption of capital and the creation of a market in bank shares that existing marketing mechanisms in the person of a 'knowledgeable solicitor or agent' and press advertisements proved inadequate. The founding of the Manchester Stock Exchange in 1836 was due 'primarily to the success of the joint-stock banks in creating an active market for bank shares'. Indeed, it is the belief of F. Stuart Jones that the 'success of the Manchester joint-stock banks as banks is less striking than their success as mobilizers of capital'.[9]

Perhaps it was this feature of the companies that dissuaded Robert Barlow from the 'junction' with the Bank of Bolton? Before the approach of this joint-stock bank Barlow's son had already questioned such 'prominent London Bankers' as 'Mr. Gurney' 'Mr. Loyd' and 'Mr. Sanderson'. Gurney proved a frank informant and 'said, in

92

reference to the J. S. Banks,"that they would not manage the banking business so well as private banks, that his friends at Norwich would as soon think of jumping up to the moon as transfer their private bank; that in the end he had no doubt the private system would prevail"; and he very significantly asked me if the profits of our Bank had decreased; if they had, in that case it would be worth while to think of a change, but if not, he would wait for the knock on the head before he made the alteration'. The longer Robert Sharpe Barlow remained in London the more he doubted the wisdom of a change in the bank's 'constitution: for, the opinion against it has increased with me since I wrote you, from the fear of its not being received and taken up by the public at the premium of £5 per share and the consequent odium which would be attached to the failure'. The young man's impressions proved of 'some help' to the partners, who allowed their scheme for conversion into a public company to lie dormant, while the proposal of the Bank of Bolton, later in 1836, calling for a fusion of the two enterprises in a joint-stock company was 'seriously' received and led to a 'proposal' from 'H.C. & Co.', which the Bank of Bolton deferred. Gurney's significant comments on the profitability of the bank came in the year when the business made its 'first fundamental change' to the policy of ploughing back profits. Retained profits had 'accumulated to £30,860' and it was decided to charge this 'major part of the capital ... with interest at the rate of 4% per annum and divide this sum amongst the partners', who were anxious 'for some sharing of the fruits' of their 'endeavours' after eighteen years. Barlow had 'misgivings' over this change of policy, though it raised his salary above £500 a year. The rate of 4% 'on the accumulated profits was the same rate that we were charging our customers on their overdrafts, and when in 1838 we reduced the charge to customers to 3% I told my partners that I thought we ought to reduce the amount distributed to 3%, but they would have none of it'.[10]

IV

The 1840s witnessed significant changes in the railway industry as company amalgamation, the work of the Railway Clearing House and more powerful locomotives led to an emphasis on freight as a source of revenue. Already, from 1839 and 1840, 'there was a clear recognition by government that railways should exclude private operators and monopolise the conveyance of traffic on their lines'. It is therefore not surprising that the retirement of John Hargreaves Jnr. from railway carrying coincided with the amalgamation of several established railways into a larger company, where the operations of private carriers would be viewed as an irksome anomally prejudicial to a safe and efficient system of working. A Bill for the amalgamation of the Liverpool & Manchester, Grand Junction and North Union Railways was introduced in April, 1845, and received the Royal Assent in August. Under this Act the Bolton & Leigh and Kenyon & Leigh Junction Railways were consolidated into an enlarged Grand Junction Railway.

Nine years earlier the independent Bolton & Leigh railway had acquired the power 'for a lease of and to take to farm' the Kenyon & Leigh Junction company for 25 years. The Bolton company in turn then arranged for Hargreaves to work the line. In 1845 both the Bolton and the Kenyon & Leigh companies were dissolved and Hargreaves role as an operator ceased at the close of the year. The evidence suggests that Hargreaves Jnr. responded to changing circumstances by winding up his carrying enterprise. In November a list of his locomotives, with remarks on their condition, was forwarded to Henry Booth, Secretary of the Grand Junction Railway, by Henry Bradshaw, clerk to Hargreaves Jnr. As the amalgamation of the Liverpool & Manchester and Grand Junction Railways had been under discussion since August, 1844, Hargreaves Jnr.

had ample opportunity to adjust his business affairs and negotiate a copartnership in Hick & Son with the Executors. Hargreaves clearly had access to knowledge of railway affairs and he knew Rushton. Hargreaves was chairman of the Bolton & Preston Railway in the early 1840s, while Rushton was a director who, from October, 1843, helped carry through the company's amalgamation with the North Union Railway. The disposal of Hargreaves locomotive stock at the close of 1845 marked the start of a new venture in partnership with John Hick, a partnership enlarged soon afterwards with the arrival of William Hargreaves.[11]

The question that inevitably arises is how large a manufacturing enterprise, in terms of size and capital employed, was the Soho Foundry at this time? Do we know how many hands were employed over how great a site and with what level of fixed-capital equipment? The deeds drawn up when the sole proprietorship was evolving into an enduring partnership do offer a clear outline of the scale and value of the Soho Foundry. The evidence yielded by the legal documents, when read in conjunction with the records of labour employed, reveals that from an early date the Soho Foundry was one of the 'outstandingly large works' in Britain's engineering industry.[12]

One point that immediately emerges from a study of the deeds concerns the speed with which Benjamin Hick created an extensive site for his business. At the close of the century, when Hick Hargreaves & Co. Ltd. raised a loan through secured mortgage debentures, the enterprise extended over 31,259 superficial square yards. The deeds show that by 1839 the premises of Hick & Son already extended over no less than 31,172 square yards due to the proprietor's vigour in creating a compact site securely bounded by Crook Street. Mention was made earlier of the Pinfold Plot of land, containing 522 square yards, that Hick acquired at an early date. This was just one of several freehold

and leasehold plots upon which the Soho Foundry was built and that provided the substance of Benjamin Hick's estate. The premises of Hick & Son in 1842 were clearly delineated through several Indentures of Lease and Release concerned with four freehold and two large leasehold plots of lands. In these deeds the value and significance of Hick's acquaintanceship with the town's governing oligarchy is clearly emphasised. The first freehold plot secured by Hick was conveyed by James Spencer, a machine maker, in April, 1833. His trustee was another machine maker, Benjamin Dobson, the former business associate of Hick from their days together in Blackhorse Street, while Hick's trustee was Ralph Boardman, the attorney and town clerk to the Trusteeship of Great Bolton. For the sum of £116 Hick contracted with Spencer 'for the absolute purchase ... in the fee simple' of a cottage and ground plot 'situate at or near Sweet Green near Bolton le Moors ... Together with the vacant land thereto adjoining'. More significantly, Hick secured the 'title and inheritance' of Spencer's land for his own use 'without impeachment of waste', an important point of detail for an entrepreneur with an ambitious scheme. Spencer's parcel of land comprised 100 square yards and was bounded to the north by Crook Street, while to the south east and west lay 'waste land' and ground 'belonging to the Lecturer of the Bolton Parish Church'.[13] Here, lying to the south of Crook Street, was a tract of land suitable for Hick's purpose and held by fellow entrepreneurs and Trustees of the town, men who were likely to prove sympathetic to Hick's scheme.

The greater part of the site was acquired by lease, but in order to secure the firm's frontage along Crook Street two plots were conveyed for £408: 11s: 0d in September, 1839, from Hick's colleagues the Trustees of Great Bolton. The two freehold plots lay adjacent to each other and extended over 522 and 1,030 square yards respectively. Hick

had leased the former plot since October, 1837, which had then 'been joined and added to a yard or close of land' purchased earlier from Spencer. The plot was subject to a yearly rent of £3: 5s: 3d, but this was not paid for long. In 1839 Hick 'contracted to purchase the reversion' of this plot, the 'buildings erected thereon and chief rent ... and also to purchase a further plot of land', together with 'appurtenances', extending over 1,030 square yards, for a total sum of £408: 11s : 0d. A more substantial plot of land on the north side of Crook Street had already been demised by Jeremiah Crook, a Liverpool Merchant, in December, 1834. Hick was granted this plot of 2,000 square yards, 'lately forming part of a certain field called Park Field', in return for the yearly rent of £20. The lessee was also 'subject to the observance and performance of certain covenants and conditions'. One of these declared that Hick 'shall ... within the space of two years next ensuing at his ... proper costs and charges erect build and finish ... one or more good firm and substantial Buildings ... worth to be let at all times ... and shall produce the clear yearly value of forty pounds'. Hick was permitted by the lease 'to purchase the said rent of £20' for £400 within the term of five years after first giving twelve months 'previous notice in writing'. The Indenture of Release, through which Crook conveyed 'the reversion and inheritance of the said plot', bears date September 26, 1835, and came only 9 months after Hick leased the plot.[14] It is therefore likely that Hick had already given Crook notice to buy at the time the lease was made out in December, 1834, and that this instrument was bargained in order that Hick might secure use over an important plot of land until the time his finances permitted its purchase. It is clear from the Indenture of Lease that the parties to the deed had agreed on the size of the purchase money.

All in all, during the period 1833-39, Hick bargained for the

purchase of 3,652 square yards of land at a cost of £924 : 11s: 0d. But a far greater proportion of the firm's premises was made up of two large leasehold plots demised to Hick through two Indentures of Lease in June, 1833, by the Trustees of the Lecturer's Charity. This charity dated from the 17th century when the rent from 'certain lands in Balderstone' was bequeathed by one James Gosnell for the provision of a Stipendary Preacher 'distinct from the Vicar of the Parish of Bolton' who, in return for a yearly salary of £30, should preach to the parishioners of Bolton the 'Holy word of God ordinarily'. The charity was administered by eight Trustees and in January, 1790, they acquired eight acres of land 'on a certain place then called Bolton Moor on the South East part thereof', land originally assigned for similar 'charitable and pious uses' by the 'Chief Lords and owners of the Manor and Sovereignty of Bolton'. Rents and profits from these eight acres were to have been put 'to the use and towards the maintenance of a Lecturer or preaching Minister of the Gospel conformable to the Church of England as by law established and duly licensed'. However, the promised 'uses' were not discharged and the Trustees of Gosnell's charity were granted the land to fulfill their charitable 'intents and purposes'. A significant 'power' of the Indenture of Sale and Bargain, dated 1790, reflected the decision of the Trustees to provide 'for the better carrying out' of their trusts after the death of five members through the appointment of new Trustees nominated by those surviving. In 1792 two of the eight Trustees - John Gartside and John Leigh - became town Trustees. But in October, 1828, when by deed of appointment new Trustees were appointed to Gosnell's Charity, the trusteeship attracted leading men of Bolton who represented new interests. Thirty-eight years before the Trustees of the Lecturer's Charity had included the Rt. Hon. Thomas Baron Lord Grey de Wilton, The Rev. John Parker of Astle, Cheshire, John Leigh, a Bolton merchant, and several

gentlemen. In 1828, only Thomas Parker remained from the trusteeship of 1790 and it was he who 'applied to and requested' certain men to administer the charity. The new members were drawn from the townships' oligarchy: William Hulton of Hulton Park; Thomas Tipping of Davenport Hall, Cheshire, Esquire, and Lord of the Manor of Little Bolton; John Mawdsley of Little Bolton, cotton spinner; William Bolling of Darcy Lever, cotton spinner; William Garnett Taylor of Little Bolton, cotton spinner; John Moore, Surgeon, of Great Bolton, and John Fletcher of Haulgh, Gentleman. Tories and manufacturers made up the reconstituted Trusteeship and Hick was familiar with most of them. At least three members can be identified as colleagues of his as Trustees of Great Bolton. It was through Gosnell's Charity, for the provision of a Lecturer of Bolton, that Hick was granted two adjacent plots of 10,694 and 16,826 square yards respectively, lying to the South of Crook Street.[15]

In some respects the terms of the leases granted to Hick preserved clear benefits to Gosnell's Charity. The lands were granted for terms of 99 years each during which the lessee could enjoy the lands 'privileges', 'profits' and 'advantages'. But the trustees 'reserved all mines beds and seams of coal...and all other minerals of whatever description. Together with full and uninterrupted liberty and power...to search...and carry away...the said...minerals'. They also reserved for themselves 'all such waggon and other roads...for that purpose' and held the 'liberty to sink drive and make pits shafts...use fire engines and all necessary buildings for the same', as they 'might have done in case these presents had not been made'. Under 'these presents' Hick was obliged to build within 3 years, 'upon some part' of the ground, 'good and substantial buildings...of the clear yearly value of fifty' and, in the case of the larger plot, 'seventy pounds'. The

yearly rent Hick had to pay was derived from a valuation of 1d per square yard of land. However, the lessee was in the early years subject 'to certain progressive yearly ground rents', which meant that in the first year of the term for the largest plot, Hick paid a sum of only £17 : 10s : 6d rather than the full price of £70 : 2s : 2d. The total rent burden upon Hick was therefore deferred until the erection of 'one or more' buildings of 'brick or stone set with good lime mortar and covered with slate'. In another direction the new trustees of the charity found themselves able to promote Bolton's improvement. In 1828, Thomas Parker transferred through William Hulton the land bargained in 1790 into the 'Occupation of the Overseers of the Poor of the township of Great Bolton'. But some 'piece or parcel of land...on Bolton Moor', amounting to 12,715 square yards, was leased for £66: 9s: 5 3/4d by the 'Company of Proprietors of the Bolton and Leigh Railway' for the benefit of the trusts expressed in the Indenture of Bargain and Sale of January, 1790.[16]

V

Out of a charity appointed to provide the inhabitants of Bolton with a Stipendary Preacher land was settled and subsequently leased to support the greater part of an engineering enterprise. Apart from minor transfers of land in 1849 the extent of the Soho Foundry under the new proprietors was the same as that established by Hick. What became of these leasehold and freehold plots after his death in 1842? The several plots of land demised and conveyed to Hick were clearly that part of his estate which his son, John, had 'full power to purchase...as fully as a stranger'. Did he choose to acquire his father's business and if he did what evidence exists to show how the contract was undertaken? The evidence of an Indenture of Release and Assignment, dated March, 1847, reveals that John Hick 'contracted' with the other executors of his

father's estate for the purchase of the several plots to the South of Crook Street. In his father's lifetime these had been 'formed into one plot of land', upon which Benjamin Hick had built 'numerous messuages workshops warehouses counting houses buildings erections and structures for the carrying on the trade or business of an Engineer and Ironfounder and set up and affixed thereon...certain Steam Engines millgeering fixtures fixed machinery and millwork'. This enterprise John Hick contracted to purchase 'for the sum of £16,736...that being the largest sum which could be had or gotten' by Robert Sharpe Barlow and Thomas Lever Rushton, who 'agreed to accept the same'. However, the deed also recites that 'whereas it hath since been agreed by and between the said John Hick and John Hargreaves that they should together purchase the same', the Indenture witnessed the assignment of the plots 'in manner hereinafter appearing' and the 'release and discharge' of Hick and Hargreaves with the payment of the said sum. Barlow and Rushton were requested to 'grant assign and convey' unto Robert Armitstead, Rushton's partner in the legal practice of Rushton & Armitstead, the two leasehold plots, their structures and fixtures, rights profits and advantages, and 'all the estate right title interest terms of years yet to come ... To Have and To Hold ... Upon Trust nevertheless to assign the same unto ... Hick and ... Hargreaves ... equally as tenants in common'. The other, freehold, plots of land astride Crook Street, with their 'edifices', were also conveyed to Armitstead 'In Trust as hereinafter mentioned that is to say as to one undivided moiety thereof to such uses...for such estates...intents and purposes...as' Hick and Hargreaves should direct. Land and appurtenances were not the only assets conveyed by Barlow and Rushton. The assignment of certain letters patent originally granted to Benjamin Hick or held under licence by him was made. For the sum of £140, 'that being the largest sum which could be gotten' by the executors, the interest of Barlow and Rushton in

101

the letters patent was transferred to Armitstead 'Upon trust nevertheless to assign the same...unto John Hick and John Hargreaves ...equally as tenants in Common'.[17]

The right to use or employ most of these patents had lapsed by 1851 when another major change of ownership occurred. The original partnership between Hick and Hargreaves had quickly become a copartnership with the arrival of William Hargreaves. But in 1851 instruments were signed relating to the conveyance and assignment of John Hargreaves' interests in the business, following his decision to retire from the copartnership. These deeds disclose not only the relative capital proportions of the partnership that survived him, but the leading role played by the trustees - Barlow and Rushton - in advancing loans to finance the purchase of the estate. By an Indenture endorsed on the Indenture of Assignment of March, 1847, Armitstead had assigned the 'same letters patent' to Hick and Hargreaves. The terms of one of these patents was still in force by 1851, while in the meantime the share and right of other patents had been acquired and assigned to John Hick, John Hargreaves and William Hargreaves. These patent shares and interests had been 'obtained and purchased on the partnership account' of the three copartners 'and on the treaty for dissolution it was agreed that...John Hick and William Hargreaves should take the share and interest of John Hargreaves...at the value thereof in cash'. Accordingly, the agreed value of the 'share' of John Hargreaves in the several patents was taken 'at the sum of £400'. In addition, the Indenture of Assignment, dated March, 1851, that witnessed the transfer of John Hargreaves' interest in the patents, granted his interest 'in the shares and proportions following...John Hick may be possessed of three fifth parts of the entirety of the premises the shares whereof hereby assigned...and...William Hargreaves...of...two fifth parts

thereof and that the entirety of the said premises may be part of their partnership Capital Stock and be held and disposed of accordingly'. The deed of transfer in the share of the patents shows that William Hargreaves appearance as a 'copartner' dates from some time between 1847 and 1851. However, a far more important point of detail concerns his share in the enterprise. Prior to his brother's retirement this was none existent and the new 'proportions' in the interest in patents shows this.[18] For John Hick to have received three fifths of John Hargreaves share of the patents, and William Hargreaves two fifths, the patent shares had to be held equally between Hick and John Hargreaves. Does the transfer of John Hargreaves' share in the freehold and leasehold lands bear out the idea that it was his original holding which provided William Hargreaves with a partnership in Hick & Son?

In the exordium to the deed of conveyance that transferred John Hargreaves' share in the land and premises, Hargreaves the younger is referred to as 'late of Great Bolton and now of Southport...Esquire', while his younger brother, William, is wishfully described in the same style as Hick, as an 'Engineer and Ironfounder', whereas in truth he was neither. The Indenture recites those instruments by which land was conveyed to uses in favour of Benjamin Hick. It also repeats the declaration made by Hick in his will, before stating 'that the said John Hick contracted with...Robert Sharpe Barlow and Thomas Lever Rushton for the purchase of the several plots...hereditaments and premises in the...Indentures mentioned and that it had subsequently to such contract been agreed by and between...John Hick and John Hargreaves that they should together purchase the same'. The instrument of March 6, 1847, that granted the leasehold plots with appurtenances to Robert Armitstead in trust for the two tenants in common, was also recited. By this document all the freehold plots and fixtures had also been conveyed to

Armitstead and held in trust 'as to one undivided moiety' to the use of John Hick 'without impeachment of waste...And as to the other undivided moiety...to the use of...John Hargreaves...without impeachment of waste...', with each man declaring 'that no wife of them should be dowable out of said premises thereby granted'. The deed of conveyance of 1851 goes on to recite the Indenture of March 8, 1847, 'endorsed on' that instrument 'signed sealed and delivered' two days before, which witnessed Armitstead's reassignment of the two leasehold plots and structures to Hick and Hargreaves. John Hick and John Hargreaves are therefore clearly established as the new proprietors of Hick & Son from early in 1847. But what evidence is present of William Hargreaves arrival as a copartner in the business? The deed of conveyance from 1851 reveals that in May, 1849, a portion of the leasehold land was assigned to one John Thompson by Hick and Hargreaves and that on the same day Thompson demised a leasehold 'piece' of land 'to...John Hick John Hargreaves and William Hargreaves' originally assigned to him four years before. The deed of 1851 at length declares: 'And whereas the said John Hick John Hargreaves and William Hargreaves have carried on the trade or business of Engineers and Ironfounders in Copartnership together but have agreed to dissolve such...Copartnership so far as regards the said John Hargreaves who has arranged to retire therefrom...it has been agreed that...John Hick and William Hargreaves shall take all the respective...interests of...John Hargreaves...in the several plots...erections...and premises...and all which are part of the Capital of the said Copartnership or late Copartnership at the sum of £9000'. It was witnessed that this sum had been paid out of Hick's and William Hargreaves' 'partnership monies and effects ...the receipt of which sum in part of his share of the net assets of the ...Copartnership...John Hargreaves' did 'admit and acknowledge'. He assigned 'that one undivided legal moiety half part and share...and

14

all the beneficial...share estate and interest whatsoever of him...in and to' the leasehold plots, structures and fixtures to John Hick and William Hargreaves.[19]

The assigned leasehold 'lands hereditaments and premises' were to be held in the 'proportions following...one fifth part of such share by...John Hick...and four fifth parts...by the said William Hargreaves...to the intent that...Hick may be possessed of and interested in three undivided fifth parts of the entirety of the said two plots of land messuages buildings erections fixtures hereditaments and premises and...William Hargreaves...possessed of...two undivided fifth parts thereof but that the entirety may be part of their partnership capital stock and be held distributed and disposed of accordingly'. The deed dated 1851 further witnessed how John Hargreaves' 'one undivided legal moiety half part and share' in the freehold plots and premises, originally conveyed to Benjamin Hick and later transferred to his eldest son and John Hargreaves, should be granted. These lands and their edifices, together with 'reversion and reversions remainder and remainders...profits...estate...title...claim and demand whatsoever', of John Hargreaves were to be held to Robert Armitstead with 'uses' to John Hick and William Hargreaves. 'One undivided fifth part of such moiety' was conferred 'to such uses' as Hick would 'appoint', while 'the other undivided four fifth parts' were given to the use of William Hargreaves. 'To the intent that' the two partners 'may be seized of the entirety' of the freehold plots and premises 'in the respective proportions...John Hick of three undivided fifth parts...and...William Hargreaves of two undivided fifth parts...but that the entirety thereof may be part of their partnership capital stock and be held distributed and disposed of accordingly'.[20] Once again, the 'proportions' of this transfer of John Hargreaves' share

15

in the leasehold and freehold lands and premises supports the notion that William Hargreaves holding in Hick & Son from 1851, was assigned to him out of his brother's half-holding in the enterprise. Before John Hargreaves' retirement in 1851 his brother William had no capital in the Soho Foundry.

By an assignment of credits and release of claims John Hargreaves did 'remise release and quit claim' his brother and Hick' of and from all...manner of actions suits causes of action and suit controversies reckonings sum and sums of money claims and demands whatsoever both at law and in equity which he...John Hargreaves now has or claims...against...the said John Hick and William Hargreaves...by reason or on account of the...recited Copartnerships'. The role played by Barlow and Rushton in financing the changing partnerships is clearly revealed in this instrument which released the executors from the financial burden of their trust. The deed stated that John Hick and John Hargreaves had 'for some years next preceding and up to' January 1, 1847, 'carried on business in partnership together...under the firm of Benjamin Hick and Son and on' the said date 'William Hargreaves joined them in partnership and...John Hick John Hargreaves and William Hargreaves thenceforward carried on the same business in copartnership'. It was the case that 'a sum of money was lent by the trustees' to Hick and John Hargreaves 'during their first named copartnership', a loan which was continued to them 'during the subsequent copartnership', and 'applied and employed' for the 'use and benefit' of Hick & Son. The deed recited that 'there were considerable sums of money owing to and by the ... first named copartnership on the accession of William Hargreaves... and the accounts of such first...partnership were kept distinct from...last named Copartnership' and that there were 'still considerable sums...owing to...first...partnership as well as to the

10

said secondly named copartnership and certain sums including the said debt due to the trustees of...Benjamin Hick...still owing from such first named partnership and...also debts due and owing from and by the...secondly named copartnership'. The deed further recited that John Hargreaves had 'agreed to retire from...said copartnerships', having willingly assumed 'the sole liability to pay...the sum of £10,000 part of such debt to the trustees...and all interest...due...from and after' March 31, 1850. The remaining copartners were indemnified by Hargreaves 'from and against the payment of said sum and interest...to accrue after...last named day', while 'such sum of £10,000 should...be considered as so much money advanced' on the said day by Hargreaves 'to the said copartnership of John Hick and John Hargreaves and paid to the trustees...on that day on account of the...copartnership of John Hick and John Hargreaves'. This sum of money 'should be accordingly transferred in such copartnership accounts from the credit of the...trustees...to the credit of...John Hargreaves' with Hick and William Hargreaves assuming the 'sole liability to pay...the remainder of such debt to the trustees...and all interest...due on the remainder of such debt' after March 31, 1850.[21]

The assignment of credits shows how both the wishes of the trustees and the retiring partner were accommodated, given that it was beyond the remaining partners to discharge the trustees debt and simultaneously pay John Hargreaves a sum equal to his share of the business. Moreover, the retiring partner belonged to the 'first named copartnership' that owed at least £10,000 to Barlow and Rushton. How was the capital of Hargreaves and the trustees in the business realised? The release and repayment of these parties was achieved through an intricate arrangement whereby the trustees loan of £10,000 was repaid by money that would otherwise have been taken out of the business by John Hargreaves as

part-payment of his holding in Hick & Son. It was his partnership money that discharged Rushton and Barlow, while this part of the copartnerships' indebtedness to them was transferred to 'the credit' of John Hargreaves. The trustees loan of £10,000 became 'so much money advanced' by Hargreaves to John Hick and William Hargreaves, the two remaining partners undertaking to pay the remainder of the trustees debt and interest after March 31, 1850. How was the remainder of the trustees debt treated?

The two partners indemnified John Hargreaves 'from and against' payment of the remainder of the trustees debt and the interest 'then due or thereafter to accrue', while it was agreed that the 'remainder of such debt should as amongst...John Hick John Hargreaves and William Hargreaves be considered as so much money advanced' on March 31, 1850, 'by the said John Hick and William Hargreaves and paid to the...trustees...on that day on account of...John Hick and John Hargreaves'. This sum 'so considered as advanced should accordingly be transferred in the copartnership accounts of...John Hick and John Hargreaves from the credit of the ...trustees...to the credit of the said John Hick and William Hargreaves, so as by the payments and accounts and other means aforesaid' the debt owing from the 'firm of John Hick and John Hargreaves to the trustees' would be 'extinguished'.[22]

It was 'further arranged...that the stock and accounts of the...two copartnerships should be taken and the interest of...John Hargreaves therein ascertained' in order that he could be 'paid off' and discharged. In consequence of an investigation of the accounts of the two partnerships 'the value of the shares therein of...John Hargreaves' was ascertained and 'such share...(including the...sum of £10,000...agreed to be paid by...Hargreaves...) was fixed determined and agreed to be £42,000'. This figure represented the 'respective values

of the shares of...John Hargreaves in the lands buildings erections steam engines millgeering fixed machinery fixtures utensils stock in trade implements bonds Bills notes securities credits contracts and effects respectively of the...two copartnerships and of each of them...apportioned and agreed upon in cash'. It is clear from the two other instruments of 'even date' what value was placed on Hargreaves 'share estate and interest' in the lands, buildings and fixtures, and letters patent. The assignment of credits recited these transfers and noted that Hargreaves 'hath also delivered...the share of him...in the machines tools implements stock in trade utensils and effects of the said Copartnership'. The deed goes on to disclose that the retiring partner 'has agreed to join in these presents for more fully and effectually dissolving the said several copartnerships so far as...John Hargreaves is concerned and for assigning his share of the credits and releasing all claims in respect of the said two several Copartnerships...upon payment to him of...£12,000 in full for the apportioned several shares of...John Hargreaves in the credits bonds bills notes and securities of the said two several copartnerships'.[23]

The assignment of credits witnessed 'that in persuance and part performance of the...recited agreement and in consideration of...£12,000 to...Hargreaves paid by...John Hick and William Hargreaves', the late partners declared 'that the...copartnership between...John Hick and John Hargreaves firstly...mentioned was dissolved and determined on' January 1, 1847, 'And...John Hick John Hargreaves and William Hargreaves...declare that the ...copartnership secondly...mentioned so far as relates to...John Hargreaves was dissolved and determined on' April 1, 1850. This instrument further witnessed Hargreaves' assignment of 'All that one undivided equal half part and share...right and interest of him...to all...credits and sums of money...now or at'

January 1, 1847, 'due or owing to...Hick and John Hargreaves...and all bonds...notes...papers and writings whatsoever...relating to...same credits and sums...and all and every covenants contracts and agreements made...by any person...with...Hick and John Hargreaves...on...behalf of the said first named Copartnership'. John Hick and William Hargreaves were assigned 'All those two undivided fifth parts and shares...in...the credits and sums of money...at' April 1, 1850, 'due or owing to...Hick John Hargreaves and William Hargreaves as such partners...and all Bonds...securities Books of account...and writings whatsoever...relating to the same credits and sums of money...And all and every...part share...of all and every covenants contracts and agreements...on...behalf of...said copartnership of...Hick John Hargreaves and William Hargreaves'. Hick and William Hargreaves received the 'said several shares estates and interests of John Hargreaves 'for their own proper use and benefit' in clearly determined 'proportions'. Hick became 'possessed of three fifth parts...of the premises the shares whereof...assigned' and William Hargreaves became 'interested in two fifth parts', while 'the entirety...may be part of their partnership capital stock'. The retiring partner 'by these presents' did appoint Hick and William Hargreaves as his 'lawful and erevocable attorneys in the joint names of...John Hick and John Hargreaves...and also...John Hick John Hargreaves and William Hargreaves...to ask demand and receive...for their own use...the respective...interests of him...respectively assigned... in all and every...of the...credits sums of money benefits and premises...belonging...to the said two copartnerships'. John Hargreaves agreed to pay 'the said sum of £10,000 part of the monies owing to the trustees and executors of...Benjamin Hick...and all interest to accrue' from March 31, 1850, 'And...keep harmless and indemnified' his former partners, who indemnified John Hargreaves from 'costs, charges and

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damages by reason of...any action or suit' brought by Hick and William Hargreaves. All debts and liabilities on account of the two copartnerships, with the exception of the 'said sum of £10,000... and interest', became the responsibility of Hick and William Hargreaves, who promised to 'keep harmless and indemnify' John Hargreaves from such demands.[24]

Once the share of John Hargreaves in Hick & Son had been 'agreed to be £42,000' it remained for the surviving partners to pay him off and this was accomplished through an instrument of mortgage - raised on the land, structures and effects of the Soho Foundry - that conveyed the premises to John Hargreaves as security for securing a sum of £30,000 and interest. The indenture of mortgage between John Hick and William Hargreaves 'of the one part' and John Hargreaves of the 'other part' opens with a lengthy recitation of all the previous instruments bearing upon the Soho Foundry. It is once more declared that Hick and Hargreaves were joined in partnership by William Hargreaves on January 1, 1847, and that they 'thenceforward carried on the same business in copartnership under the same firm of Benjamin Hick & Son'. John Hargreaves' decision to retire led his partners to take his 'estate share and interest' in the business once it had been 'ascertained'. Hence, 'an account was taken and the value of...John Hargreaves in the said two Copartnerships...was fixed determined and agreed' on April 1, 1850, to be £42,000.[25]

The value of the 'share estate and interest' of John Hargreaves in the copartnerships of Hick & Son, and how it was 'apportioned', on April 1, 1850.

111

£400	The value of Hargreaves' share in letters patent.
£20,600	The value of Hargreaves' share in machines, tools, implements, stock in trade, utensils & effects.
£12,000	The value of Hargreaves' share in the credits, bonds, bills, notes & securities.
£9,000	The value of Hargreaves' share in the lands, buildings, engines, millgeering & fixtures.
£42,000	The total value of Hargreaves' share in the Soho Foundry.

The mortgage document declared that 'of the...several apportioned sums amounting' to £42,000, the sum of £12,000 had been paid leaving a 'residue' of £30,000. Payment of this 'residue with interest shall be secured by a mortgage to...John Hargreaves of all and singular the...freehold and leasehold' plots, 'conveyed and assigned by the said hereinbefore recited Indenture of the day next before one before the day of the date hereof and also...the...effects specified in the schedule hereunder'. Within John Hargreaves share of £42,000 in Hick & Son £20,600 represented the value of machines, tools, implements and effects, while a further £9,000 'was apportioned as the value' of his share in the several plots and the buildings, engines, millgeering and fixtures. The mortgage of the Soho Foundry's plots, workshops and machinery had the aim of securing £30,000, and interest, the outstanding 'residue' of Hargreaves share in the two copartnerships and assets. The assignment of credits made two days before the indenture of mortgage acknowledged Hargreaves receipt of £12,000, his share of credits and bonds etc., and the mortgage was the means whereby the 'residue' was

12

paid. The freehold and leasehold lands have already been described, but Hick and William Hargreaves also assigned to John Hargreaves in the mortgage 'All and singular the machinery tools implements utensils and moveable effects...specified in the schedule hereunder written'. It is through the 'Particulars of Fixed Machinery Tools and Fixtures'[26] appended to the indenture of mortgage that a unique impression is given of the physical structure of Hick & Son. Moreover, this can be read with a detailed listing of the size and composition of the labour force at the Soho Foundry on April 1, 1850.

The enterprise was employing 179 workers at the close of its first year in 1834 and by 1839 the labour force had grown to 297. It was at a similar size in 1850, following a contraction to 196 workers in 1842, the year of the founder's death. 'In 1850', Ashworth declares, 'a factory or works which employed more than 200 people was outstandingly large'. Hick & Son was such an enterprise and it also employed steam-powered machinery on a comparable scale. Amongst the several departments of the enterprise there was a 'Room used for making Engine models in', whose equipment included a powered 'Circular Saw', 'wood Gantries' and lathes. The 'Boiler Shop' had three 'Large punching engines', another engine for punching 'Gasometer sheets', a drilling machine, a plate bending machine, a rivetting machine and one 'machine fitted with screws and handles for cutting plates by hand'. Within the 'Large Smithy' there were 14 'Smiths Hearths with cast iron plates Brickwork, Fire Irons etc complete', a Nasmyth steam hammer, screwing machines, lathes and 'Ryders Forge complete'. The numerous Smiths and their mates the Strikers, also known as hammermen, were employed here and at the hearths in the smithy attached to the locomotive shop. The 'Locomotive Shop and Smithy attached' was fitted out with several lathe beds 'with headstocks etc complete', drilling and radial drilling

machines, and a 'new Plaining machine by Collier and Company'. A prominent feature of this shop was the 'Moveable crane' running on cast iron rails. Indeed, there were '544 yards of Railing from Bolton and Leigh Railway through yard and Locomotive shop to side pipe Boring Shop'. The locomotive shop also possessed a 'Cast Iron Turntable', 'small Fire Engine, one moveable Railway Crane...Four Smiths Hearths' and a 'Wrought Iron Crane and fixings'.[27]

Motive power was provided from an 'Engine House' and an 'Engine House Boiler House and Fan House'. The former accommodated a '30 horse independent Frame Condensing Engine with two wrought iron Boilers and apparatus complete'. Housed in the latter structure there was a '10 horse high pressure steam engine with two wrought iron Boilers', a 'Large fan for cupolas with driving geer', and an 'Upright Drilling machine'. However, the 'Grinding Shop' consisted entirely of a 'wrought Iron Tank, wood framing and horse, stone and geering for driving stone' and '2 Glazes with shafts pedestals etc'. Hick & Son employed just one 'Grinder', while Philip Bibby was the sole 'Brass Moulder' for a considerable shop. His department, the 'Brass Foundry', had 'Large and small furnaces with Brick work', a 'case hardening furnace', a 'cooking furnace' and lifting tackle that included '4 sheave blocks and chain used for breaking up old metal'. In addition to which there were 'gas piping and metre water pipes for supply of works, millwork for all the shops, Engine wheel and sundry models and patterns'. Hick & Son also employed three book-keepers and two draughtsmen in 1850, who performed their duties in the 'Counting House'. This was fitted out with a 'Desk with 12 drawers', a 'new Desk, writing Tables Book Case, Large Drawing Table' and 'Sundry drawing Tables and covers'. A concession to comfort was the 'Steam Stove and pipes'.[28]

Engineers, millwrights, turners and fitters together represented over forty per cent of the labour force, constituting the valuable mainstay of an enterprise adapted for turning out stationary engines, steam locomotives and millwork. In the 'Boring and Turning Department' there were six 'Face' and 'Slide' lathes, a 'plaining' machine and a 'Large upright Boring machine' that had foundation plates of cast iron and an entablature supported on four fluted columns. The 'Large Slide Lathe' had a bed over 38 feet long and 3 feet wide, while the face plate to the largest face lathe was over 14 feet in diameter. All the lathes appeared 'with headstocks etc complete' and the department was also fitted out with a double-jib crane with 'Sheave Blocks and Chain'. The 'Engine erecting and fitting Department' was also equipped with lifting and moving devices in the form of a 'Large' double-jib crane with cast iron upright and a 'Large' single-jib crane whose boom was 30 feet long. Sunk into the shop floor there were '5 pits including Brick walls wood framing props and covers'. The machine tools here consisted of a 'Large Radial Drilling machine', equipped with a 'cast Iron upright pillar Jib', several upright drilling machines and a 'Large Slotting machine'. Other notable fixtures included '5 vice Benches, 10 Drawers, 7 Cupboards and one Desk'. A more extensive arrangement of machine tools was present in the 'Turning and Fitting Up Room'. Here were thirteen substantial lathe beds, each with 'headstocks driving geer etc complete', a 'Hand Lathe Bed' and a lathe 'with Screw cutting apparatus'. Moreover, there was 'one Bodmers Lathe', a 'Bodmers Polishing machine', a nut cutting machine, five slotting machines, a 'Drilling and Slotting machine with revolving table' and several drilling machines, that included one 'with Whitworth's descending drill'. Other tools installed in this 'Room' were a drilling and boring machine, several 'Plaining' machine beds, one built by Roberts, and a Lillie screwing machine.

The emphasis on the hand fitting of components into finished products is evident in the fixtures of the 'Millwrights fitting up shop'. Once again there were lathe beds with headstocks and driving geer, and drilling and boring machines. But in addition there was a sizeable fitting-up pit for spur wheels, as well as 'Vice Benches, drawers tool boxes and cupboards'. Later in the century William Fairbairn was to acknowledge the 'great advances made in the division of labour' within engineering. Yet he was not able 'to state where the millwright ends and the engineer and machinist begin'. In Fairbairn's opinion a sharp 'line of demarcation' was absent from these mechanical skills. 'They seem to run into each other without any definite outline of distinction, and the millwright of the present day appears to maintain as in past times his original character of a "Jack of all Trades", and there are none of the varied forms of mechanical manipulation pursued in this country in which the millwright is not employed'. By the early 20th century the millwright had come to be defined as a 'workman of a class whose numbers are diminishing owing to the increasing specialisation of engineers' work'. Following the advent of 'modern engines and machinery', and the 'factory system', the 'Jack of all trades' was seen to have lost ground to such specialists as the fitter and turner, who performed specific roles in an industry where tasks were 'divided into several distinct departments'. In 1850 turners were on their way to becoming a 'distinct class' of men, 'seldom leaving the lathe for the vice', whose skills lay in 'fast chucking and ... ready manipulation of tools'. Fitters were responsible for bringing component parts together in a finished state through the use of vice and hand tools. In the structure of the Soho Foundry, with its several shops, we find an enterprise purposely created for the production of all kinds of metal goods, that each required the same combination of machine tools and skilled hands. The same foundry fixtures that turned out spur

wheels for engines also produced railings and gate posts, while the manufacture of presses for the textile trade allowed the firm to produce a hydraulic press 'for expressing the oil from olives' in Italy. Floud has shown 'that the emergence of specialised engineering manufacture was quite well advanced by the middle of the century'. Specialisation could be achieved by a firm 'concentrating on a range of products which presented technically similar problems in their design and manufacture, although they differed greatly in ultimate use and were sold to a wide variety of customers'. Floud cites the example presented by the steam engine where a 'class of products' existed in the variety of engine types. There existed, therefore, a technical reason behind Hick & Son's production of steam locomotives and mill engines. However, a second reason accounted for specialisation: specialisation by customer. Here a firm grouped 'its products to satisfy the requirements of a particular customer or a group of customers'. By the close of the century the 'specialities' of the Soho Foundry met the power requirements of several dissimilar industries, such as paper and coal, where there existed a common demand for efficient power plant and millgearing. The emphasis had shifted to the supply of mill engines and a complete array of auxiliary equipment that met the needs of an exclusive group of power users, whereas in 1850 Hick & Son was specialising in technically related products available to a wide range of customers. Marine engineering was one field of activity that the Soho Foundry had entered by 1850. Little is known about this aspect of the firm's work. But in 1849 John Hick patented an improvement to the machinery for propelling vessels, while five marine engineers were numbered among the firm's engineers in 1850. Whatever this activity entailed it soon required the building of an octagonal 'Marine Shop', built of brick, measuring 61 feet from flat to flat, and covered with a slated conical roof.[30]

Chapter 5

Steam and Steel at the Soho Foundry in the late 19th Century

Under the provisions of the indenture of mortgage John Hick and William Hargreaves agreed to pay the principal sum of £30,000 and interest in an agreed schedule of payment. An indenture made in May, 1856, acknowledged John Hargreaves discharge of his brother and John Hick, who henceforth held the enterprise as partners. The two large leasehold plots were assigned 'to be held' by Hick and William Hargreaves 'as part of their Partnership Capital Stock', with Hick 'possessed of three fifth parts of the entirety and William Hargreaves the remaining two fifth parts'. The freehold plots were similarly assigned and held in the same proportions. 'All and singular the machine tools implements ... specified in the schedule' became held 'absolutely' by Hick and Hargreaves 'as part of their partnership property in the proportions of three fifth parts thereof to ... John Hick and two fifth parts ... to the said William Hargreaves'.[1]

William Hargreaves became a partner in Hick & Son at the age of 25 in 1847 and for the next forty-two years he pursued an 'active and progressive' career, supervising 'affairs' at the firm until a few weeks before his death in October, 1889. This 'engineer', the patentee of improvements to prime movers, was not a member of either of the two professional bodies for engineers and presents an enigmatic personality by comparison with Benjamin and John Hick, both of whom belonged to the Institution of Civil Engineers. Benjamin Hick was a pupil of Matthew Murray while John Hick was taught by his father and educated at Bolton Grammar School 'where he received a sound commercial and classical education'. When John Hick 'retired from business' in 1868 'in order to devote himself to Parliamentary duties', Hargreaves became the sole

'head' and 'proprietor' of an enterprise ranked in 1889 'among the finest industrial shops in this country'. It was observed in his obituary that Hick Hargreaves & Co. had become a 'notable name in the engineering and mechanical world', the firm's achievements, such as the introduction of the 'corliss engine into this country', were commended in detail and mention was made of the Soho Foundry's displays at major exhibitions. Hargreaves was the head of this 'concern directing operations with all that keen interest and earnestness which he was known to possess'. Clearly, his influence upon the firm was great, yet there is little evidence in Hargreaves early years of a training in the mechanical arts. William Hargreaves was born in November, 1821, at Hart Common, Westhoughton, where his family had resided for two centuries. He was the ninth of John and Tabitha Hargreaves ten children and at the time of William's birth the Hargreaves family was well established in the carrying trade. John Hargreaves Snr. was a carrier by land to 'all parts of the kingdom', who had already seized upon the opportunities for profit offered by the canals. New rewards arose with the appearance of railway companies. William's father and elder brother, John Hargreaves Jnr., undertook the working of railways by leasing them from their proprietors. It was as a result of John Hargreaves Jnr.'s dealings with his brother-in-law, John Hick, that William Hargreaves arrived at the Soho Foundry. His obituary declares that 'he chose the engineering business for his future avocation and to this pursuit he very soon and very earnestly turned his attention'. We have already seen that Hargreaves share in the partnership with John Hick originated out of his elder brother's joint purchase of the business with Hick. When John Hargreaves Jnr. retired in 1850 William benefited by becoming Hick's partner. But William Hargreaves acquired capital cannot explain by itself his subsequent proprietorship of Hick Hargreaves. Did William Hargreaves come to possess technical expertise in his own right? The

evidence for this is not strong as Hargreaves 'educational training' was as a pupil at the 'old parochial church school adjoining St. Bartholomew's Church, Westhoughton'. Evidence that Hargreaves came to possess commercial expertise, that equipped him for the entrepreneurial role he was to play, is provided by the activities of his brothers.[2]

Hargreaves brothers were proprietors of enterprises in cotton and coal where William Hargreaves could be expected to acquire a knowledge of management. In the 1840s John Hargreaves Jnr. began to gain possession of Burgh and Coppull Collieries at Chorley, adjacent to the North Union Railway. From 1838 John Hargreaves & Brothers were active as cotton spinners and manufacturers in Bolton. Hargreaves was aged 17 in 1838 and over the next ten years Hargreaves could have become an experienced business manager, the ideal partner to relieve Hick of the whole management of Hick & Son and free him to deal with engineering matters. In such a partnership between Hick and Hargreaves there is an instance of 'unification of ownership and control' in a partnership founded 'on professional and commercial skill and personal knowledge'. Reliable testimony of Hargreaves ability as an entrepreneur was evident in his direction of the Bolton Iron & Steel Co. from 1860. This 'gigantic establishment in the centre of the Borough' was operating 'on an extensive scale' by the 1880s as a result of substantial investment. This made the works one of the 'finest and best' in the steel industry, 'one of whose specialities ... has long been the manufacture of Bessemer steel, many thousands of tons of which they produce annually for exportation or home consumption'. Hargreaves became the 'principal proprietor' of this enterprise and his activities there and at the Soho Foundry led to him being regarded as 'a gentleman of exceptional business ability, veracity and energy'. But it is significant that Hargreaves obituary referred to his 'active and practical interest in the manifold operations of the industrial undertakings'. As

professional engineers the Hicks had exploited their skills on their own account, but Hargreaves had to rely on hired engineering expertise. Indeed, so valuable did one of the managers prove to the manufacture of the firm's specialities that Hargreaves entered into a partnership with him. The Hicks were professional engineers who exploited their skills for their own benefit, whereas Hargreaves had to rely on hired expertise because he was the Master of an engineering business, not an engineer.[3]

II

John Hick's retirement from business in 1868 was not the signal for the onset of what Aldcroft termed 'enterpreneurial sluggishness', namely the absence of 'drive and dynamism' in those entrepreneurs who followed the pioneers of the industrial revolution. On the contrary, the years from 1868 were marked by a rejuvenation of entrepreneurial control and works management at Hick & Son, arguably more important than the changes in ownership that occurred in the 1840s. This era of renewed vitality closed in 1890 with the death of William Inglis, a notable figure in mid-Victorian engineering, who rose from engineering manager of the works to partner in Hick Hargreaves & Co. Inglis's contribution to advances in steam engine efficiency placed the Soho Foundry at the forefront of engine design and manufacture, and bestowed upon Hick Hargreaves a proud reputation as suppliers of industrial power that endured well into the 20th century. Inglis was not the only manager of the firm. Benjamin Hick III, the grandson of the Foundry's founder, entered the business from school in 1862. 'It was this member of the third generation from the founder who was to be later mainly concerned with the foreign trade of the firm, for which he made many visits to Russia and other places'. Three sons of Hargreaves also entered the business before 1868 and one of them, John Henry Hargreaves, rose to

become a 'practical engineer', 'machinist' and the first Managing Director of the private limited company. Yet prime managerial expertise originated from the appointment of Inglis and Robert Luthy outside both families. Luthy, a Swiss, 'entered the service' of Hick Hargreaves in 1863, following employment as a draughtsman at R. and L.R. Bodmer. Luthy remained at the Soho Foundry for over twenty years and first with Hick and then alone he worked as a designer and experimenter at the Soho Foundry. Born at Solothurn in Switzerland Luthy's 'aptitude for mechanics' was promoted in the schools of his home town where 'he received instruction in mechanics, mechanical drawing, mathematics and kindred subjects'. Luthy 'acquired a practical knowledge of machines' under the proprietor of a 'repairing establishment' at the same time as he attended 'technical classes'. At the age of 16 Luthy entered the works of Sulzer Bros., Winterthur, and it was here over a stay of four years that he 'received a thorough practical training' as an engineer while 'continuing to attend evening classes in mechanics, mathematics, and other subjects'. In 1862, at the age of 22, Luthy 'came to London, and at the close of the exhibition of that year was engaged' by R. and L.R. Bodmer. Eighteen months later Luthy 'entered the service' of Hick Hargreaves.[4]

After his arrival in Bolton Luthy 'designed a hydraulic cotton-packing press' and not long later produced 'a variety of hydraulic balanced-valves'. A 'new construction' of hydraulic balanced-valve appeared in 1868 that became 'largely used in steel works and by makers of hydraulic machinery in this country and abroad'. Luthy's talents were employed to satisfy the demand for heavy machines required by the Bolton Iron & Steel Co. His Patent Slide Valve equipped Ingot Cranes designed for this company by the Soho Foundry in 1873 and a Tyre Mill designed in 1878 was fitted with Luthy's Double Acting Hydraulic Slide Valve. Luthy's expertise proved beneficial to Hick

122

Hargreaves work for several steelworks, but his most valuable contribution as a designer and experimenter lay in a quite separate activity. According to Luthy's memoir, a major investigation of his was undertaken into the 'efficiency of cold-air machines for freezing and preserving meat'. The decision having been taken in c. 1876 to manufacture cold-air machines at the Soho Foundry, it was Luthy who investigated the 'efficiency of cold-air machines' and the heat-exchangers used in them. He also attempted 'to ascertain the quantity of heat transmitted through walls of different thicknesses and of different materials, used for insulating the cold rooms to contain frozen meat in ships and in stores'. The first refrigerated cargoes from Australia and New Zealand arrived in Britain in 1879 and 1881 respectively and surviving drawings of Hick Hargreaves reveal that the early interest shown by the firm in this new aspect of engineering was rewarded with several contracts. Hick Hargreaves provided refrigeration equipment for the steamships Marsala and Sorrento of the Australian Co. Ltd. in 1881-82 and also installed freezing plant at Rio de Janeiro and at slaughter houses in Australia. The part played by Luthy in this undertaking was great and he was called upon to visit Australia from the Summer of 1883 'on business connected with the shipping of frozen meat, and to inspect the machinery made in Polton for a large freezing establishment there'. Over a year elapsed before Luthy arrived home in Bolton where he died suddenly of heart disease on the morning following his return.[5]

The other engineer whose expertise was hired by Hargreaves was William Inglis, who was appointed engineering manager of the Soho Foundry in December, 1867, shortly before Hick's retirement. A significant question therefore surrounds this appointment which bears on the entrepreneurial role performed by Hargreaves, a man who had no engineering skill of his own to offer the firm. As the decision-taker

it fell upon Hargreaves to ensure that the human and fixed capital of the firm were organised to meet demand in order to cover the cost of the inputs combined at the firm and reward his own services as entrepreneur with profit. The advent of refrigeration machinery represented an opportunity that an engineering enterprise, such as the Soho Foundry, could exploit because it was already organised to meet demand in the market for industrial power. Stationary steam engines constituted the mainstay of the Soho Foundry in Hargreaves lifetime as factory employment and the use of machinery extended throughout the economy. Engine jobs were an activity for which the whole works was organised, crucial not only to profitability in the short term but in the long term also because of the goodwill secured by the firm's repute for meeting power-users needs. Hence, it was of great importance to Hargreaves that plant management was the charge of a responsible engineer capable of fully utilising the resources of the firm for the maximisation of profit. William Inglis was the engineer appointed to succeed Hick in the engineering management of the works, but Inglis did more than simply direct labour and organise production to achieve profit. He proved an innovatory engineer and designer of high ability through his improvement to the economy of stationary engines. Inglis's contribution to the improvement of the steam engine was inspired by the inventiveness of George Henry Corliss in the United States, whose search for economy had 'far reaching effects on steam engines'. Inglis seized upon this American improvement to valves and valve gear, applied it to the British mill engine, where considerations of economy were of cardinal importance to mill owners, and by adopting the horizontal form helped to supplant the rotative beam engine, in order to obtain more power and economy of steam consumption at higher speeds and steam pressures. Indeed, it was Inglis's demonstration of the superiority of the Corliss valve gear in the horizontal engine that led to Hick & Son's adoption of the Corliss

engine and hire of the most ardent practitioner of its mechanical principles.[6]

John Hick's retirement from the partnership led to a change in the title of the firm from Benjamin Hick & Son to Hick Hargreaves & Co. However, the new style under which the Soho Foundry operated fails to acknowledge the profound influence William Inglis exerted on the design of the Soho Foundry's steam engines. Inglis was born in Ottawa, Canada, in 1835 and apprenticed at the St. Lawrence Engine Works, Montreal. In 1856 he travelled to Glasgow, spending two years at the firm of R. Napier & Sons as well as attending the engineering classes of Prof. Rankine at the university. From Glasgow Inglis entered the locomotive works of Robert Stephenson & Co. before returning to Canada in 1860. Here he became 'engaged for two years in designing and erecting machinery, including a walking-beam paddle-engine, fitted with Corliss valves, for the river paddle-steamer "Montreal"'. At the time of his arrival in Britain the long-established beam engine was having to compete with the horizontal slide-valve engine. This design was noticeably different in the United States where the 'trend was towards much higher speeds', which revealed disadvantages in the slide valve on account of the increased steam pressures. The American response was the invention of new valve designs that manufacturers could adopt because of the gradual improvement of machine tools that raised accuracy while reducing costs. In 1849 George H. Corliss, a non-professional engineer with a 'flair' for engineering, 'patented his gear with cylindrical rocking valves' for the admission and release of steam from the cylinder. The large Corliss-valve engines he built achieved widespread fame as a result of displays at the Paris Exhibition in 1867 and the Centennial Exhibition at Philadelphia in 1876. But well before these events the Corliss valve had reached Europe when it 'was imported into Scotland in 1859'. It is claimed that the first European Corliss engine

emerged from Douglas & Grant's Dunnikier Foundry, Kirkcaldy, in 1863, while 'almost simultaneously Hick of Bolton began manufacturing them'. Steam valves 'were a most important detail in the design of an engine' and here the best American practice exceeded that in Britain in the same decade as the Great Exhibition.[7]

Inglis's experiences in Canada seem to have made him aware of the scope that existed in Britain for improving the steam engine by fitting an improved valve arrangement to the cylinder and he returned to Britain in 1863 with the Corliss gear in mind. In Edinburgh Inglis opened an office as a Consulting Engineer, but the next year the office was removed to Manchester. Here Inglis 'designed an improved type of Corliss engine, with which his name is so closely and deservedly associated'. After his death in 1890 the professional body to which Inglis belonged did not hesitate to ascribe the 'large development of the Corliss valve and gear' to the '"Montreal" and to Mr. Inglis'. In support of this assertion Inglis's obituary recorded the circumstances of the Corliss engines appearance in Britain. In 1861 one J.F. Spencer met Inglis in the engine-room of the "Montreal" while visiting Canada and was so 'impressed with the efficiency of the Corliss valves and gear' that on his return to Britain he 'patented what is known as the "double-clip gear"'. Spencer fitted his 'improved gear' to Corliss engines at Bradford and Blackburn in 1862-4. 'This type of engine excited great controversy for many years, and its present success, and almost universal adoption for large mill-engines, is greatly due to the energy and pertinacity with which Mr. Inglis upheld its advantages'. From Manchester Inglis 'superintended the construction (on the Clyde), and shipment in plates to Canada, of several large steamers'. The exact circumstances of Inglis's arrrival at the Soho Foundry are lost, but it is not difficult to see why Hick Hargreaves would be interested in the Corliss engine. Its economical steam consumption and steady governing

were essential considerations to power users in the textile industry, 'where constant breakage of thread would seriously hamper production'. By 1868 there were little more than 60 Corliss engines in use in Britain and of these two were described by Inglis as an 'improved construction of the Corliss engine' in his paper on Corliss valve-gear before the Institution of Mechanical Engineers. These 'improved' Corliss engines had been built by Hick Hargreaves 'from designs by the writer' in collaboration with Spencer. By appointing Inglis as engineering manager of the Soho Foundry, William Hargreaves and John Hick determined the firm's destiny as mill-engine builders, because it was the direct-acting horizontal engine fitted with Corliss gear which became the common mill-driving and general purpose rotative engine down to the turn of the century. Prior to Inglis's appointment Hick Hargreaves exhibited an engine equipped with Inglis and Spencer valve-gear at the Paris Exhibition of 1867. This was the 'first public appearance' of the gear arrangement based on the Corliss principle devised by Inglis and Spencer in 1863. A treatise on Corliss engines, published in 1879, declared that 'close inspection' of their gear 'displays at once the completeness of its design, and shows that, if it is constructed with good workmanship, the mechanism will work for years without needing stoppage or repairs'. It was also noted that the Soho Foundry was 'still turning out a large number of engines fitted with this gear' over a decade after its first appearance. Inglis's appointment to a responsible managerial post has to be seen as his reward for producing a design that possessed the potential for generating profit. Corliss engines working with the Inglis and Spencer valve-gear became a speciality of the Soho Foundry despite their severe test of foundry and machine-shop practice. The casting of cylinders became more demanding with the appearance of Corliss valves and required the production of 'foundry master pieces'. The machining of cylinder faces in one setting was only permitted

12

through improved machine tools. Cylinders had always been an important engine component, but the Soho Foundry paid particular attention to the finish of the Corliss-engine cylinder. The firm developed an 'improved method of constructing the cylinders of Corliss-engines, with separate internal liner, separate steam-jacket-casing, and separate end-valve-chests, a construction which ensures a thoroughly sound and substantial cylinder, and admits of very close and hard metal being used for the internal cylinder or liner'. Under Inglis's management Hick Hargreaves became the 'first firm to manufacture the Corliss engine in this country under the Inglis and Spencer patent' and exploited this lead by perfecting 'many improvements' in Inglis's lifetime. At his death in 1890 some 'nine hundred Corliss engines' had been built by the Soho Foundry, 'ranging in powerfrom 80 to 10,000 HP'. 'Perhaps more than any one individual', his obituary remarked, 'Inglis was instrumental in bringing mill-engines to their present high state of perfection'. Inglis advocated those features of design - high piston-speed and high steam pressures - that marked the 'most advanced practice in steam engineering' and Hick Hargreaves steam engines were the embodiment of his talent.[8]

Inglis had been able to compare the features of British engine design with the novel practices that arose in the United States. Both here and on the Continent of Europe innovations to the build of engines occurred in the late 19th century which allowed the foreign penetration of the home market for mill engines. 'It is clear', one work declares, 'that the apotheosis of the steam engine was not just a British achievement'. British firms certainly 'did not always lead' in the evolution of steam-engine technology, but they 'readily adopted good practice' from whatever quarter it came. Nevertheless, foreign enterprises such as Tosi of Italy and Carels Freres of Belgium were successfully competing for mill-engine contracts in Lancashire by[98]

c.1900. Yet British firms throughout the period were alert to advances in design. The Corliss engine was introduced to Britain by Hick Hargreaves, who fully exploited this design in the highly competitive market for textile-mill engines, but this engine type was rapidly adopted by other builders for roles as diverse as the driving of electric generators and the raising of coal at collieries. After 1908 Hick Hargreaves was one of several firms who adopted and built under licence the uniflow engine, the 'last major development of the reciprocal steam engine', following the appearance of a practicable engine at Charlottenburg. The erosion of British commercial and technical superiority in machine tools after 1850 discussed by Floud could have a parallel in the engine trade, particularly as there were close links between sectors of the specialised engineering industry. Further study of the performance of the engine trade might reveal whether the commercial, as apposed to the technical, ability of engine builders was stultified as a result of half a century of industrial pre-eminence. Hick Hargreaves experience shows a strength of enterprise at both the commercial and technical levels, but how representative was this one firm of the whole engine building sector? This question raises the issue of differences in entrepreneurial performance within industries and between firms. In his discussion of international trade in machine tools Floud considered whether the British and American machine-tool industries were operating at different production functions. He believed that this hypothesis was unlikely to have applied to the two economies, but found it 'difficult to disagree' with the idea of a 'spectrum of technologies in use at any one time' found in Saul's 'alternative' hypothesis of a 'spectrum' of customers for machine tools. Hick Hargreaves was a best-practice firm both in terms of entrepreneurial and managerial control of the firm's direction and organisation, and the technical practices employed in the shops.

William Hargreaves exercised a firm grip over commercial policy, while Inglis as engineering manager ensured the attainment of a possibly outstanding technical performance that met the demands imposed by new engine constructions with a demanding arrangements of parts. It was a high level of shop practice that first enabled the Soho Foundry to produce Corliss engines to the advanced designs of Inglis. The automatic variable expansion gear of Inglis and Spencer was a new principle of engine build first taken up by Hick Hargreaves in 1867 because the firm recognised the advantages of applying it and was technically competent to construct it. By 1879 Corliss engines working with expansive gears were 'still comparatively little understood', yet much progress had been made in America, Britain and the Continent of Europe in the design and manufacture of Corliss and 'allied' engines working with and without automatic variable expansion gear. The valve-gear of Inglis and Spencer's devising was just one of several types that were developed. J & F Wood of Bolton, for example, designed and constructed their own arrangement of expansion gear based on the Corliss valve-gear and such firms as Douglas & Grant, Hathorn Davey of Leeds and Daniel Adamson of Dukinfield were also builders of engines working with Corliss valve-gear. However, the great majority of 'approved designs' in Uhland's treatise were the products of American and Continental firms. Indeed, the Inglis and Spencer valve-gear taken up by Hick Hargreaves had been adopted by four other engineering firms by 1879: L. Poillon of Lille; G.Sigl of Vienna; Escher, Wyss & Co. of Zurich and Socin & Wick of Bale.[9]

III

Experimentation and the search for innovation was undoubtedly a theme to the activities at the Soho Foundry. It was this receptiveness on the part of Lancashire manufacturers as a whole which drew inventors

in search of patronage to a region where the competitive basis of the engineering trades spurred the search for fresh avenues of profit. One such man was William Siemens who helped transform the iron and steel industry with the open-hearth process. This successful invention of the late 1860s followed years of failure in which Siemens had attempted to apply the regenerative principle to the steam engine. When this principle was applied to the blast furnace it achieved savings through the reduced cost of fuel consumed. Nevertheless, the Cowper hot-blast stove that embodied the regenerative principle and the regenerative furnace for manufacturing steel that came later were the results of Siemens prolonged attempt to utilise waste heat in the steam engine. In a heat engine, such as the steam engine, heat is employed to do mechanical work and Siemens believed that the efficiency of the steam engine could be raised considerably by using the wasted heat to increase the work done.[10] It is the part played by John Hick and other engineers in supporting Siemens attempt to extend the science of steam engines which is significant, because it shows a willingness on the part of some engine builders to undertake the development of a fundamentally new principle in the construction of steam engines.

William Siemens was drawn to Manchester in 1847 shortly after his arrival in Britain 'because of the prospect of profitable employment there'. His technical training and engineering background at Magdeburg meant that he could command some respectful attention, yet he was little more than a footloose engineer drawing his reward from whatever quarter he could. Nonetheless, his belief that the heat engine might be made to use a greater proportion of the heat supplied was not dismissed out of hand as an aberration. When Siemens 'consulted, confidentially, Mr. John Hick, an eminent mechanical engineer', the theory of the performance of the steam engine established by Carnot had still to be consolidated in the science of thermodynamics. Siemens had 'conceived

the idea of an arrangement' which would save the heat wasted in engines, but he required support from a respected engineer. Hick conducted his own experiments and concluded 'that though there would be many practical difficulties in applying the invention, yet the principal was good and promising, and it deserved a trial'. The outcome was that Hick 'liberally agreed' to build under Siemens direction an experimental engine whose results were so encouraging that Siemens patented his invention at the close of 1847. The project developed further in 1848 when Fox, Henderson & Co. of Smethwick, later the contractors responsible for Paxton's Great Exhibition building, undertook to adopt Siemens design, following its realisation in the form of an experimental engine at the Soho Foundry. Under the new arrangement Siemens received a salary of £400 from Fox, Henderson for his 'personal services' and was allowed an office, as well as the assistance of the firm's chief draughtsman. Siemens career certainly benefited from his presence in a renowned engineering works and the advice of Edward Cowper, the firm's chief engineer, but the project for a regenerative steam engine was a failure. The experimental engine of 4 H.P. built by Hick & Son did not work satisfactorily and the same was true of a modified design produced at Smethwick in 1853. The potential reward offered by the commercial exploitation of Siemens' idea weighed heavily with Fox, Henderson and after calling for an independent report on the project a 'new construction on an altered design' was begun. Apparently, the form of engine Siemens had developed was 'not favourable to the beneficial application of the principle'. However, the principle was such that it merited further development and when the new design was ready early in 1854 it was submitted to John Hick 'who had in this case undertaken the manufacture'.[11]

By 1854 Siemens was receiving a handsome reward from several firms, including Hick & Son, through the royalties payed for the exploitation

of his inventions. From his residence in London Siemens was in regular correspondence with Hick & Son, discussing his latest projects, requesting terms of agreement and pursuing his old notion of a regenerative engine. Early in the year Siemens declared that he had 'commenced a portable Engine of 30 Ind HP of which I enclose an unfinished tracing that will enable you to judge the arrangement adopted'. Hick & Son quickly replied, stating the terms upon which they would construct his patent portable engine and permitting Siemens to promise personal delivery of the detail drawing with 'all explanation that may be necessary'. It is apparent from Siemens letters to John Hick that the contractual arrangements agreed between them had matured into a harmonious understanding of each others motives. The Soho Foundry was not alone in undertaking to build Siemens' inventions, but a rapport existed between Siemens and Hick founded on a long-standing acquaintanceship between two men, inventor and entrepreneur, who had the same rewarding end in view. An instance of the trust that existed between the two men is provided by Siemens' comments on the governor he had recently devised. In one letter Siemens wrote to Hick he asked whether the 100 copies of the governor paper had reached him safely, while he promised to return Hick's model from an exhibition at the Society of Arts. Siemens subsequently wrote: 'you will receive tomorrow a parcel addressed to me containing the draght of license as drawn by Mr Rushton with certain objections of Messrs Cox & Wilson of Oldbury. I think it would be desirous if Mr Rushton could remove those objections and simplify the arrangements'. Later in the year Siemens announced that Bolckow, Vaughan of Middlesbrough had placed an order for one of his governors to be fitted to an engine 'driving Rolling mills of extremely variable load'. Further 'particulars' were promised but in the meantime 'a governor with 17 inch Wheel (£40) will be sufficient which plan to prepare'. The terms of the governor licence, and the

response to it by such licensees as Martin Samuelson of Hull, occupied Siemens attention a great deal. 'Messrs Cox & Wilson near Birmingham', Siemens wrote, 'the constuctors of the Engines for the new Crystal Palace and friends of Mes Fox Henderson & Co have also agreed to take a License for the Midland Counties and to min. payment of £100 a year'. Cox & Wilson insisted on alterations being made to the terms of the licence and Siemens provided Hick with a draft licence 'and their Letters on the subject'. He went on: 'Considering that they leave us the power to terminate the arrangement at any time I think there will be no need of the Minimum clause - Please to cause Mr Rushton to examine the papers and to prepare a draught for signature without delay - The same will be accepted of Mr Samuelson of Hull'.[12]

Siemens' letters to Hick reveal that he enjoyed Siemens' confidence to the extent that Hick was entrusted with responsibility for Siemens' affairs. An illustration of this is the role played by T.L. Rushton, Hick's friend and confidant, who provided Siemens with legal assistance by drawing up the licence for Siemens' governor. The fellow feeling that existed between Hick and Siemens explains why responsibility for the building of the improved regenerative engine was granted to the Soho Foundry. Siemens had faith in Hick's understanding of his ambition. At the beginning of the year, when Siemens was preoccupied with the governor licence, he informed Hick that 'detail drawings' of the new design of engine would soon be ready. Shortly afterwards he wrote: 'having forwarded the drawings and specifications of the 15 HP Regenerative Engine to Messrs Fox, Henderson & Co yesterday I hope they will reach you at the same time with this. The detail drawings being mostly of the real size with dimensions & remarks written in, I hope no personal explanation will be required'. Siemens added:

> Considering the importance of having the Engine completed before the Summer I have to request as a great favor that you will commence upon the same forthwith and without waiting for the completion of the formal arrangements with Mes Fox Henderson & Co offering to be held responsible to you for eventual losses on that account.

Less than a week later Siemens wrote: 'I trust you have put the Engine in hand although some little time may elapse until Mr Henderson will have considered your estimate which I think is reasonable. Some time since I wrote to my friend Mr E Krupp, the celebrated Steel manufacturer at Essen in Germany asking whether he could undertake to make the crank axle of the Engine of his Steel. In reply he says he has made it waranted to be perfectly sound throughout and to stand for 10 years. He makes at present many Locomotive axles Steamboat cranks etc which give great satisfaction. Hoping you entertain no objection to use the axle in question I shall direct it to be forwarded to you'. Within a few days Siemens was seeking confirmation that Hick & Son had 'received the definite order for the engine from Messr Fox Henderson & Co'.[13]

Siemens was eager to see his regenerative engine built from the moment the design was ready in early March. Once the fifteen drawings of the engine were available, it only remained for Fox, Henderson to give their approval to Hick & Son's terms for its manufacture and their consent was quickly given. Siemens desire 'to see it soon completed' is understandable and by April not only was he trusting that 'the Engine was progressing favourably', but he was also involving himself in its construction. In June Siemens felt moved to write:

> The time for the completion of my Engine drawing near, I should be glad to learn the present state of the work and to know the time when it will be sufficiently advanced for me to superintend the

35

coiling on of the wire guaze and the preliminary trials of the engine.

Siemens added that he would be at 'liberty' to attend the engine the following week. His next surviving letter dates from late October, 1854, following an interval of over four months, which suggests that the project encountered difficulties that impeded its progress over the Summer. Perhaps there was no need for Siemens to correspond with Hick because he was actually present at the Soho Foundry for much of the time. Or does the break in the correspondence suggest the 'loss' of some critical comments by Siemens of Hick & Son's performance? Siemens died in 1883 and his biographer, William Pole, produced his account of Siemens' life when both John Hick and William Hargreaves were alive. The project for the regenerative engine meant a great deal to Siemens. In the 1850s the application of Siemens regenerative principle to the steam engine was, in the words of Pole, the 'matter that occupied him most'. Yet Pole has nothing to say about the building of the regenerative engine in 1854. He remarks that its manufacture was entrusted to 'Mr Hick' and when tried 'in January 1855 ... the result showed considerable improvement'. Siemens letters are more informative and show that Hick & Son had built his engine by the Autumn, albeit an imperfect one. Siemens wrote: 'Considering the defects that still impede the satisfactory working of the Engine I think it advisable to remedy the same previous to working the Engine for any length of time'. He then presented a number of 'alterations' he wished to see made to the engine. By November the project seemed to be progressing well and Siemens wrote that he was prevented from visiting Bolton again as planned because of a journey he was making to the Continent. He added: 'Under these circumstances I trust entirely to your intelligent care for the success of the fresh alteration in the Engine'. Siemens then

offered a remedy for 'one point of difficulty' that had not been dealt with. When Siemens returned to London he found Hick's 'favor of the 27th ult, stating that the Engine was again ready for trial - In consequence thereof I intend to be at Bolton on Friday morning and shall feel much obliged if you will give the necessary instruction to work the Engine'. Siemens certainly regarded this trial as a success because he soon wrote to thank Hick for his 'statement of the late performance of my Engine which I think will suffice for the purpose intended'. He went on:

> On monday morning I intend to be again at Bolton and shall feel obliged if you will give instructions for the Engine to be worked again for some days previous to its leaving your works and if you will take the trouble to collect further information about its working, that may serve for your own satisfaction and for a further statement that you may be inclined to make.[14]

More regenerative engines followed the improved 15 H.P. model built by Hick, ranging in size from 5 to 40 H.P. and erected in Britain and on the Continent. Two engines were exhibited at the Paris Exhibition of 1855 where the invention was awarded a premier medal. According to Pole, Siemens was satisfied with the performance of his design and the saving of fuel it realised. But as a practical design Siemens regenerative engine was a failure, although the regenerative principle of heat conservation was sound and did find a successful application in the making of iron and steel. For over a decade Siemens enjoyed the support of many engineers and the 'practical aid of two of the best manufacturing firms in the country'.[15] In truth, Siemens work was sustained by the commercial ambition of Hick and others to be at the forefront of what promised to be a breakthrough in the technology of the heat engine.

IV

It was William Siemens brother who applied the regenerative principle to furnaces in 1856, giving rise to the Cowper hot-blast stove, while William attempted to apply the principle of regeneration to the puddling furnace. This work was carried out in 1857 at the Bolton ironworks of T.L. Rushton, who was willing to promote the mechanisation of the wrought iron industry. The interest of Rushton, Hick and Hargreaves in the technology of iron and steel-making was understandably strong, because engineering was adapted to satisfying the capital demands of new processes, and would directly benefit from the use of a new industrial material. Bessemer's steel-making process provided engineering with a uniform material of greater tensile strength than wrought iron, one that could be manufactured in quantity. Cheap steel replaced iron in the highly stressed components of steam engines and extended the limits that constrained designers. Moreover, the advent of new tool steels set in motion a fresh advance in the design of machine tools and brought further improvement to workshop practice. It was the greater cutting power of tool steels that permitted steel components to be machined, while demanding alterations in the build of machine tools. The Corliss engines built at the Soho Foundry exhibited a high standard of finish that was noticeable to contemporaries. It was noted by Uhland that steel was 'largely used in all engines made by Hick Hargreaves & Co' having been adopted for cylinders, piston rods, crossheads and mainshafts. This use of a new material was part and parcel of the 'improved method of constructing the cylinders' evident in the firm's Corliss engines. The properties of mild steel were similar to wrought iron, but steel was capable of controlled manufacture into a variety of bars, sheets and other forms. Bessemer steel superseded wrought iron as a general purpose engineering material because of its mechanical method

138

of production, whereas wrought iron was dependent on skilled puddlers, who were notorious for their intractability. Hick Hargreaves were quick to seize the commercial opportunities offered by the Bessemer process by entering into a contract for the right to manufacture converter plants.[16] This was not all. William Hargreaves was also involved in the creation of the Bolton Iron & Steel Co. Ltd., one of several Bessemer steelworks in Lancashire, as well as helping to diffuse the new steel-making technology. Bessemer's invention prompted a response on the part of William Hargreaves and his enterprise that signifies a recognition of fresh opportunities for reward. The close proximity of steel production to the Soho Foundry conferred certain benefits on both enterprises, as the steel company had a ready consumer close at hand while Hick Hargreaves could rely on an adjacent supplier of steel bars, plates and sheets, one that was also a purchaser of its steel-making plant. It would be an exaggeration to perceive the close commercial and entrepreneurial links between the two enterprises as evidence of an integrated steel and engineering combination. Hick Hargreaves and the Bolton Iron & Steel Co. Ltd. were complementary firms and within the context of an insecure and unstable market environment it is conceivable that a merger might have been considered. However, it is doubtful whether Hick Hargreaves was a major customer of the steel company, with demands so great that vertical integration was a feasible venture, even assuming that the entrepreneurs behind both enterprises were prepared to undertake a merger of their separate interests.

Although the Soho Foundry was deeply involved with the supply of plant for the iron industry of Andalucia, the home market for iron mills was limited by the self-reliant practices and conservative outlook of ironmasters. It is possible to distinguish two trends in the course of the iron industry during the 19th century. The first trend of an irregular growth in pig-iron output from 1815 was the result of the

revolutionary technological innovations inspired by Darby, Wilkinson and Cort in the previous century. Only 'one conveniently clear-cut innovation' occurred in ironmaking between 1830 and 1870 and that was Neilson's hot-blast. Technical progress did not cease, but was characterised by improvements to known principles of production. Riden has recently claimed that within the technological history of the industry 'There was a continuing process of plant becoming larger, more powerful and more complicated' in the period 1830-70. This 'great capital deepening' took the form of larger furnaces and bigger blowing plant, but the demand made on Hick & Son for this fixed capital was slight. A pair of blast engines was provided by Hick & Son for the Dowlais ironworks at an early date, but it was only with the invention of the Bessemer process for mild-steel manufacture that an opportunity arose to equip the Bessemer steel industry on a large scale. The second trend in the iron industry unfolded with the 'new decisive innovations' that began with Bessemer and the appearance of mild steel. Commercial use of the pneumatic process only got under way in the late 1860s because it required novel skills on the part of commercial users. Moreover, the Bessemer process was not a perfect one even when the production difficulties had been solved. A fundamental problem was the inability of the process to convert steel from pig iron produced from phosphoric ores. This difficulty had still not been overcome in 1868 when a second process of steel manufacture became available, the open-hearth process devised by Siemens and Martin. This was an improvement on the Bessemer process because the quality of the steel could be controlled by analysis over the many hours necessary to convert a melt of pig iron into steel. But both techniques required pig iron derived from non-phosphoric haematites. The dephosphorisation of pig iron was realised in 1879 by the cousins Gilchrist and Thomas, whose process permitted the manufacture of basic steel from phosphoric pig

14

iron in both the Bessemer converter and open-hearth furnace.[17]

According to Birch, it was the 'connection' with engine and textile machinery manufacture on the part of Lancashire engineering firms that permitted the region to play 'an important part in the second half of the nineteenth century in developing the new product, mild steel'. John Galloway of the Knott Mill engineering works, Manchester, had long been acquainted with Bessemer and his inventions: the first experimental converters were built at Knott Mill. Galloway was one of the first to take out a licence for the manufacture of Bessemer steel and later became a partner in the Bessemer steel works at Sheffield. The strong interest shown by Lancashire engineers in steel was reflected in the number of 'prominent Manchester engineers' who quickly adopted the Bessemer process. This satisfied a widespread interest in new materials which could be applied to meet existing requirements in engineering. Bessemer had not been alone in seeking to refine molten iron by blowing the charge. James Nasmyth was one of several investigators who anticipated Bessemer's pneumatic process by patenting a process for puddling iron with a jet of steam, conducting experiments at the Bolton ironworks of his friend T. L. Rushton. Entrepreneurs in Lancashire were also alive to the commercial benefits of Bessemer's process in addition to the industrial opportunities it afforded. The Galloways and John Platt of Oldham belonged to a syndicate of 15 members who, in 1862, purchased a one-quarter share of the interests in the patent royalties for a total price of £50,000. It would be interesting to learn the identities of this syndicate as William Hargreaves, T. L. Rushton and Henry Sharp were amongst those who raised the Bessemer-steel industry to prominence in Lancashire.[18]

The iron industry of the north west region - Cumberland, Lancashire and Cheshire - had flourished in the 14th century and could boast

of the attention it received from Abraham Darby four centuries later. Following the Napoleonic Wars, at the outset of a period of rapid and sustained growth in pig-iron output, the region had become a backwater, with production concentrated on the coalfields of South Wales, Staffordshire and Shropshire. This geographical concentration of production altered as the century advanced. There was the 'spectacular growth of the Scottish iron industry' after 1830 and the 'significant shift' of output to the Cleveland ores of North Yorkshire, Durham and Northumberland in the 1850s. It was from this time that the iron district around Barrow-in-Furness became more active. But the region's rise to primacy came in the 1860s and '70s, following the invention of the Bessemer process which was dependent on the high quality haematite ore found in Cumberland and Furness. The adoption of the Bessemer converter and its dependence upon phosphorus free pig-iron 'was the most important reason for the renewed importance of Cumberland and Lancashire'. Iron production was stimulated and steel-making attracted to Cumberland and Barrow because of the value attached to the region's haematite ore deposits. Haematite pig-iron production rose sharply in the late 1860s and attained a peak in 1890 when the region was responsible for almost a fifth of Britain's total output. Underpinning the prosperity of the region's pig-iron industry was its unique role as the only domestic source of high quality haematite pig-iron for the acid Bessemer steel process. Other iron districts took up the production of haematite pig-iron using imported ores, whose influence on the location of the iron and steel industry was pronounced from 1870, but the Cumberland and Furness coastal region remained an important source of haematite iron down to 1913 because it was able to alleviate the handicap of costly mining from deep-seated and discontinuous seams by importing ore. In 1885 nearly half the haematite iron made in Britain originated from the Cumberland-Furness district and the proportion was

almost a quarter in 1913. Economies in fuel consumption and the dependence of the Bessemer process on haematite pig-iron meant that ironstone, not coal, became the 'keystone' of location and growth. Nevertheless, the market held a strong influence over the location of the early Bessemer steel industry. Barrow may have developed into the 'Sheffield of the North' from 1859, but it was inland Lancashire which possessed the largest concentration of converters. The small size of producing units determined the location of steelworks within the market, but it was quickly apparent 'that greater savings could be effected by production at the place where pig-iron was manufactured'. The original distribution of Bessemer steel production had given way by 1880 to a regional concentration based on Cumberland-Furness, South Wales and Sheffield. The Bolton Iron and Steel Co. Ltd. was formed in 1876 and employed the Bessemer and open-hearth processes for the manufacture of steel products within the heavy engineering market of Lancashire. Despite the attraction exerted by, for example, the rich, low-phosphorus ore of Cumberland and Furness, steelmaking in Bolton proved rewarding into the 20th century. In 1906 the works of the company were considered worthy of acquisition by Henry Bessemer and Co. Ltd. and the plant was only demolished in the 1920s when the site was cleared and a portion of it used for the town's new wholesale and retail market.[19]

In 1859 a technical journal 'remarked that Bessemer tool steel had become a recognised article of manufacture'. This was as a result of the rapid response of a number of firms to the quality and competitive price of Bessemer's new tool steel, while some entrepreneurs, such as John Platt, went further and acquired an interest in Bessemer's patent royalties, so certain were they of the value of Bessemer's process for steelmaking. The early buyers of Bessemer tool steel were based in Lancashire and represented the premier engineering establishments of the industry. They included Platt Brothers, Whitworth, Beyer Peacock, Sharp

Stewart, Fairbairn and Hick Hargreaves, who were notable manufacturers in a number of trades that ranged from textile machinery to machine tools. Bessemer's process promoted widespread technological change within the iron industry between competing enterprises 'who were not handicapped by a conservative concern for quality or by the amount of capital vested in wrought iron manufacture'. This transformation of the iron industry benefited engineering from the outset. Modern methods of forging and rolling were adopted that placed a demand for more powerful rolling-mill engines on such engine builders as Galloways of Manchester and Davy Brothers of Sheffield, who were at the forefront of those supplying power to the metal trades. Bessemer & Co's steelworks at Sheffield drew on John Galloway's experience as a builder of heavy engines and boilers to provide converters and blowing engines. The firm also valued Galloway's engineering skills because the partnership foresaw a 'substantial business ahead in converters, engines, pipework and other equipment' arising out of the commercial success of the process. This anticipation on the part of Bessemer and his partners was realised with the manufacture of converter plant for many works and Hick Hargreaves quickly shared in the rewards of this new market. According to Lord, a business agreement was struck whereby Bessemer and his partner, Robert Longsdon, allowed only two works - Galloways and Hick Hargreaves - to fulfil orders for converter plants. Under this arrangement the Soho Foundry was permitted to manufacture blowing engines.[20]

The advent of mild steel had a direct influence on the development of the steam engine and boiler by permitting improvements to the details of construction and allowing designers to set new standards of performance. For many years cast iron had made up the greater part of the engine structure, employed for cylinders, beds and flywheels, while the more expensive wrought iron was used for the highly-stressed moving

parts. Farly crankshafts were, for example, solid objects made of cast iron that were liable to fail if blow-holes were present. Wrought iron offered an improvement, but steel had greater tensile strength. Its adoption for crankshafts and cranks as a superior substitute for cast and wrought iron is an instance of the improvement in construction that followed the cheap and plentiful manufacture of Bessemer steel. The high-speed engine of Peter William Willans, which made a profound contribution to the generation of electricity from the 1880s, was the expression of an exacting design dependent upon equally exacting production engineering. But Willan's economical and daring concept and the precision expression of it were dependent on the replacement of cast iron by steel as the constructional material for engine building.[21]

Improvements in the efficiency of engines called for boilers capable of satisfying increasingly onerous demands through the higher temperature and pressure of steam. The Lancashire boiler of Fairbairn and Hetherington met these demands and ensured its continued dominance for mill steam-raising plant with improvements in construction. It was from 1865 that mild steel replaced wrought iron in boilers, following early attempts to utilise steel plates by boiler makers in Lancashire. According to Lord, 'Lancashire business men' stood out among those prepared to apply this new material: William Fairbairn and the Lancashire & Yorkshire Railway used steel plates for the manufacture of locomotive boilers; Daniel Adamson & Co. supplied a battery of six Bessemer steel boilers to Platt Brothers and Jones, Quiggin & Co. of Liverpool adopted steel plates in the construction of ships. Steel had a particularly profound influence on the shipbuilding industry, whose recent transition 'from an industry of small handicraft firms into one of large, highly capitalized concerns' was based on technological improvements in the engineering and metal industries. The Engineer commented in 1865 that Jones and Quiggin were one of the few firms to

have applied Bessemer steel to shipbuilding. The performance of one of the Liverpool firm's steel vessels appeared to The Engineer 'sufficient to place steel in the forefront position as a material for shipbuilding'. But the widespread use of mild steel for hull construction occurred from the late 1870s when its technical reward became apparent. Steel permitted a significant reduction in hull weights which in turn gave rise to vessels of greater size and power. Consequently, steel 'was adopted very quickly' once the cost of this new material declined. The economic gain to shipbuilding of steel was, however, of greater significance than the technical gain which helped alter the nature of shipping in favour of the steam vessel. Steel was crucial to the competitiveness of an industry that was internationally supreme from 1870 and the regional distribution of shipbuilding reflected the influence of its raw materials. Indeed, the 'striking' differences in the location and concentration of the shipbuilding industry between 1841 and 1913 can be attributed to the influence on costs and profitability of the industry's accessibility to cheap raw materials, as well as the pull exercised by the capital funding of the northern shipping industry. The 'general concentration along the Clyde and the North East Coast' partly arose from the 'easy access to coal, iron and steel works, and engineering capacity' in those districts. Pollard and Robertson declare that the 'links of the shipbuilders with iron and steel makers were only less close than those with shipowners'. But they go further and largely attribute the northern migration of shipbuilding to the influence of raw materials. 'Granted the volume of overseas trade, the capital formation, and the engineering ability that formed the background of British strength in world shipbuilding', write Pollard and Robertson, 'it was the cheap supplies of iron and steel plates and bars, of machinery for the yards and of coal to drive the steam engines that were ultimately the basis of the location of the

46

industry along the Scottish and northern rivers'. Where Pollard and Robertson discuss the specialisation of output evident in the several shipbuilding districts, the influence of adjacent iron, engineering and coal enterprises in their development is clear. The model shipyard laid down at Barrow 'was entirely a creation of the iron and steel age'.[22]

Lord comments that Bessemer steel was 'established as a sound commercial material, as much by the enthusiastic encouragement of Lancashire business men, as by the untiring technical efforts of the inventor himself'. Once the Bessemer process was seen to be a practical method of manufacture engineers in Lancashire did not hesitate to employ Bessemer steel. At the same time, the manufacture of Bessemer steel also attracted the participation of Lancashire engineers, representing the culmination of their search for new principles of iron production. James Nasmyth anticipated Bessemer's pneumatic process by devising a means of puddling iron through the use of a jet of steam. His friend Thomas Lever Rushton encouraged this invention by urging Nasmyth to patent his process and allowing trials at the Bolton ironworks of which Rushton was proprietor. Nasmyth's steam puddling process was taken up by several iron manufacturers when certain imperfections to the principle limited its commercial value. Nasmyth was planning to eliminate these bars to his invention's widespread use when, in 1855, Bessemer 'patented the use of air to remove impurities from melted iron'. In Nasmyth's words, the 'results were so magnificently successful as to totally eclipse my process and to cast it completely into the shade'. Bolton remained the site of further research of value to ironmasters. From 1857 William Siemens investigated the 'applicability of the principle of regeneration to the puddling furnace'. But it was as a centre for steelmaking that Bolton became notable.[23]

V

It was the demand for haematite pig-iron on the part of Bessemer steel makers in Sheffield which stimulated the development of blast furnaces at Barrow and Carnforth from 1859. The identity of interest between iron and railway interests led to the creation of the Barrow Haematite Steel Co. Ltd. seven years later. This modern and well managed works was the expression of 'an attempt to emploit the new and growing market for steel railway lines', thereby raising Barrow into the first rank of British cities. It was towards fulfilling this ambition that 18 converters were set down, 'the ingot output from which was worked up by a series of rolling mills and twelve steam hammers made by the firm of John Musgrave & Sons of Bolton'. Carnforth, too, was promoted through the Carnforth Haematite Iron Co. Ltd., but there were steelworks at Liverpool, Manchester and Bolton which also hoped to exploit the Bessemer process for manufacturing steel products, steelworks that lay within reach of the furnaces at Carnforth and Wigan. The Mersey Steel & Iron Co. Ltd. installed converters in 1865 and made rails for the American market from Wigan haematite pig-iron. It was noted by The Engineer that this firm had recently been 'transformed into a limited liability company' and upon a site 'near the Harrington and Toxteth Docks', acquired in 1862, two 5-ton converters were being installed. 'All the machinery is being erected by Messrs. Galloway ... who, with Messrs. Hick, of Bolton, are the two engineering firms allowed ... to undertake these contracts'. It was arranged that the steel department would receive 'liquid iron melted in a Siemens regenerative gas furnace'. Steel manufacture at the Mersey ironworks declined as rapidly as it had begun, once the boom in railway steel broke and the competition of low-cost producers in Barrow and Carnforth was felt. An outright failure was the Lancashire Steel Company established at Gorton

in the 1860s with capital of £150,000. This enterprise aimed to turn out '200 tons of steel a week in the form of rails, engine tyres, axles and shafts, piston rods, boiler and ship plates, and weapons of war'. Unfortunately, the high expectations of the promoters were frustrated through a combination of competition, conservatism and hostility. The site was acquired by Bolckow, Vaughan as temporary capacity and later sold to the Standard Iron and Steel Co. The Gorton steelworks unrewarding life owed much, Birch suggests, to the absence of 'engineering shops of its own to establish the use of the new material'. This was not a problem faced by the Bolton Iron & Steel Co. Ltd.[24]

The ambition of the Lancashire Steel Co. was to manufacture 200 tons of steel a week and fashion it 'for all purposes where it is desirable to substitute Bessemer steel for iron'.[25] The prospectus envisaged the production of steel rails, locomotive tyres, piston rods, boiler plates, crank shafts, cannons and mortars etc., and to this end the company aimed to set down 'some of the largest and most powerful Turning Lathes, Shaping, Drilling, Planing, and Slotting Machines etc'. Investors were assured that the prospects for a return on capital were promising and that the site chosen at Gorton would allow 'a good supply of suitable iron and coal, besides being contiguous to large Engineering and Railway Plant establishments'. Operations commenced in 1864 and ended in failure after seven years when the company was liquidated. The failure of this promising enterprise in steelmaking is startling when set against the rewards achieved elsewhere by such established firms as the Bolton Iron & Steel Co. This prospered because it was favourably secured to the demands of local engineering firms, such as Hick Hargreaves, whereas the Lancashire Steel Co. enjoyed no such connections. Some steel demand was therefore denied to this company because of its independance from steel users. But this is not the only reason for the different experiences of these two enterprises in

steelmaking. Both ventures had to achieve sales over a market wider than that offered by the adjacent engineering trades. Here was a test of entrepreneurship in identifying those areas of demand where sales would prove the most rewarding and selling in the identified markets. It appears that the entrepreneurs behind the Gorton works failed this test, while John Hick, William Hargreaves and John Sharp succeeded. At Gorton the risk of failure was great in an enterprise 'dependent entirely upon its own resources in the direction of successful technical and commercial operations'. But was this risk unique to the Lancashire Steel Co? Lang, the company's chronicler, believed that it was, because the probabilities confronting this venture and the 'adversity' it encountered seemed to prove 'That the undertaking was premature'. The Bessemer works at Gorton, 'unsheltered from the hostility of long established vested interests and prejudices, and encountering a far greater degree of conservatism and limitation of markets than had been expected', was destined to fail in Lang's opinion.

It is correct that the Lancashire Steel Co. had to cope with novel technical difficulties in applying the new technology of steelmaking and contend with vested interests in prevailing techniques, who exploited the difficulties in order to condemn the Bessemer process. But these frustrations were widely felt. The metallurgical judgment of wrought-iron workers, for example, was of little help to an understanding of the Bessemer process and mastery of it had to be learnt through experience. Steelmaking at Gorton could not have begun at a more auspicious time, because Bessemer's successful contest with the Ebbw Vale Co. 'removed the last barrier to the quiet commercial progress' of his invention. The moment had arrived when the Gorton works should have exploited the superiority of the new material to the full in those markets open to it. The events at Dowlais are instructive. Steel began to be made here in 1865 and from the start a

handsome return was made on solid steel rails despite the technical problems that made steelmaking 'one of great anxiety and labour'.[26] Once these were overcome at Dowlais costs fell and the only problem that remained was the sales resistance to the new product. A sizeable profit margin, the result of efficient production, permitted price reductions to stimulate sales. By the late '60s 20,000 tons of steel rails were being shipped to the United States in a trade that 'yielded an average profit of £2 8s. 8 2/10d per ton of steel rails as against a mere 18s. 3d. margin on wrought iron'.[27] Dowlais steelworks contributed 30% of the company's profit for the year ending 1871. This encouraged the installation of 'another steel rail mill, a decision which was justified by mounting orders, a bigger profit margin, and increased sales in 1871-2'.[28] While events at Dowlais demonstrated the 'triumph of steel', the Lancashire Steel Co. experienced failure. The conservatism of the War Office and Admiralty was apparently 'reflected on the fortunes' of this company. There were doubts over the suitability of boiler plates made from steel because of the dangers of its variable quality. Such worries were unfounded but 'one of the most serious difficulties' faced by the Gorton works was the lack of skilled personnel capable of operating the plant. This was a significant failing because it allowed the potential of the Bessemer process to pass unrealised. As a result, the company's performance was impaired by the inability to master the techniques for producing Bessemer steel of uniform quality, thereby dissuading shareholders from financing the provision of engineering shops. This investment was crucial to the production of steel articles in competition with wrought iron.

It is arguable whether the Lancashire Steel Co. was alert to the rewards offered by Bessemer steelmaking. Lang declared that the 'better trading position' enjoyed by such competing Bessemer plants as Dowlais

and Ebbw Vale also weakened the company. This, together with the evidence of inadequate control over the innovatory practices, reflects on an unsatisfactory level of entrepreneurship at the company, as revealed by poor production and marketing management. The early fortunes of the Bessemer steel industry were bound up with the use of steel rails at home and overseas. The supplantation of wrought-iron rails by steel could have proved highly rewarding for a pioneering venture organised to seize the opportunity offered to it. Indeed, Bolckow, Vaughan acquired the Gorton works from the liquidators in 1871 specifically 'to fulfil orders for steel rails', because they were alive to a 'falling off in demand for rolled-iron products and the growing demand for steel'. The Lancashire Steel Co. suffered disappointment because its planned speciality, boiler plates, had an appeal limited to stationary engine builders and not the locomotive engine builders who also constituted the local market. Lang's conclusion was that the company 'having overcome all technical difficulties, nevertheless failed in the end to achieve sufficient commercial success to justify its further continuance'. That the commercial rewards proved elusive was the inevitable result of failure of entrepreneurial performance. The company's promoters possessed the initiative and drive to create a 'pioneer undertaking', yet they failed to conduct operations with that capacity for achieving the greatest return. Steel rails were manufactured at Gorton, achieving some success, but plates and gun-forgings were also turned out. It appears that there was no identification of the most suitable article for the Gorton works to manufacture that would realise the greatest potential for profit.

The formation of the Bolton Iron & Steel Co. Ltd. in 1876 came two years after a peak in industrial effective registrations and at a time when the cycle of company registrations was declining to a lower turning-point in 1878. Drawing on research by Shannon into public and

private company registrations in the period 1875-83, Cottrell shows that industrial companies accounted for a majority of private effective registrations. The cyclical movement of private industrial registrations rose from a trough in 1876 to a peak seven years later and these registrations were the predominant form of all private effective registrations throughout the depression of the middle and late 1870s. This prompts the question: what was the motive behind the creation of a limited steel company in Bolton at this time? Was it the rational response of proprietors in a period of falling prices, interest rates and profits? The appeal of the limited company varied from one industry to another. By the 1880s limited liability had proved attractive in mining, iron manufacture and general engineering, and limited companies were also becoming widespread in cotton. Elsewhere, the limited company had made little headway. This was true of shipbuilding where registrations 'tended to be predominantly for the establishment of public companies'. The engineering trades of Birmingham had embraced the new form of organisation with vigour, as numerous old private firms had become limited companies by the 1880s. In the opinion of witnesses to the Royal Commission on the Depression of Trade and Industry, these conversions had occurred because the firms were 'getting unmanageable and too large for private undertakings'.[29] What was the purpose of the Bolton Iron & Steel Co. Ltd? Was it simply a passive measure to secure the wealth of the entrepreneurs? Or was it the means to a particular end, such as further growth?

The response of ironmasters to the advent of revolutionary steel-making processes stimulated the emergence of company promoters from the ranks of accountants, whose professional skills interpreted the recently liberalised company law for the benefit of entrepreneurs, once they no longer regarded the partnership as the ideal business organisation. The heavy capital outlays required of ironworks organised

around the innovations of an earlier technological revolution had been met through the partnership and technical innovation as a result of the inventions of Bessemer and Siemens-Martin did not immediately disturb the long-standing organisation of the iron industry in private hands. Changes in the structure of iron enterprises to take advantage of the reform of company law only needed to be considered when the capital requirements of ironmasters could no longer be satisfied by ploughing back profits and resorting to bank finance. In Sheffield steel manufacture was initially undertaken by the established iron partnerships, because they were capable of financing investment in steel plant without calling upon the investment of anonymous capital through their conversion into limited companies. As Anderson and Hoe point out, the strength of the private partnership in the Sheffield iron and steel industry lay with its ability to finance itself out of profits and secure bank loans for the provision of fixed capital. However, bank lending policies were not immutable. The commitment of banks to industrial clients through long-term loans in highly illiquid assets was hazardous, a point demonstrated in the steel slump of the 1870s. But irrespective of the risks attached to industrial loans 'there were limits to the extent to which the banks could provide working capital ... and especially grant loans for the provision of fixed capital'.[30]

Anderson and Hoe argue that 'permanent additions to the capitalisation of large-scale industrial undertakings ultimately meant raising new equity. The role of the banks may have postponed industry's need to adopt limited liability incorporation; it could not be a substitute for it in the long-run'. Indeed, the 'company form had become paramount in the Yorkshire steel centres' by the 1880s as a result of two influences that reached a final stage in the boom and

slump of the 1870s. Firstly, the entrepreneurs behind the large private firms who were keen to manufacture steel perceived the limited company as a means of adapting to 'changes in technology and scale by bringing in additional capital', while at the same time allowing 'industrialists who were risking ... their own capital to spread that risk rather more widely then before'. Secondly, there were many iron conversions in the boom of the 1870s where the incentive to some proprietors was to realise their assets before the end of the boom when the inadequacy of their private firms would be revealed in bankruptcy. However, there was another and 'more important reason' for the rush of limited company promotions in the Sheffield iron trade in the 1860s and '70s, that stemmed from the 'rapid ageing' of private patnerships in this period. It was brought home to ironmasters that the enterprises they controlled had grown beyond the grip of an individual proprietor or partnership 'given the coincidence of capital resources and technical knowledge that would have been required'. Once private partnerships recognised that the limited company offered both an involvement in the converted enterprise and a limitation of their personal risk through extended ownership, the opportunity arose for the accountancy profession in Sheffield to act beyond the keeping of industrial accounts and exploit their links with the local stock exchange and banking system for the promotion of companies and reconstruction of enterprises. By the 1880s the accountancy profession in Sheffield was closely 'involved in the affairs of the town's major industrial concerns' having found a role for its services by promoting the company conversions desired by ironmasters.[31]

Shipbuilding like iron was an industry where the 'traditional partnership form of organisation became less and less appropriate as the average capital value of individual firms increased'. Yet it was not

until the 20th century that 'genuine joint stock enterprise' began to alter the appearance of shipbuilding, because the families who exercised long-standing control over this industry had successfully adapted by resorting to incorporation in order to preserve the yards in private hands. To the family shipbuilding enterprise registration as a private limited liability company was a 'refuge against problems arising from the death or withdrawal of a partner and rises in death duties'. Down to 1914 the British shipbuilding industry was a family industry in which outside capital or influence was resisted and company conversion aimed to secure the private ownership of yards for a further generation. Public companies did appear, however, even if the 'changeover was slow and did not begin until the depression of the 1870s when it was usually the result of financial troubles or the desire to expand'. Self-financing was no longer adequate to meet the capital requirements of modern shipbuilding and from the depression of the mid-1880s the 'structure of a number of firms' was altered. 'Apart from the bankruptcy or reorganisation of a number of well-known yards, the slow metamorphosis into public companies began'. The 'change was usually completed by stages, each new financial embarrassment or physical expansion leading to a higher stage' until private partnerships became public companies. The more complex scale of shipbuilding touched the arrangements between builders and their suppliers, and the yards sought to purchase components at a low price while ensuring a steady supply. Some yards integrated vertically with suppliers; others remained independent. Palmer's Shipbuilding on the Tyne was the 'outstanding example of a comprehensive and self-sufficient combine' which, at the time of its conversion into a limited company by David Chadwick in 1865, 'was the largest vertical combine in Britain', exercising ownership over all the stages of production from the mining of ironstone to the building of steam colliers for the carrying of Palmer's coal and

ironstone. 'Connections between builders and steelmakers ... were classic examples of backward integration for "defensive" purposes'. Yet 'with few exceptions shipbuilders and steelmakers remained separate until' the Great War. The industry's 'principal raw material' was the speciality of steelworks, which were expected to fashion the rough steel and supply finished bars, plates and angles for use at the shipyards.[32]

Cottrell has concluded that the joint stock company became widespread 'in only a few areas of industry before 1885', such as iron and steel, and that it was common for limited companies to appear 'from either the public or private conversions of existing partnerships'. The reasons for the adoption of corporate status probably varied from one firm to the next 'but in not a few instances the main motivation would appear to have been to stave off bankruptcy'. In the iron industry incorporation 'provided a way to raise extra finance required for new investment, including the introduction of the Bessemer process'. The progression of the Bolton Iron & Steel Co. Ltd. owed much to the influence of T. L. Rushton. It was largely through his efforts that an insignificant venture based on a single forge became one of the most extensive steelworks in Lancashire, employing upwards of 600 men, with customers 'among the first railways and shipbuilding firms at home and abroad'. The company had its origins in "The Forge", an enterprise begun by one William Platt in c. 1830. His trustees were T. L. Rushton and James Eckersley, who soon became proprietors of the ironworks. As Rushton & Eckersley the iron foundry grew from 'limited dimensions', producing bars, plates and forgings. It was because of the 'spirit' of the partnership that the foundry was 'considerably extended, and its resources and capabilities developed to a high degree. Appliances of the newest and most improved kind - including one of Mr. Nasmyth's colossal and celebrated steam hammers - were introduced ...; and in the

course of time the firm ... became well-known throughout this country and many parts of the Continent'. In spite of his 'other pursuits, Mr. Rushton found opportunity for the display of an immense amount of energy in connection with the iron branch of industry, and he manifested much practical interest and skill in conducting operations at "The Forge"'. Rushton's 'personal exertions and ingenuity' overcame many difficulties and 'were rewarded by the establishment making very satisfactory progresss, frequent extensions having to be made'.[33]

At the close of 1859 Rushton retired from the business and for a time the foundry was known as Sharp & Eckersley, following the arrival of Rushton's brother-in-law, Henry Sharp. From 1860 Sharp's fellow partners were John Hick and William Hargreaves and it was these three men who formed the Bolton Iron & Steel Co. Bessemer steelmaking commenced in 1863 and four years later the Siemens open-hearth process was also adopted by a works that was 'reconstructed from end to end, and much enlarged in later years'. In 1876 the organisation of the business was changed when it became a private limited company. John Hick had already retired from an active life in industry after his election to Parliament in 1868, leaving William Hargreaves and Henry Sharp as the vendors to the contract. In the company's Memorandum of Association they were described as iron and steel manufacturers, conducting a co-partnership for the manufacture and sale of wrought-iron, steel rails, bars, plates and sheets, forgings, castings and other articles in both the rough and partly finished state. The vendors possessed fixed plant made up of engines, boilers, steel converting apparatus, rolling mills, steam hammers, furnaces, gearing, shafting and other property, as well as 'Things constituting the Moveable Plant', such as rolling stock and implements. The contract was between the vendors and The Joint Stock Company Limited. It was the case that Hargreaves and Sharp were 'willing to associate with

themselves [and] other persons desirous to share in the business' and for this and other purposes a company was formed with a capital of £225,000, divided into 9,000 shares of £25 each. The vendors' consideration or purchase money passing from the Company amounted to £218,443 13s. 4d. and was derived as follows:

£131,387 0s. 6d.	Lands, Buildings, Works, Hereditaments and Fixed Plant.
£ 64,701 12s. 9d.	Moveable Plant, Tools, Utensils, Raw Materials, Finished Goods, Stock-in-Trade, Articles and Effects, capable of transfer by delivery.
£ 22,355 0s. 1d.	Purchase money for the credits and assets of vendors.

The purchase money was paid to the vendors for their property through the issue of debentures, the issue of a number of ordinary shares with a nominal value of £25 'treated as having had £18 paid to the Company', and the award of cash to discharge the balance. In detail the creation of this private company conformed to contemporary practice, with securities in the form of ordinary shares awarded to the vendors in partly paid form. But at a time when the bulk of ordinary shares issued by companies had a value of £10 or less, those issued by the Company had a high denomination, a reflection of the private nature of this registration open only to a small circle of friends to the proprietors. The use of debentures as well as partly-paid shares was commonplace in the formation of coal, iron and steel companies during the early '70s. 'In nearly all cases before the mid-1870s, debentures were issued for a limited time, seven years being common, and so in nature were analogous to those issued by the domestic railway companies from the late 1830s

until the mid-1860s'. From the mid-70s the 'practice of issuing debentures, and other fixed loans of longer maturity, grew steadily', with the result that by 1885, 'in the case of companies quoted on the London Stock Exchange, such loan capital in aggregate amounted to 26% of the companies' aggregate paid-up capital'. The composition of the purchase money and the holders of shares in the Company were as follows:

£ 60,000	In Debentures of the Company (£100 at rate of £5 per annum per centum) William Hargreaves £40,000; Henry Sharp £20,000.
£147,636	In 8,202 Ordinary Shares. Nominal Value £25. William Hargreaves 4,597; Henry Sharp 2,534; John Sharp 200; John Henry Hargreaves 249; Francis Hargreaves 249; Benjamin Hick 124; William Inglis 75; Thomas William Willett 125; and John Butler Parkinson 49.
£10,807 13s. 4d.	Balance paid in cash William Hargreaves £7,205 2s. 2d; Henry Sharp £3,602 11s. 2d.

The contract between the vendors and the Company involved several leasehold and freehold plots of land. The largest of these had been conveyed to Henry Sharp, William Hargreaves and John Hick in 1864. In 1883 the Bolton Iron & Steel Co. Ltd. acquired the premises of the former Union Foundry and extended over 30,000 square yards in 1889, abutting 'upon four thoroughfares - Moor lane, Railway street, Blackhorse street, and New street'. At this time the works was devoted entirely to steelmaking and possessed sheet, plate, tyre and deck-beam rolling mills, forging and casting shops, and well equipped machine shops, as well as 'various other departments incidental to a thoroughly

160

representative industry of this kind'. The same description of the company went on:

> The mechanical plant in operation in the works is one of the most extensive, powerful, and valuable in England, embracing every apparatus and machine necessary in steel-working, forging, casting, rolling etc., and all of the newest and most improved type.

This 'industry' had won a universal reputation for its steel boiler plates and shovel sheet. The company's railway siding afforded the 'utmost facility for [the] transport of goods and receipt of raw materials', while sales were promoted by travellers active 'all over England'. By 1889 the Bolton Iron & Steel Co. Ltd. was an enterprise 'of magnificent resources and great vitality', one that 'bids fair for many a year to stand in the ranks of its British contemporaries of the same order', as a result of incorporation and the adoption of a new structure of ownership.[34]

Lancashire was deeply involved in the creation of limited companies because 'Most of the important iron, coal and steel company promotions of the 1860s and 1870s were undertaken by the accounting firm of Chadwicks, Adamson and Collier of Manchester and London'. Savings from Manchester and the surrounding cotton towns were mobilised into industrial companies through the activities of David Chadwick. The vocation of this accountant and one-time Treasurer to the Corporation of Salford was the tapping of people's savings and the promotion of companies. 'Between 1862 and 1874 he was involved in the establishment of at least 47 limited companies, most of which were the conversion of family-owned industrial concerns'. This essentially 'private activity' became less private in the 1870s when Chadwick acted 'as an intermediary between industrialists who wished to turn their partnerships into limited companies, and savers who were willing to invest in industrial

shares'. The 18 conversions he undertook between 1862 and 1868 involved capital amounting to in excess of £15m. and among the enterprises were the Ebbw Vale and Bolckow, Vaughan iron and steel firms and the Manchester Carriage and Yorkshire Engine engineering concerns. Iron, steel and coal firms made up one of the two groups into which Chadwick's industrial promotions of the 1860s fell. The whereabouts of the iron, steel and coal conversions was in Sheffield, the surrounding locality and the North Midlands, a region that had close ties with Manchester, the most important source of subscribers to the companies converted by Chadwick. But there were 'other important regional sources of subscriptions', such as the South East. The geographical composition of shareholders was a reflection of a 'mixture of local finance' and 'extra-regional sources of subscriptions' from the regions served by Chadwick's offices. As for the occupational composition of shareholdings in Chadwick's industrial promotions, Cottrell's research reveals that manufacturers were an important source of subscriptions. This was 'due in part to two factors: first, intra-industry and trade investment both in the case of iron and cotton conversions: and second, subscriptions by cotton manufacturers to iron conversions'. The Bolton Iron & Steel Company would have had little difficulty attracting subscribers to the promotion of a public company, but the vendors had no wish to create such a company.[35]

Cottrell asks why it was that the companies promoted by Chadwick were converted when they were and by Chadwick in particular? A possible answer lies with the financial environment of the mid-1860s which was 'favourable for flotations' and the stimulus to domestic investment arising out of the buoyant level of business activity associated with a cyclical upswing. This promoted investment in the capital goods industries as the existing capital stock proved incapable of satisfying the increased demand because of 'the short-run inelastic

nature of the supply curve of the heavy industries'. The response of entrepreneurs to 'rising product prices' was investment in additional capacity. Rising export values would also have influenced expansion plans in the iron industry, 'coupled with the decision whether to take up the Bessemer process', which was now a 'practical proposition'. Chadwick's industrial promotions of the 1860s must therefore be seen within the favourable 'general background conditions' of the time. The crash of 1866 ended Chadwick's promotional enterprise, but once 'real and financial activity' recovered 'he once again brought domestic industrial shares and debentures to the attention of his clients and friends', converting 'a further 15 industrial companies' in the period 1871-74, that included the West Cumberland Iron & Steel Company. This was a 'reformation' of a company set up in 1860 with a capital of £400,000 by a local family of coalowners. In his second period of activity Chadwick again drew on subscribers from Manchester and district, although 'its dominance was not as great as it had been in the 1860s'. Within the occupational structure of shareholdings the same group of subscribers were again important, but manufacturers were no longer the single most important group. Professional people now assumed this role. However, 'another important change' was that the 'individual shares' of the leading groups of subscribers - the professions, manufacturers and merchants - were now 'more comparable in size'. Chadwick's conversions in the 1870s took place against a backdrop of prosperity similar to that of the '60s, 'with a boom in both economic and financial activity'. The 'initiating stimulus' to the upswing of a major business cycle was foreign demand. This induced investment in the capital goods industries as a consequence of price increases in a market characterised by inelastic short-run supply curves. 'Issues by manufacturing, trading and mining companies played a substantial role in the new issues boom of the early 1870s'. Cottrell remarks that

industrial companies were 'an all-important feature of flotations' in the second period of the '70s when the public flotation of companies became for the first time a 'general feature' of the new issue boom. But the Bolton Iron & Steel Co. Ltd. was formed in 1876 in the settled aftermath of the domestic crisis of the previous year and at a time when industrial production was in the downswing phase of the cycle. This was a time for implementing measures that had been carefully weighed and judged appropriate. Hargreaves, Sharp and company had no need of Chadwick's agency or any other member of that 'considerable number of industrial promoters acting in the provinces and the metropolis in the 1870s'. The motives of Sharp and Hargreaves for forming a limited company stemmed from a desire to limit their liability for loss, while retaining control over the management and direction of an enterprise that would continue to be soundly based on self-finance.[36]

The method by which Chadwick converted a concern emphasises the desire of the vendors to alter the structure of their business in a changed legal framework of company law, without restriction of ownership and control. Chadwick's practice converted an enterprise in return for a commission of one per cent, plus a 'trifling' allowance for expenses. It operated on behalf of the vendor and saw itself as an agency drawing together investors and sellers of property. Chadwick regarded himself as an agent, not a promoter. In his view the promoters were the seven signatories to the memorandum of association, but in reality these included the vendor, the vendor's friends and friends of Chadwick. Moreover, in several instances Chadwick himself participated as a 'promoter'. In several conversions, such as the Ebbw Vale and Manchester Carriage companies, the vendors did not sign the company memoranda. Those who did were Chadwick's friends, Mancunian merchants and manufacturers, and 'As these people normally became directors of the concerns that they "promoted", they formed a major interlocking

management block in the iron, steel, coal and engineering industries in the 1860s'. Chadwick declared that his agency saw to it that the vendor was not allowed 'to take his hands off the property', but they often omitted to sign the company memorandum. Vendors could be paid in several ways, involving cash, shares and debentures. The evidence offered by six conversions of the 1860s shows that in almost 'all instances the vendors received a substantial proportion of the selling price in shares'. Consequently, 'the vendors became major shareholders in the new companies', sitting with 'members of Chadwick's Manchester circle', who also possessed a large shareholding. Although the vendors 'held a substantial proportion of their converted concerns' shares', the holding of the companies boards did not constitute a 'majority of the issued shares' and was in some instances no greater than two fifths. Palmers Shipbuilding & Iron was converted by Chadwick in 1865 and was one of those company promotions where the vendor, C.M. Palmer, did not sign the memorandum of association. The burden of risk had become heavy in this integrated enterprise, comprising collieries, iron mines, shipyard and ironworks. Palmer himself had no doubts why he converted his business: 'alone, as it were, and having such large undertakings in my hands, I felt it not only due to myself, to my family, and to the whole district of the North of England, and, I may also say, to the nation, that such a gigantic concern should be placed upon a broader basis than depends upon the individual'. Why it was that companies such as John Brown, Charles Cammell and Vickers, Sons & Co. adopted limited liability in the mid-1860s remains a point at issue. Cottrell remarks 'in the case of Browns and Cammells that it was the need to finance expansion which led to their conversion'. Yet investment in new plant had occurred before as well as after conversion. Heavy investment took place at Vickers in the 1860s and limited liability here followed the 'financial distress' caused by the crisis of 1866. Parkgate Iron had

produced rolled armour plates since the mid-1850s in common with Browns and Cammells, but 'unlike the urban Sheffield companies, large-scale steel manufacture at Park Gate was not embarked upon until the late 1880s'. The experience of the Bolton Iron & Steel Co. is also instructive. This concern adopted the Bessemer process after the retirement of Rushton and the admission of new entrepreneurs to the business in the 1860s. Steelmaking did not require the creation of a limited company; the enterprise and capital of Messrs. Sharp, Hick and Hargreaves proved adequate for the laying down of converters and Siemens' open-hearth furnace. When the works were extensively reconstructed in the 1870s this was accomplished through the security of a private limited company of trusted acquaintances.[37]

Whether vendors known to Chadwick were motivated by a desire to broaden the basis of their enterprises, or retire while the going remained good, is an imponderable question. One point is however clear and this is that as a result of Chadwick's activities his 'Manchester circle of friends and clients became an important management group in the nascent steel industry'. Knowing this the vendors at the Bolton Iron & Steel Company may have resolved to convert the firm through their own agency. Rushton, who had retired from the ironworks sixteen years earlier, was one of the seven subscribers to the company, and other shareholders included John Butler Parkinson, a local accountant, as well as engineers and steel manufacturers drawn from the Sharp, Hargreaves and Hick families. The limited steel company in Bolton was the creation of a close-knit group of industrialists active in southern Lancashire. Another motive for acting alone may have been the effects of the crisis of 1866 on Chadwick's company promotions. His own companies had to be rescued from embarrassment or failure as a result of the shock of events. One of Cottrell's concluding remarks is that Chadwick was 'an interface between a private commercial and industrial "grapevine" with

funds to invest, essentially Mancunian, and a group of industrialists who wished for various reasons to take advantage of the recent liberalization of company law'. Other agencies converted iron, steel and coal companies in the 1860s and 1870s, producing a 'wave of conversion activity in the iron industry which peaked in the early 1870s'. The outcome by the 1880s was that the joint stock company was, in Firch's words, an integral part of the industry's financial structure'. The Bolton Iron & Steel Co. Ltd. was an expression of this activity, one that did not need to resort to Chadwick's accounting practice, because it was self-promoting and financing.[38]

17.

Chapter 6

Profits, Output And Incorporation

Not long after the death of William Hargreaves his sons converted Hick Hargreaves & Co. into a private limited company and a new form of business organisation was adopted at the same time as a new generation of entrepreneurs took charge of the firm. In this chapter the possible motives for incorporation will be studied by examining the firm's profits over the years prior to incorporation in 1892. It is possible that the adoption of a new structure of ownership was a response to a poor perception of the firm's performance. Do the surviving values drawn from the firm's Profit & Loss Account show that profits had become harder to achieve on the eve of incorporation by comparison with earlier years? If incorporation was undertaken with a particular end in mind, it is likely that the organisation and layout of the workshops altered following conversion. Is there evidence to show that this was the case? Moreover, if incorporation was a conscious attempt to adapt the engineering enterprise to changed circumstances the new policy adopted by the directors might be expressed through fundamental alterations to the marketing of the principal product, the stationary steam engine for industrial power. Is there evidence of a dissimilarity in the construction of Hick Hargreaves steam engines with the 1890s as the point of departure?

I

In the light of Cottrell's research it is apparent that profits remained crucial to the financing of manufacturing enterprises throughout the 19th century. The liberalisation of company law offered access to external sources of finance but few firms explored this

avenue. Banks 'were generally very reluctant either to supply working capital on a continuous basis or more particularly to support investment in plant and machinery for any length of time'. Bank finance had met the capital and credit needs of entrepreneurs in the early stages of industrialisation. In the boom of the early 1820s it was bank finance that enabled many mills to be built in the Manchester district. 'There was an even greater reliance on banking facilities during the 1830s boom of which a feature was the upsurge of joint stock bank formation in the North West'. The structure of the English banking system underwent change in the late 19th century, beginning with the promotion of limited banks in the 1860s and 1870s. This led to a concentration of banking in a few joint stock banks each with an extensive branch network by the century's close. Such structural changes as the extinction of private banking through the activities of joint stock banks were accompanied by improvements to bank liquidity, partly a result of the amalgamation of bank deposits into fewer concerns, and the consequences were changed lending practices, with industrial clients accommodated through overdrafts rather than discounting.[1] Did the changes to the banking structure lead to policies that entrepreneurs found inimical?

Evidence from the first half of the century shows that banks were prepared to tolerate overdrafts that extended over years and provide capital as well as credit to industrial firms. The danger to banks of long-term finance to manufacturing enterprises was revealed in the 1850s with the failure of two banks heavily committed to the iron industry. The same industry 'also received long-term assistance during the slump of the second half of 1870s ... Apparently the failures of the mid-1850s had gone from memory'. It is because the nature of mid and late-nineteenth century banking practice is difficult to comprehend that Cottrell studied the source material of four country joint stock banks,

in order 'to establish case studies of lending policies by fairly typical banks in industrial areas'. In the case of the Swansea Bank of 1873, Cottrell found a bank linked intimately with new industrial developments through its directors to the extent that it 'can be described as an industrialists' bank'. This local tie with industry was a commonplace feature of a banking system comprised of numerous private and joint stock banks where credit-worthiness was determined by personal knowledge of clients extending over years. Although Cottrell believes that it would be 'extremely rash' to make general claims for the lending policies of the case studies examined, 'they are pointers to the behaviour of English joint stock banks' over the last 60 years of the 19th century. Industrial clients did receive prolonged accommodation under a variety of circumstances and the several banks 'activities did make a contribution, not only to the provision of working capital but also the finance of medium and long-term investment projects. It would appear that they undertook such lending because their managements had a sound grasp of both the needs of their clients and their credit-worthiness'. The 1890s witnessed the appearance of balanced branch networks in the wake of the amalgamation movement initiated in the late 1880s. 'Competition through size' became the new objective of bank mergers, leading to a concentration of banking into a number of joint stock limited concerns each with a branch network extending throughout the provinces. The implication for lending policies of the absorption of country joint stock banks into metropolitan concerns remains open to conjecture. But there is evidence of a change in banking practice in the provinces once managements became established in London, regulating activity through restricted branch managers, whose lending decisions conformed to the requirements set out at head office. On the eve of the Great War it was clear to bank representatives 'that the amalgamation movement had had the result of changing lending

practice, with the result that customers were not accommodated to the same extent as previously'. The influence of local bankers and bank directors yielded to the centralised control of the 'new nationwide banks' that emerged from the 1890s, leading 'not only to more restrictive bureaucratically controlled bank lending but also to tighter security requirements for loans'.[2]

From the moment William Hargreaves sons took charge of the firm they may have been confronted by a response to their requests for accommodation noticeably different from that which had previously existed. The year after Hargreaves death in 1889 the Manchester & Salford Bank absorbed its London agents, Williams Deacon's & Co., acquiring a new title and a seat in the London Clearing House. Although the Manchester & Salford Bank had absorbed Hardcastle, Cross & Co. in 1878, T.L. Rushton had been retained as the local Managing Director, exercising a 'watchful supervision' over the Bolton branch. The first manager of this branch was John Greenhalgh, who had joined Hardcastle, Cross & Co. as a junior clerk in 1823. Rushton died in 1883 and two years later Greenhalgh's role as Manager was assumed by one George Richardson Carter. He was a servant of the Manchester & Salford Bank for some years, becoming agent at their Southport branch and retaining this office following his installation as Assistant Manager of the Bolton Branch in 1878. It is likely that the new generation of entrepreneurs at the Soho Foundry found their bankers displaying an impersonal nature that had been absent from the dealings between an earlier generation of businessmen. A new distinction probably arose between those requests for advances that were acceptable to changed notions of banking business and those proposals that were not, proposals formerly undertaken by country bankers but now deemed to lie in the province of finance and therefore the exclusive responsibility of

firms. It is also conceivable that an adjustment to the financial structure of Hick Hargreaves, through a changed form of business organisation, was regarded as a necessary prerequisite to the continued support of the enterprise by the bank. This explanation for the incorporation of Hick Hargreaves in 1892 also rests upon the importance attached by the proprietors to the continued support of the firm's bank at a time when the firm required costly investment in new plant and a reorganisation of works capacity. Indeed, one of the several objects for which the company was established was the right to borrow money by means of 'the issue of debentures or debenture stock ... charged upon all or any of the Company's property .., including its uncalled capital'. When the new proprietors of Hick Hargreaves turned to the long-established commercial tie with their bankers, they found that the personal network of trusted friends belonged to the past and that bankers could no longer be regarded as personal creditors. The accommodation of the business by the bank required an adjustment to the relationship between the bank and its industrial client, one that was conditional on the adoption of limited liability.[3]

The increased cost of investment projects may have undermined the traditional reliance of Hick Hargreaves on self-finance for investment, even assuming no deterioration in its profitability, while the impersonal nature of banking required the transformation of the enterprise into a private limited company to retain the confidence of the bank. Once the firm had enhanced the traditional link between internal savings and investment by a revision to the family partnership, the bank would have been happy to support the finance of the company. Cottrell has observed that some firms became joint stock companies from the mid-1880s in order to perpetuate the ploughback of profits for the fulfilment of schemes aimed at expanding or re-equipping enterprises.

'It would appear', Cottrell declares, 'that the predominant reason why concerns adopted the limited company form of organisation was to obtain the legal privilege of limited liability so as to insure against possible future losses and ultimately bankruptcy'. Banking practice 'became more uniform and more conservative as a result of the amalgamation movement in the 1890s and 1900s'. This trend resulted in industrial firms seeking finance and accommodation in trade credit, the introduction of new partners, loans secured by mortgage, or profits generated by trading. These were not new sources of finance, but they may have acquired a new significance in the trading environment of the late 19th century that followed the era of 'comfortable profits' and 'easy margins'. Appendix 3 shows the Particulars of Profit & Loss Account for Hick Hargreaves & Co. in the period 1869-91. One would expect a high return on capital in the early 1870s because the period witnessed a vigorous boom in economic activity in which wholesale prices and levels of home and foreign investment reached new peaks, while the terms of trade moved strongly in Britain's favour. By the decade's close the gains in the terms of trade had diminished and an improvement did not occur until the mid-1880s when the rhythm of business activity quickened once more. The year 1890 marked the upper turning-point of a resurgence in production out of the slump of 1886 and was followed by the recession phase of the next business cycle that reached a trough in 1894. It is important to set the firm's profitability within the context of cyclical fluctuations within the economy, although it should also be borne in mind that the experience of trade in Bolton did not always correspond to cyclical movements in the economy. In terms of aggregate economic activity 1883 marked the peak of a boom, the culmination of four years of recovery out of the slump of 1879, and the commencement of another cycle, that of 1883-90, one in which prices fell almost continually and industrial production declined to a trough in

173

1886 before rising to a peak in 1890. But the impression given by local commentators in Bolton is quite different. It was noted that 'Trade [was] generally dull throughout' 1883, while 1884 was 'Another year of trade depression'. When 'signs of more confidence and greater activity' eventually appeared in Bolton they did so at the close of 1886. A study of Hick Hargreaves performance set against the contemporary pattern of business cycles would by itself constitute a major undertaking demanding rigorous handling of the data. Here the evidence of the firm's net profit, the return on capital and how the net profit figure was derived is offered, as well as an interpretation of the Particulars. This is necessary before one can begin to reflect on whether there were 'reasonable', 'good' or 'poor' returns on capital, because one has to comprehend what was meant by such terms as 'profit' and 'capital'. The inclusion of an allowance for depreciation in the Particulars is significant, but did this allowance represent a constant proportion of the assets? It appears likely that the values for capital in the Particulars correspond to the traditional accounting notion of capital as the partnership capital and are not strictly analogous to fixed capital. It is meaningful that the Particulars include an item for Interest on Capital, a cost payment to the partners that partly determined Net Profit or Loss, the net surplus available for distribution to the partners after interest on capital and other costs were paid. Net profit can be seen as a surplus reward to the partners received after the payment of interest. The fluctuating nature of the Capital values suggests that the original nominal capital created at the outset of the partnership was adjusted from year to year by a valuation of the Soho Foundry's buildings, fixed machinery, tools and fixtures in order to derive current capital values. This was a practice based on the 'assumption that profits are not directly related to the quantity of capital, and therefore are not payment for capital or created by

capital'. The reward for capital was 'interest at the current rate', while entrepreneurship had its reward in profit. This was dependent 'on skill, the concrete business situation or sheer luck, the entrepreneur using capital merely as a tool for which he pays the market rate'.[4]

Unfortunately pre-industrial accounting practices were least appropriate to an enterprise, such as Hick Hargreaves, which was in possession of a high proportion of fixed capital. One can understand from the Particulars the rationale of the 'distinction between interest on capital and profits of the partnership'. But how is profitability to be measured if it is today defined as the rate of return on fixed capital employed when fixed capital fitted awkwardly into accounting and business notions of the past. Today profits arise from the ways that capital is deployed, whereas in the scheme of 19th century partnership accounting profit was the reward of entrepreneurs who were assisted by fixed capital assets. Here capital was 'an auxiliary to entrepreneurship instead of the central motive force behind the firm'. In order to judge the performance of Hick Hargreaves prior to incorporation attention should be focussed on the values for Capital and Gross Profit given in the Particulars. The 'unspoken assumption' referred to earlier explains why these two items are unrelated to each other, allowing Gross Profit to be likened to the earnings generated by the firm's trading over the periods established in the Particulars. Net Profit or Loss is determined by the size of earnings. The Capital values vary from one year to the next and have no bearing on the magnitude of Gross Profit. It is these features that offer an understanding of Capital. At first it seemed likely from the two values that profit was obtained by valuing total assets, deducting liabilities, allowing for the partners' original capital and arriving at a 'capital-cum-profits' sum. The movement in Hick Hargreaves Capital

actually conforms to the 'bewildering fluctuations' in capital that Pollard ascribed to the state of trade, the valuation of assets and the discount for bad debts inherent with a determination of profit concerned with capital as a balance-sheet liability. Alas, Hick Hargreaves Gross Profit does not arise from changes in the sum for Capital over one valuation period to the next. Another method arriving at a valuation of a firm's capital was concerned with its earning capacity. Assets were appraised and their value adjusted in the light of changes in the state of trade that altered their earnings capacity. By 1869 it appears that Hick Hargreaves had resolved the widespread confusion made between capital and revenue. The former was determined annually when a balance of the firm's assets and liabilities was struck, while the latter was arrived at from the Profit & Loss Account. This revealed the outcome of actual trading over a comparable period of time and the basis of Gross Profit was the total sales revenue or earnings of the firm.[5]

This impression is supported by the elementary principles of accountancy as they were understood by the early 20th century. A Balance Sheet offered a statement of the total assets and liabilities of a business concern, presenting a summary of the state of affairs brought about by transactions. The Balance Sheet in Pollard's terms saw 'capital as a balance-sheet liability'.[6] Capital could increase from one year to the next, with the increment accounted for by the profit realised on the year's trading, assuming no addition to or withdrawal from the original capital of the business. It was not the purpose of the Balance Sheet to show what profit had been made. This was the function of the Profit & Loss Account. The Balance Sheet merely confirmed the profit shown by the Profit & Loss Account. The surviving accounting records of Hick Hargreaves offer the Particulars of the Profit & Loss Account, plus the changing value of Capital as derived from a Balance Sheet. Why the two sets of figures were subsequently

brought together can be explained by reference to accounting practices that arose in the wake of extensive changes in the scale and organisation of production and the appearance of capital-intensive industry. To the mind of the accountant profit made by a limited liability company would leave Capital in the Balance Sheet unchanged if taken from the business in the form of cash and distributed to shareholders as Dividend, or carried forward, or placed in a Reserve Account. In a private concern profit if not withdrawn merged into the Capital of the business, which increased through the increased value of stock, cash and debts due to it, or other tangible assets. In the case of the proprietorship at the Soho Foundry the variable Capital values reflected variable appraisals of the fixed capital, that could be written both up and down depending on the state of trade. Did Hick Hargreaves & Co's Capital also embody profit? It is tenable that Capital did include valuations of fixed assets and profit because Interest on Capital was paid annually to the proprietors. Capital at the Soho Foundry, an enterprise with a high proportion of fixed capital, demanded to be linked with earnings capacity, while Gross Profit reflected earnings actually achieved. Reinforcing this interpretation is the fact that the Capital values are divorced from the changing balance of Net Profit, whereas under the practice outlined above increases in Capital would accurately reflect increases in net profit. Indeed, it became a principle of accountancy that the outcome of trading was either a profit or a loss and capital either increased or decreased in proportion. Subsumed within the Capital values of Hick Hargreaves & Co. are the Net Profit values realised over the previous time period. The Particulars of Profit & Loss Account can now be examined in detail.

Profit and loss accounts ought to provide a record of trading results over a set period, often a year, and Hick Hargreaves statement

of Capital, Gross Profit and Net Profit or Loss should prove valuable. Unfortunately, the use of company financial statements by business historians is 'fraught with dangers'.[7] In Sheila Marriner's opinion: 'The battery of criticisms that can be directed against their accuracy, reliability and consistency is so intense that one might be tempted to conclude that they contain no useful information at all'. Marriner had in mind the balance sheets and profit and loss accounts that incorporated companies were required to keep in conformity with company law. The requirements of the Companies Acts and their failure to provide a strict definition of terms, together with accounting conventions, gave rise to 'many defects' in financial statements. Company law paid less attention to profit and loss accounts than it did to balance sheets 'apart from continually reiterating that "No dividend shall be payable except out of the Profits arising from the Business of the Company"'. But the legislation omitted to specify the meaning of profits, leaving the question of a definition to the interpretation of individual cases in the courts. 'A clear warning to business historians that they should on no account regard either the declared profits of a company or its dividend distribution as a guide to the company's real net earnings'. Capital was another term that judges had to comprehend in implementing the legislation and the principal was established 'that a firm's "capital" must be kept "intact" - certainly that dividends must not be paid out of "capital"'. But what was meant by 'capital'? The capital alluded to in company law was the shareholders paid-up capital in a company, something very different from the accountants definition of capital as the difference between the value of the company's assets and liabilities. 'Profit' was therefore regarded as the addition to the firm's 'capital' over a year and a dividend might be paid out of the increase in the company's capital. At the heart of the accountants determination of 'profit' and the payment of a dividend was a valuation

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of company assets to determine its net 'worth' at a particular moment in time. It was the changing value of the assets in a business over time that reflected the gains made by the business through its trading operations and allowed profits to be calculated. In the words of one judge: 'To render the ascertainment of the profits of a business of practical use it is evident that the assets, of whatever nature they may be, must be represented by their money value'. But as assets existed 'in the shape of things as rights and not in the shape of money' it was apparent 'that in almost every item of the account a question of valuation must come in'.

Marriner discusses the judgements passed on the valuation of assets and shows that companies had a great deal of room for manoeuvre in the preparation of financial statements. 'They could legally distribute dividends, even if their "capital" was dwindling away; they could re-value their assets upwards if they could claim that the market value had increased and they could treat the additional value as revenue'. In the light of the perplexing nature of financial statements how can Hick Hargreaves Particulars of Profit & Loss Account be interpreted? The Particulars extend over a period of 23 years and offer comparable values in a continuous time series. The usefulness of the Particulars stems from the standardised practice employed in drawing up a statement of gains and losses based on the record of transactions in each trading year. Thus we have changing values of Gross and Net Profit that permit a tentative examination of the firm's performance, bearing in mind that the fundamental problem confronting the student of financial statements is understanding the basis of calculation. Gross Profit in the Particulars was taken to represent Hick Hargreaves total sales revenue and these earnings are expressed in Appendix Five as a percentage of Capital in order to measure profitability. But this expression may be

wholly misleading because of the difficulty posed by a definition of Capital. For this reason the Capital values were also reduced by the size of Net Profit realised in the previous period in an attempt to arrive at a notional value of the firm's stock of fixed capital assets. Admittedly, this attempt to gauge the rate of return on capital employed is a rough-and-ready measure, because it is not known how the Capital values were reached and what treatment was accorded to, for example, work in progress and debts owing to the business. We can only assume that the Capital item corresponds, albeit loosely, to the difference between assets and liabilities, a value that represents the changing "worth" of the firm. Economic fluctuations are another complicating feature behind Hick Hargreaves shifting Capital values, obscuring the rate of return on capital employed through adjustments to the value of assets brought about by cyclical fluctuation impinging upon their earnings capacity. In the peak-to-peak cycle 1865-74 Hick Hargreaves Capital rose in the upswing phase, rising from £123,005 in 1869 to £132,862 in 1873 when activity had still to reach an upper turning-point. This occurred the next year when a downswing was initiated, but two years later the firm's Capital had increased dramatically to £243,347 at a point in the cycle of 1874-83 when activity was declining into the slump of 1879. By then Hick Hargreaves Capital had risen to a new level and it continued to increase, attaining a peak of £273,386 in 1883. The economic boom of that year was followed by the slump of 1886 and over these years Capital values appear to reflect weakening demand, waning confidence and falling prices. In 1885 Hick Hargreaves Capital stood at £240,378 at a time of thin trade. However, Capital rose the next year, one of depression, and continued to rise to another peak of £275,544 in 1888, as another upswing worked itself out. Yet there was a severe decline in Capital to £195,778 in 1889, a year of booming activity in the cycle of 1883-90. But by 1891

180

Capital had grown to £220,148 when growth had already reached a peak and economic activity was entering a period of recession.

An important feature of the period 1869-91 in which the firm's Capital showed a rising trend was the substantial fall in prices, which was bound to have influenced the valuation of assets. The price index of Gayer, Rostow and Schwarz (1867-77 = 100) shows that prices in Britain fell from a level of 101 in 1865 to 72 in 1890, while the Board of Trade wholesale price index displays a fall from 100 in 1871-5 to 68.3 in 1891-5. A more pronounced decline is evident in the coal and metals index of this series, although the trend of both coal and pig-iron prices was distorted by the upswing of the early 1870s, 'probably the most vigorous of any nineteenth-century trade cycle'. Once the influence of famine prices are recognised the long-term trend acquires a different appearance. Indeed, coal prices appear to have fluctuated gently around a straight-line trend. It is remarkable that against a backdrop of a fall in prices Hick Hargreaves Capital almost doubled, a feature of the Particulars that points to additions to fixed capital assets and focuses interest on that autonomous item of the Particulars concerned with Outlays on Buildings Machinery & Fixtures. Further words of caution emerge from Marriner's discussion of the value of balance sheets to students. She declares that the monetary value given to assets may 'have very little significance' due to the 'subjective element' inherent in the concept of valuation, which can alter with the aim of the valuer. 'The "value" of an asset has in fact no precise meaning at all until it is qualified in some way. Assets can be valued at the price the whole company would fetch if it were sold as a going concern, or at the current market price if each individual asset were newly purchased or at their probable future replacement cost'. It is likely that Hick Hargreaves fixed assets were valued in

accordance with the method of historical cost accounting, with the value of assets expressed in terms of the original costs incurred in their acquisition. At the same time it is possible that account was taken of the earnings capacity of the assets as a whole, that is if the firm 'were sold as a going concern'. Provision was made for the depreciation of assets by an allowance that partly determined Net Profit or Loss. Appendix Five shows Depreciation expressed as a proportion of Capital and Capital less Net Profit of the previous year. The values for Depreciation may hint at the increasing size of fixed assets through the reserves set aside annually for the wear and tear of assets. But as with the valuation of assets themselves the provisions for depreciation 'introduce a highly subjective element together with extensive opportunities for deliberate manipulation'. Moreover, the absence of customary practice in setting a 'charge' for fixed-asset wastage poses such a problem that 'within one firm's accounts depreciation can be treated differently from one year to another'.[8] These reservations may weaken the impression given by the values for Depreciation at Hick Hargreaves of a rising trend in the amounts written off assets. But without a doubt capital expenditure took place at the Soho Foundry in the form of Outlays that totalled almost £60,500 in the period 1869-91. Not all years witnessed Outlays and the value of this item varied greatly. But average annual money expenditure on additional assets was equal to £2,630. Outlays appear to have been generated out of Net Profit, yet on one occasion they exceeded Net Profit and on another they were made when a trading loss occurred. This suggests that a reserve fund existed maintained out of net profits achieved in the past for investment in the present when Net Profit was insufficient. The motive for the creation of a reserve fund did exist where total outlays constituted 15% of total Net Profit in the period 1869-91.

On the question of profitability at Hick Hargreaves prior to incorporation Appendix Five presents Gross Profit as a percentage of Capital and Capital less the Net Profit of the previous year. The table represents an attempt to measure profitability by expressing earnings as a proportion of a notional value of fixed capital assets, namely Capital less the value of Net Profit that might conceivably have been carried to the Balance Sheet of liabilities and assets. This is a speculative representation of profitability at the Soho Foundry because, for example, Gross Profit is assumed to represent revenue generated by sales, yet the values for Gross Profit may also have included the value of stock on hand. In the absence of the accounting records that gave rise to the values of the Particulars of Profit & Loss Account and, perhaps more importantly, the conventions and procedures employed in drawing up the Particulars, the business historian has to take care that his speculations do not become specious calculations. Here an attempt has been made to determine whether or not Hick Hargreaves experienced lower profits on the eve of incorporation. The firm appears to have prospered during the boom of the early 1870s and in the years after the peak in 1873 when a 'surprisingly high level of activity was sustained from the beginnings of the downswing in 1873 to 1878-9'. Returns on capital appear to have been particularly high in 1872 and 1873. But was the firm as profitable as Appendix Five suggests it was, with a rate of profit equal to over a third of Capital in 1873? The high level of profits does not seem to be illusory when the number of Fngine Jobs undertaken by the Soho Foundry are considered.[9] In 1873 Hick Hargreaves turned out 48 steam engines, exceeding this number by one the next year. But thereafter production fell to reduced levels and did not equal the level of 1873 until 1883. Perhaps the attempt to establish a correlation between engine production and profitability is also misleading. Nevertheless, some account must be taken of the firm's

major activity. Steam engine jobs in 1889 attained a peak not seen since 1871 when 73 engines were built. In 1889 the firm produced 68 engines, twenty more than the previous peak in output reached in 1883. However, the value of Gross Profit in 1889 was surpassed by the values in the years immediately before and after 1889 when output was much lower, while the undistinguished rate of return in 1889 represents a proportion of a particularly low Capital value. The reduction in Capital values from 1889 may be a feature of the Particulars crucial to an understanding of the firm's performance, permitting certain conclusions to be drawn on the contemporary perception of the firm's value as a generator of profit in the future. If profits fell perhaps Capital also declined as the earnings capacity ascribed to fixed assets was reduced, so that Capital corresponded to changed expectations. Without knowledge of the earnings content of Gross Profit we can only speculate that earnings fell to levels that compelled an appraisal of fixed assets at reduced values. But it is clearly evident that a reappraisal of Hick Hargreaves resources followed William Hargreaves death and that new methods of production based on labour saving machine tools were adopted in order to achieve established goals in the market for power. At the heart of the latest innovations at the Soho Foundry was concern for a sufficiency of profit in the future to meet costs and finance further investment, as well as rewarding the proprietors. Some discussion of the future direction of the enterprise was inevitable because the sole proprietor and his professional managers, Luthy and Inglis, were no longer alive by 1890. William Hargreaves was succeeded by sons who had in their turn to appoint an engineering manager. It is not difficult to assume that the new proprietors and head of engineering were confronted by the need to adapt the firm's organisation and methods of production in response to squeezed margins. Incorporation in these circumstances signals the adoption of an up-to-date response to the

quest for profit within the traditional range of products and customary markets. This response was, however, dependent on bank accommodation in order to secure the necessary replacement investment in new machine-tool technology, and a change in capital structure at Hick Hargreaves was required that would appeal to the bank.

II

The financial history of Hick Hargreaves in the years following its conversion into a private limited company excited greater interest as a result of an examination of its output of steam engines. Saul's reference to Hick Hargreaves as an 'outstanding' manufacturer of steam engines inspired a study of this product in an attempt to illustrate the firm's approach to the market by revealing the degree to which the principle of standardisation was adopted. It seemed that the mid-1890s marked a break of trend in both the annual number of steam engines produced and their size in terms of horsepower. Indeed, from a particular point in the mid-1890s Hick Hargreaves appeared to be turning out fewer engines of a significantly increased power than they had hitherto. This change of policy vis-a-vis the market for industrial power apparently coincided with investment in replacement plant and equipment evident from several sources, such as the Minutes of the Board of Directors and detailed inventories of the Soho Ironworks dating from 1890 and 1900. In order to test this impression of a new trend in engine build a multiple linear regression analysis was carried out, using the data offered by the Engine Job book.[10] This log revealed the annual production of steam engines from 1871 and gave a detailed description of each engine job undertaken, that included the name of the purchaser as well as the type and size of engine. A problem with some of the early entries was that not all of them disclosed engine power and

allowance had to be made for this omission through the horsepower of recorded engines. For example, in 1880 a total of 26 steam engines were built and of these engine jobs only 7 entries recorded the engine's Economical I.H.P. The total horse-power of this proportion was equal to 2,490 I.H.P., providing an average I.H.P. of 355.71, and allowing a value of 9,248 I.H.P. to be found for the total horsepower of all engines produced in 1880. The proportion of horsepower recorded engines in the later years is large and in the early period there are several years when the proportion of recorded engines is high. In 1881, for example, figures for Economical I.H.P. are given for 26 of the 28 steam engines built. As the statistical appendix shows, (See Appendix Six and Seven) the proportion of horsepower recorded engines to total entries fell below 25% in only one year.

The multiple linear regression analysis quantified the relationship between the several variables derived from the Engine Job book, dealing with output and horsepower, and national income and capital formation estimates assembled by Feinstein.[11] The first results shown here involved the coefficient of correlation between variables derived from the firm's Fngine Job book to arrive at linear relationships. Fig. 1 shows the number of engines built 1871-1913, the values plotted into a chart. Two distinct trends in production are evident marked by a dramatic fall in production in 1897. The correlation coefficient for the two variables involved, time and output, was a significant negative value, establishing a correlation between the two variables. The high statistical correlation permitted a regression line to be plotted that would represent the linear equation to which the related behaviour of the two variables most closely approximates. The plotting of one line of regression shown in Fig. 1 suggested a steady decrease in output over the period 1871-1913. But two distinct trends could also be discerned,

186

separated by the dramatic fall in output in 1897, through the plotting of two regression lines shown more clearly in Fig. 2. Another variable was the average horsepower of recorded engines and Fig. 3 shows the course of this variable superimposed upon the course of output. Once again, there was a high statistical correlation between the two variables involved through a strong positive value. This allowed the fitting of more than one regression line and this is shown in Fig. 4, which also charts the value of total estimated horsepower from all engines built. The break of trend evident in 1897 is not as noticeable in the chart of total estimated horsepower and it is possible to plot a regression line pointing to a gradual growth in engine size throughout 1871-1913. However, two regression lines would seem to give the best fit for this and the other values plotted, that confirm two distinct trends in output, engine size and total horsepower, with 1897 as the point of departure between one manufacturing and marketing strategy and another.

It is asserted here that the incorporation of the business as a private limited company signals the response of the proprietors to a financial performance perceived to be poor. By re-modelling the works within the framework of a new business organisation and financial structure it was hoped to improve profitability by attaining certain ends, namely the marketing of an improved range of steam engines. Incorporation brought little change to the control and direction of the firm. The Hargreaves family possessed a large proportion of the share issue and three of William Hargreaves sons became directors. Consequently, the conversion of the proprietorship into a limited company entailed hardly any change in the management of the concern. Yet there was a difference because the directors were faced by a novel predicament. From 1892 the financing of investment in modern workshop

equipment had to be reconciled with the interest of shareholders, particularly an emergent group of anonymous shareholders outside the family, whose interest in the company lay with its ability to make dividend payments. The directors were motivated out of a desire to employ profit for the purpose of investment, but they were also required to reward shareholders. This irreconcilable conflict of purposes was aggravated by the elusive nature of profitability in the years immediately following incorporation and the bad dividend record of the company. Confronted by the need to improve the company's productive capacity the directors placed the interests of the company first to the extent of withholding information from the shareholders on the true state of the company's finances.

The first Board of Directors was made up of the three vendors of the concern who were sons of William Hargreaves, his son-in-law, Charles Stewart Pickering Robson, and three 'engineers', one of whom was John George Hudson. He had been appointed Chief Engineer of Hick Hargreaves & Co. in 1891 ten months after the death of William Inglis. Hudson's influence over the direction of the company was profound. His 'active work' came to a close in 1903, yet he was retained 'in an advisory capacity until 1910' and remained as a director until shortly before his death in 1931. The occasion of his retirement was greeted with sorrow on the part of his fellow directors, who regretted the 'loss of your assistance in our deliberations, assistance distinguished always by your long experience, great technical knowledge, your courage and common sense'. Hudson's final retirement came when he was aged 83, but the Board expressed the wish that 'we shall continue to have the benefit of your help and advice when difficult problems have to be considered'. Hudson was undoubtedly 'an Engineer of ... great reputation', the director who determined from his appointment that the company should

adhere to the manufacture of Compound engines when rising steam pressures had called forth Triple and Quadruple Expansion engines. Hudson's reluctance to commit the company wholeheartedly to the production of the latest three and four-stage types, then popular among power users, was not an instance of technical conservatism, but a sound judgement founded on wide experience and a deep knowledge of engineering. Hudson's articles were obtained through an apprenticeship served at G.H. Stothert's shipyard, Bristol, an early iron shipbuilding firm that was also responsible for marine and stationary engines, boilers and foundry work. From Bristol Hudson joined the staff of a Dublin shipyard, serving as a draughtsman for three years. It was in 1871 at the age of 24 that Hudson joined T.F. Spencer as a consulting engineer at Westminster. As head draughtsman Hudson 'was largely responsible for the design of Marine Engines and Boilers for a large number of vessels built to Mr. Spencer's specifications and under his inspection'. Among these vessels were notable passenger ships employed in the North Atlantic trade. In 1877 Hudson left the consultancy and became General Manager of Mirrlees, Watson of Glasgow, the manufacturers of sugar machinery. Hudson became a partner in 1882 and remained with the firm until 1888 'when he returned to London to open an office as Consulting Engineer'. While at Mirrlees, Hudson was able to 'standardise' and improve their products, particularly the sugar cane mill machinery.

Hudson's career as a consultant did not prove agreeable, lasting for only two years. It was because 'he found it difficult to keep in sufficiently close touch with practical matters' that Hudson became the Chief Engineer of Hick Hargreaves, a firm where Inglis had been instrumental in setting an exacting standard for the design and build of durable and efficient mill engines. Hudson proved a worthy successor

189

because the 'reputation for good design and reliability' acquired by the Soho Foundry 'did not suffer during his regimen'. At the time of his arrival steam pressures were increasing and Triple Expansion engines were being set down for the generation of industrial power. Hudson's response was to deny 'that three stage expansions were necessary with the steam pressures 160-180lbs. per square inch, then in vogue'. Hick Hargreaves went so far as to express their faith in the 'good Compound Engine' at lower pressures in a circular letter issued in 1892. Hudson's 'opinion was quite justified in practice, as with the advent of superheated steam compound engines showed an actual saving in steam consumption over triple expansion engines'. Hudson's conviction that the compound engine was the type best suited to the needs of power users stemmed from his proficiency in engineering matters. His policy did not subsequently become correct with the advent of superheated steam from the late 1890s. The practice of superheating steam was long familiar to engineers and in the 1850s attempts had been made to adopt it for marine use where economy of fuel was particularly important. When superheat was rediscovered from c.1890 as a practical innovation, Hudson was probably already aware of the potential value of superheat because of his background in marine engineering. Chance and conservatism were not features of Hudson's tenure as Engineering Director. Like Inglis before him Hudson was responsible for the introduction of 'ingenious improvements'. Indeed, 'Some very fine engines were built to his designs, mostly of the Cross Compound, Horizontal type, the largest units being 4,000 I.H.P.'.[12]

At the time of the celebrations and reflections marking Queen Victoria's Diamond Jubilee it was possible to read a review 'of the character and resources of the most notable works and business places in modern Bolton'. None was more notable than the 'colossal business now

controlled by Messrs. Hick Hargreaves and Co., Limited', whose directors collaborated with the authors of the review to the extent that in tone it reflected the sentiments and feelings of the directors. Only by recognising this bias can the meaning of the sketch be properly understood. The demonstrable truth behind the 'vast progress ... made in material prosperity and industrial enterprise' over the previous sixty years and a firm belief in Britain's future primacy clearly underlay the review. It assumed that the existing arrangements of the state and economy were unquestionably beneficial to the wellbeing of society, while the promise of further progress in industry, the arts and sciences rang true. Although there had long been criticism of the products of British engineering, few would have disputed the assertion made by the review: 'The engineering trade is admittedly the great industry, par excellence, of the nation, and it is the one in which Great Britain enjoys the most distinctive and undisputed superiority over foreign competitors'. The reports from international exhibitions may have told of the loss of British pre-eminence and a weakening of British competitiveness, leading to the strong competition of American and German machine tool builders, for example, both at home and abroad, but within all the engineering trades opportunities for gain existed and further commercial and technological progress was attainable. Hick Hargreaves incorporation was a first step towards the firm's re-modelling, a programme underway when the review appeared, so that the pride exuding from the article should not be seen as conceit. The first years as a limited company had proved poor, with only two dividend awards. But from 1898 the financial record of the company was altered and on the eve of this improvement in the company's profitability it was possible to look over the development of the business and explain how it had 'developed into a large and important undertaking'. This understanding of the past offered by the directors can also be

interpreted as their perception of how success in the future would be assured. From the outset of the enterprise the

> proprietors acted on the conviction that, in order to establish their business on a firm and permanent basis, it was absolutely essential to maintain an unimpeachable reputation for turning out work of the very highest class, both as regards soundness of material, excellence of design, and perfection of skilled workmanship. Neither trouble nor expense over-influenced them in the immediate adoption of genuine improvements in any department of their business, and the firm in time gained a worldwide reputation for the undisputed superiority of their products, and orders poured in steadily from all parts for engines, boilers, and machinery of all descriptions, until it almost seemed as if they would be overwhelmed with the immense inflow of business. In the engineering trade, as in many other departments of human enterprise, prosperity is often the severest test of principle. When men are in a subordinate position and are fighting their way to fame and fortune, they are, as a rule, careful of their reputation, and take elaborate precautions to turn out the best work of which they are capable; but when the have fought their way to the front and have made an established name, they are sometimes tempted, in the rush of commissions which their reputation brings them, to scamp their work so as to meet the emergency of the moment. The firm of Hick, Hargreaves, and Co. never pursued such a reckless and suicidal practice as that. They increased their accommodation, equipments and general resources to meet the constantly-increasing inflow of orders, but under no circumstances would they consent to rush emergent orders through at the risk of turning out inferior or defective work, and they have their reward

to-day in the unique and distinctive reputation they enjoy all over the world, and in the vast and ever-increasing business they control at home and abroad.

Bound up with this public explanation of the firm's rise was an interpretation of incorporation that stressed conversion as the means 'to establish the business on a broader basis than private ownership, and to give the management a freer hand in developing its full resources and capabilities'. Incorporation gave rise to 'the energetic administration of a strong directorate with abundant capital'. John Henry Hargreaves was the Managing Director, a 'practical engineer' who had managed the firm since his father's death. J.H. Hargreaves provided a 'personal superintendence to the entire administration of the works', while his brothers and co-directors, Percy and Francis Hargreaves, apparently had no specific responsibilities. Robert Harwood and J.G. Hudson did hold responsible managerships, being managers of the millwrighting and engineering departments respectively.[13]

The concern was converted into a private limited company in the early part of 1892 and within a few months of its formation Hick Hargreaves & Co. Ltd. secured a sum of £60,000 by means of a mortgage and deed of trust of plots, fixtures and premises. Six years later in July, 1898, Gustav Westendarp was appointed a new trustee of the deed of trust that had secured the debenture issue in place of George Carter, who was no longer manager of the Bolton branch of Williams Deacon and Manchester & Salford Bank. The issue of debentures in 1892 did more than partly pay the vendors their purchase money. The debentures were an instrument for raising capital through, in the first instance, the firm's bankers and ultimately private lenders. The Manchester & Salford Bank accommodated the capital needs of the new company by means of a debenture issue. Nominally, the issue of these fixed-interest

193

securities was used to pay the vendors, but their proper role was to raise capital, with the vendors, the first directors of the company, 'offering' their own assets as collateral for bank accommodation. It was the special claim on company assets conferred by debentures that provided their appeal as a capital instrument. Debenture holders as creditors of the company held a prior claim on the assets and the trust deed gave security to Hick Hargreaves debenture holders through remedies enforceable in the event of, for example, interest falling into arrears. Under the terms of the prospectus the amount of the company's nominal, later authorised, capital was £240,000 divided into 24,000 shares of £10 each, a total sum of £9 per share to be paid up one month after allotment. Once the vendors had been provided for some 5,000 shares were offered for subscription through the private prospectus, but not all friends of the firm were acceptable to the vendors as shareholders. The notice inviting the purchase of the outstanding shares was not drawn up for circulation among all friends of the firm, because the vendors wished to discriminate in favour of members of the Hargreaves family, the professional men engaged by the company and certain friends. The new company was intended to be a private company and this is evident in the response shown to friends who considered applying for shares well before the allotment of the applications themselves. At the time when the shares were offered Harry Alfred Richardson, one of the signatories to the memorandum of association, was approached by a friend, who wrote:

> My dear Richardson,
>
> When I saw you last at your Works in Bolton, you promised to let me have a prospectus of the New Company of H.H. & Co. Matters of this description escape one's memory so easily, that I now

194

take the liberty of reminding you of it,

as I am much interested to see a Pros.

William McGill's request was answered by the company secretary: 'We regret at the present moment we are unable to comply with your request as we are not issuing a prospectus of the new company of H H & Co to the general public or should have been very pleased indeed to have let you had a copy'. The first certificate of shares in Hick Hargreaves & Co. Ltd. testifies that J.H. Hargreaves was entitled to 8,000 shares, while among the private subscribers one Florence Nightingale Hargreaves, a widow of Brighton, was allotted eleven shares. Beyond the family circle 100 shares were acquired by the company's solicitor and 100 each by Peter and James Kevan, chartered accountants and auditors to the company, as testimony of their fidelity to the company. Shares were also allotted to acceptable friends of the firm who included cotton spinners and bleachers drawn from the surrounding districts. In later years 'outside' subscribers did appear, such as Charles Robert Fritton and the Hon. Kenneth Fitzgerald Kinnaird, Gentlemen of Pall Mall, London, who bought several hundred shares from 1908. But at the outset the majority of shares were held by the vendors and those they deemed acceptable shareholders. It is significant that not all the shares offerred for subscription were taken up, a reflection of the vendors' decision to discriminate against applications received from the 'general public' and favour only the family and friends. William McGill's interest could easily have been satisfied. Moreover, the release of initial shareholdings strengthened the existing ownership of the vendors. In December, 1894, for example, J.H.F. Hulton, the company solicitor, 'transferred' his shares into the hands of J.H. Hargreaves and Hulton was not alone in doing this. The chosen size of share denomination in the large value of £10 could be considered a move

calculated to assist the establishment of a private company. Canal and railway companies had set the tradition for large share values and the £10 share had remained typical because it was regarded as a deterrent to speculation. Recent research by Cottrell into shares and shareholders of early limited companies reveals that the £10 share was widely used by companies between the mid-1850s and the mid-1880s, 'but there was an increasing use of shares of £5 or less from the mid-1870s and £1 or less from the late 1870s'. Nevertheless, 'given that most companies issued shares of £10 or less, the size of shares would not appear to have been a major barrier preventing any person with some means from investing'. In Hick Hargreaves case, the chosen size of share denomination had to appeal to acceptable and unacceptable subscribers alike. One of the objects for which the company was formed was 'To adopt and carry into effect' the agreed sale of the Soho Foundry by the vendors and its purchase by the company. The terms of this agreement were to be 'signed immediately after the incorporation of the Company'.[14] Incorporation of the business did not see the conversion of a family-owned industrial concern into a public limited company, with the nominal capital held by anonymous investors and vendors paid in cash, shares and debentures. Hick Hargreaves & Co. Ltd. was a limited company, whose nominal capital lay in few family holdings. Incorporation made little difference to the ownership and direction of a hitherto family partnership owned wholly by the offspring of William Hargreaves. The new financial and legal structure, through which the former proprietors continued to exercise ownership of the firm due to their large shareholdings in the company, was essentially aimed at the creation of a business with corporate finance congenial to the firm's bankers. In order to assist the business through the accommodation of projected capital projects the bank required a commitment to self-finance via incorporation and registration as a limited company.[19]

How was the nominal capital of £240,000 arrived at and what were the objects behind incorporation? One purpose was to implement the agreement entered into by the vendors. They agreed that the concern should be purchased by the company in return for 'Purchase Money' of £276,000. How this sum was arrived at was set down in the prospectus, which also revealed how the purchase money was to 'be paid or provided for' (see Appendix). Thus the vendors - John Henry, Francis and Percy Hargreaves - received in payment a number of partly-paid shares that formed a shareholding equal to 80% of the share issue, an issue of mortgage debentures equal to the sum of £60,000 and a 'Balance' paid in cash. In this instance of the conversion of an enterprise the vendors purchase price was met through partly-paid shares, debentures and cash. The Mortgage and Deed of Trust of July, 1892, shows that the parties to the Debenture Trust Deed were the Company, Peter Kevan, chartered accountant, and Richardson Carter, manager of the Manchester and Salford Bank in Bolton. The Company, 'as beneficial owner' conveyed to the trustees, Kevan and Carter, the plots, works, fixtures and premises 'for the trusts intents and purposes', while the trustees permitted the Company 'to hold possess and enjoy and to secure and take the rents and profits of all and singular the ... trust premises and to manage conduct and carry on ... the businesses authorized by the Memorandum of Association ...'. The trustees could act on 'their absolute discretion' or 'upon the request in writing of the ... holders of thirty at least of the Debentures ... without any further consent on the part of the ... Company ... enter upon and take possession of the mortgaged premises and ... sell and dispose of the same ...' It was 'declared that the security hereby constituted shall become enforceable ... (1) If default be made in the payment of some financial moneys ... (2) If an order be made ... for the winding up of the ... Company (3) If the ... Company commits a breach ... of any covenant herein contained'. The debenture issue

comprised sixty mortgage debentures of £1000 each ranking as a first charge and carrying interest at 4 1/2%, the 'principle moneys' repayable in 1912. Each debenture was issued subject to conditions 'deemed part of it' and one condition was concerned with the charge created by the issue. The charge involved was a floating, not a fixed, charge on the property of the business, subject to the provision of the indentures 'whereby certain property of the Company was vested in Trustees for securing the payment of the principal moneys and interest ...' It was stated that the charge created by the issue of debentures shall 'be a floating security and accordingly the Company may, in the ordinary course of its business and for the purpose of carrying on the same, deal with the property hereby charged in such manner as the Company may think fit and in particular may sell lease and exchange the same may pay and reserve money and may declare and pay dividends out of profits'. In the 1860s and '70s debentures had been issued by financial concerns 'and, to a limited extent, by some of the iron, steel, and coal companies in order, in the case of the last, both to pay vendors and raise additional "outside" capital'. This was the purpose behind Hick Hargreaves debenture issue, which was an instrument for raising capital from 'general' investors, via the firm's bankers. The sum of £60,000 was essentially a loan in the form of an issue of debentures secured by the freehold and leasehold hereditaments and premises of the enterprise. Investors ultimately provided the loan by holding debentures secured on the property of the business, properly conveyed to two trustees, one of whom was the firm's banker. The debentures provided the means whereby £60,000 of the purchase money was paid to the vendors. It was the vendors who received the debenture issue before relinquishing these marketable securities to investors via the bank in order to generate capital for the company. Only through a debenture issue, a secure capital instrument, was the Company able to secure

substantial accommodation from the bank with a loan of £60,000. It was the capital requirements of the enterprise which determined that £60,000 of the purchase money should be satisfied by the issue to the vendors of debentures, an issue that formed the basis of a long-term loan provided by outside investors but initially provided by the Manchester and Salford Bank.[15]

The friends of the firm were introduced to the company through a prospectus that announced: 'The Company has been formed for the purpose of acquiring and working the old established and Valuable Engineering, Boiler Making, and Millwrighting business of Messrs. Hick, Hargreaves & Co.'. The Memorandum of Association listed the objects of the company, referring first to the agreement between the vendors and Peter Kevan, the trustee of the company, for the purchase of the concern by the company. This agreement had been prepared in April, 1892, and was followed by an Indenture of Conveyance made in July between the vendors, Charles Stewart Pickering Robson, John Hick 'and the said Company of the fourth part'. That John Hick was a party to the incorporation of the business is a surprise. In 1892 Hick was aged 76 and living in retirement at Mytton Hall, Whalley. His involvement in affairs at the Soho Foundry had ended over twenty years before and Hick's parliamentary career had closed in 1880. The memorandum regulating the activities of the company noted that it was 'To continue and carry on the businesses of engineers, ironfounders, boilermakers, and millwrights, heretofore carried on by the said vendors ... that is to say, the manufacture and sale ... of boilers, engines, rails, plates, bars, tyres, wheels, axles, forgings, castings, and other machinery and articles, as well of steel as of iron...' The article dealing with 'objects' consisted of several other clauses that stated in detail the manner in which the business should be prosecuted. For example, the establishment at home and abroad of agencies 'for the

purpose of the Company' was authorised and so was the acquisition of patents, the purchase of machinery and the borrowing of money. It is a reflection of the vendors unanimity on the question of a change in structure that incorporation was carried into effect without complication. The correspondence of the firm's solicitors and auditors in the early months of 1892 reveals that conversion was 'in accordance with the recognised forms'. In March, the accountants supplied prospectuses and share application forms as well as a 'copy of the articles of association of Platt Bros & Co. Ltd'. In arriving at the 'terms to be fixed upon for converting the business', the firm's accountants were employed from November, 1891, to May, 1892, 'considering & submitting proposals as to Capital of the proposed new company, Preparing Statement of Assets & Liabilities as at December 31st 1892' and, amongst other duties, holding 'Interviews with Messrs Platt Brothers & Co Limited & Dobson & Barlow Limited in respect of Employers Interest'. The Indenture of Conveyance that John Hick was a party to had to be entrusted to the solicitor's clerk and taken to Mytton Hall for Hick to sign. This was necessary because Hick had informed the solicitors that 'he was leaving ... for a tour of 5 or 6 weeks' and it would therefore not be 'convenient for him to sign the Conveyance'. The day before Hick had written to J.H. Hargreaves:

> My dear Harry
>
> I duly received your letter of the 20th Inst & was much surprised & disappointed & I can only say that I am sure you must agree with me that I have been very hardly used

Clearly, not all the parties to the conversion were pleased by the course of events. Nevertheless, it was the unanimity of the vendors on the question of a change of structure that allowed the incorporation to

go smoothly. The first Board Meeting of the company was held in May when the directors resolved that J.H. Hargreaves should preside as Chairman and the shares applied for should be 'allotted in full'. Other motions considered by the Board were concerned with procedural arrangements and the appointment of officers. The appointment of J.G. Hudson as General Manager was confirmed, for example. On the day of the meeting Hick Hargreaves and Hudson entered into a new agreement in which Hudson agreed to 'continue to act as managing engineer' and 'devote his whole time to the duties of the post to the exclusion of private practice'. Hudson's reward 'in consideration of such services, faithfully rendered', was a salary of £1,000 per annum and 'a bonus of three per cent on the net profit of each years trading'. The Board also appointed the company's bankers, solicitors, auditors and brokers and resolved 'That the allotment of 60 £1,000 Debentures and 19,000 £10 shares as £9 each paid up should be issued to the vendors or as they may direct'. Since 1888 the Soho Foundry had been providing Sebastian Ziani de Ferranti with steam engines, most notable the corliss engines installed at the Deptford generating plant of the London Electric Supply Corporation Ltd. At the first Board Meeting it was proposed by Hudson 'That the Managing Director be authorized to advance £2,000 to S.Z. de Ferranti Ltd on the security of 200 £10 Preference Shares bearing interest % 7%'. The motion was carried.[16]

III

At the time of the Diamond Jubilee the new company offered an impressive sight, the premises apparently made up of 'mammoth works, with their many great departments and vast and costly equipments'. To the sketch writer a heavy machine shop presented a 'perfect wilderness of machinery', an observation reminiscent of David Landes reference to 'the jungle of shafts and belts ... the most prominent feature of

machine rooms since ... the 1770s - a threat to safety, an interference to movement, a source of breakdowns, and a devourer of energy'. The 1890s marked the threshold of a new age, one in which electricity would supplant existing providers of energy, and both the detailed valuation of the works and the impressionistic description of the principle departments are invaluable mirrors of an innovating engineering company at a crucial time; for the early years of the Soho Foundry as a private limited company were years when, in the directors words, a programme of 're-modelling the shops' was embarked upon.[17]

The writer who visited the firm in Diamond Jubilee year found premises extending over a 'great square' of four acres, with an extensive frontage in Crook Street that included the main entrance to the offices, yards and shops. Beyond a 'splendid suite of public and private offices' and 'spacious drawing offices' lay screwing, fitting, turning and boring shops 'all equipped with powerful special machinery'. Several 'interesting and elaborately-equipped departments' caught the visitor's attention but were ignored as he was taken to see the 'heavy machinery departments ... located in four main shops occupying the centre of the works'. The first of these was the 'principle erecting and fitting department, an extensive and well-lighted building, 130 yards long by 30 yards wide, and equipped with ... a perfect wilderness of machinery'. If the intention was to impress the visitor with a tour of new plant this aim was realised, because the principal shop was described as 'one of the finest shops of its kind... seen in Bolton or elsewhere'. In addition to its other features it contained 'two 25-ton overhead travelling cranes, fixed at a low level and driven by rope gearing, and controlling one-half of the building, the other half being provided with a 50-ton traveller fixed at a high level'. The tour included a visit to the 'new moulding shop, an immense chamber recently built, and three times the size of the

former one'. This shop was 'elaborately equipped on the most improved modern lines, and is served by four large cupola furnaces seven feet in diameter, the resources of these shops enabling castings of any size to be turned out in a rapid and efficient manner'. Adjoining this department was a fitting shop that had 'also been recently enlarged' to 'twice its former size' in order to accommodate the jobbing work that had 'increased very rapidly in recent years'. On another part of the site lay the Boiler works, which constituted 'an entirely distinct branch of the works', with its reservoir and yard, the latter 'traversed by a 30-ton travelling crane'. Boiler making was carried on in a shop 'sixty yards long, and equipped with enormously-powerful machinery', such as hydraulic rivetting machines and flue welding hammers. The visitor was overwhelmed by the multiplicity of machine tools set down on the premises and closed his description of the works by remarking: 'It is of course quite impossible to give an adequate idea of the immense and apparently endless groves of machinery in the many departments of these great works - the leviathan lathes, drilling, slotting, milling, boring, punching, turning, shearing, cutting, shaping and other machines to be seen in action on all sides'. The writer of the sketch was so impressed by the 'enormous resources' organised at the Soho Foundry for the 'rapid execution' of contracts that he believed Hick Hargreaves ranked 'among the most famous seats of engineering industry in the United Kingdom'. He also recognised that the 'magnitude of these vast equipments is well calculated to daze and stun the visitor'. Nevertheless, he felt 'the works throughout exhibit one of the most striking examples of perfectly organised industry to be found in any part of England. All these gigantic equipments, with the requirements of skilled workers throughout the works, are controlled with marvellous ease and precision from the managerial department, and the whole class of the work is directed with the smoothness and efficiency of

clockwork'.[18]

It is easy to explain the appearance of larger workshops at the Soho Foundry, equipped with tools of the 'most improved' type, in terms of the gains made in the capacity of machine tools during the late 19th century. Although the speed and output of machines of all kinds increased once the basic principles of mechanisation were understood and widely applied, the gains in power and speed proved to be greatest in metalworking and engineering. Landes illustrates this development by reference to the improvements made to the durability and performance of lathe tools produced from alloy steels, using such elements as tungsten, manganese and vanadium. The advent of high-speed tool steels from 1900 was the culmination of innovations in cutting points dating from the 1850s and 60s and the activities of men such as Mushet. Increased cutting capacity called forth more robust machine tools that in turn raised the demands placed on cutting tools, leading to a fresh response from the producers of specific steels that again required more powerful machines. It was the growth in the size, speed and power of machine tools that required new layouts and larger workshops. By the close of the century the lathe had developed to the point where the skill built into the machine required less skill on the part of the operator, permitting unskilled hands to operate the highly productive and flexible lathes. At the heart of the 'machine question', the point at issue behind the engineering dispute of 1897, was the fear of skilled workers that turret and automatic lathes would render them redundant. Foreign competition in the international trade in machine tools had long eroded the British pre-eminence in machine-tool technology evident at the Great Exhibition. From 1880 Britain was perceived by contemporary commentators 'as one among equal competitors'. The qualitative evidence drawn upon by Floud also suggests that the home market in the late 19th

century was under severe competition from American and German tool producers, particularly in the market for light machine tools where demand stemmed from the requirements of new industries, such as bicycle-making, adapted to the system of interchangeable manufacture. To some observers the bicycle boom, the engineering strike and a domestic slump in America coincided to stimulate American sales of machine tools in the mid-1890s. Other commentators set aside this strong impetus and pointed to a steadily rising trend in the volume of business that extended over many years. 'Whether the growth of demand for American tools was slow and steady', observes Floud, 'or the result of a chance conjunction of the bicycle boom and the engineers' strike in 1896-7, there can be little doubt but that American tools were well established in Britain and in other European countries by the beginning of the twentieth century, and that in many cases they had supplanted British tools'.[19]

Floud's examination of French trade statistics from 1865 provides statistical evidence in support of the qualitative case of a loss of British technical leadership in the design of machine tools. What is remarkable is the delayed entry of the United States in the French market in the 1890s. The technical advantage evident in American tools in the 1860s 'was not translated into commercial success in France until 1896 and thereafter'. The records of two American tool builders - Brown & Sharpe and Bullard - confirms that American penetration of the European market came 'relatively late', with small sales abroad prior to 1895 followed by a 'spurt in demand' in Europe. A detailed breakdown of the companies sales in Britain 'allows the change to be dated even more precisely to 1896'. Why the American tool industry arrived late in the European market, why its entry came in the mid-1890s and why it was so remarkably successful are questions that Floud discusses in detail around three possible solutions. One explanation 'is that America and

Britain were using the same technology of machine tool production and use, but that either a different structure of factor costs in the two countries, or prejudice and ignorance, retarded the adoption of American machine tools overseas before the 1890s'. Floud finds the factor-cost explanation 'unconvincing', yet an alternative hypothesis, resting upon Saul's argument that the market explains some of the shortcomings in British engineering, appears to answer the timing of the boom in American exports. Machine-tool makers in Britain, argues Saul, were influenced by the demand for quality machine tools of the heavier kind offered by such engineering trades as steam-engine manufacture. The appearance of 'mass demand' for light machine tools presented a 'break-through' for machine-tool firms, as they reponded to the needs of bicycle makers. From the '90s a new pattern of demand stimulated machine-tool production that influenced machinery techniques throughout the whole industry because of the influential role performed by the machine-tool trade. It was only in the 90s, Saul argues, that American innovations in machining techniques were recognised as a new point of departure for the development of British engineering, yet one impeded by deficiencies in machinery techniques, rigidities of tradition and complexities of institutional make-up. Floud finds implausible this 'hypothesis that the American industry was operating on a different and superior production function, which it would have been sensible for the British to have adopted'. Moreover, it is difficult to accept that 'British machine tool-makers, or their customers, could consistently be significantly less efficient than American producers, perhaps for thirty years, catching up only when revelation dawned in the 1890's'. Nevertheless, Floud finds it 'difficult to disagree' with Saul's conception 'of a spectrum of customers for machine tools', a reflection of the existence of a 'spectrum of technologies in use at any one time, representing successive stages of improvement of technology which have

been diffused over time, and in which the smaller and less efficient firms are operating with less developed technologies than the best-practice firms'.[20]

Not only machines grew in size and power in the later decades of the 19th century. 'At the same time, and in large measure owing to this growth of the equipment unit, the scale of efficient working increased'. This 'trend to size' intensified the problem of 'logistical strangulation', as existing structures had to accommodate larger machines and handle larger unfinished goods that progressed through the several stages of the manufacturing process. Entrepreneurs in the late 19th century found themselves 'goaded by necessity and spurred by the prospect of higher returns to find ways, first, to ease the movement of work though the plant, and second, to draw more output from each man with a given body of equipment'. In an assembly industry, such as steam-engine building, the adoption of the overhead electric crane in addition to the small man operated boom crane, improved the flow of work, particularly in an industry where the component parts had to be brought to the machine shops before their assembly elsewhere. Hick Hargreaves shops and departments were well equipped with lifting and moving equipment, including electric 'travellers' that were quick and responsive to control and 'yielded productivity gains of the order of several hundred per cent'. By 1900 there were no less than 147 jibs, derricks, overhead cranes, hoists and pulley systems installed at the Soho Foundry, that ranged in scale from 5 cwt. blocks on overhead beams to the massive overhead cranes of H. & J. Ellis, Vaughan & Son and Craven Bros. Some of these travellers were steam driven, but several were electrically powered. The foundry yard, for example, was served by a 20-ton steam driven overhead crane, with a span of 48ft. equipped with a 'Geared Crab'. Its value in 1900, exclusive of over 500 ft. of rail, was £1,050. Within the foundry itself there were three 20-ton and a

30-ton crane, each with spans of 44ft. At the time of the Diamond Jubilee it was noted that the Boiler shop was 'controlled by a 50-ton crane operated by rope gearing'. By 1900 this had become a '50 ton Electric Driven Overhead Travelling Crane', with a span of 50 ft., powered by lifting, racking and travelling motors upon girders 175 ft. long. The value of the crane alone was £1,420. The Boiler shop alone was equipped with 17 jib cranes of various dimensions, an overhead beam and chain blocks, three other electrically driven 'travellers' of 6, 7 and 30-tons and a 'Single Geared Crab', with blocks and chain. All the workplaces at Hick Hargreaves were fitted out with a wide range of lifting and moving gear capable of handling all components, even the Shipping Warehouse possessed two travellers.[21]

Landes argues that the nature of work within the heavy assembly industries gave rise to an intricate and extravagant mode of production. Steam-engine building was an assembly process, one in which the finished product was fitted together and adjusted once the preliminary work of turners and machinists was done. In this sense work practices at the Soho Foundry conformed to the 'repeated trial and error and adjustment' of components that Landes believes was characteristic of assembling industries. His second characteristic of such industries is that few of them 'benefitted from the long production runs of homogeneous products that characterised metallurgy and the chemical manufacture'. Because much engineering work was done to order basic components 'varied with the job. As a result, there was a great deal of repetitious movement of the wrong kind, with a given object going back and forth several times over the same path until it was satisfactory; and little repetitive movement of the right kind, in which object after object follows the same path, undergoes the same processes, and emerges from the production line with the expedition that comes from practice and mechanization'. A feature of some assembling industries was their

working arrangement in which machine tools 'were grouped by type' or duty in 'separate shops'; and the components emerged from the preliminary stages of turning, planing and drilling etc., for fitting in the fitting shop. Hick Hargreaves, with its several foundries, machining departments and engine-fitting shop clearly conformed to this 'nodal traffic arrangement', namely the passage of components between work posts. It was rational to organise the turning of line shafting in one shop where lathes could turn mild steel 'within limits of 0.002 in.' and produce shafting 'free from flaws and laminations'. But this division of duties within an expanded scale of operations multiplied the 'time lost in the repetitive movement of material'. 'Logistic difficulties thus set a low upper limit to economies of scale'. Moreover, 'the same technological problems that gave rise to the nodal pattern' also 'called forth and sustained social institutions that were a source of further inefficiencies'. Production in the assembling industries was founded on the 'deft hand' of the skilled worker who would have proved 'less efficient than directly supervised semi-skilled or unskilled labour' under modern work study methods. Skilled turners and machinists embodied practices and patterns of thought incompatible with the notion that productivity improvements would flow from the adoption of automatic machine tools worked by 'handymen'. The skilled craftsmen, Landes alleges, possessed a 'vested interest' in the status quo and were therefore 'an obstacle to innovation'. This was particularly true 'because their skill and virtuosity were incompatible with the fundamental principle of industrial technology - the substitution of inanimate accuracy and tirelessness for human touch and effort'.

At the heart of the engineering strike of 1897-8 was a conflict between skilled craftsmen, who had been taught a trade through an apprenticeship, and employers prepared to innovate by adopting new tools and methods of workshop organisation that threatened to displace skill

from the shops. The great strike of 1897-8 was the culmination of a conflict that extended over many years and evoked Nasmyth's earlier faith in self-acting tools attended by labourers. Improvements to the machine tool and the appearance of new types of machine was a gradual process that was still unfolding in the '90s. Jefferys makes the point that the appearance of such new machines as the capstan and turret lathes, milling and grinding machines was not widespread, yet their introduction tended to make the decisions of the Amalgamated Society of Engineers 'out of date almost as soon as they had been agreed upon'. Clearly, changed notions of machine shop practice were exercising an influence upon the Society through the employers pursuit of 'freedom to manage'. It is not insignificant that the Society was reorganised in 1892 and in addition to important organisational changes a 'revision in outlook' took place for the resolution of 'new problems'. The General Secretary of the A.S.E., John Anderson, noted in his Annual Report for 1894 the presence of 'serious internal differences of opinion as to the future method of dealing with social and industrial questions'. Anderson's successor in 1896 was George Barnes, 'a militant and energetic "new" unionist', who favoured 'increased militancy in trade policy'. Among his supporters were Tom Mann and Sidney Webb, and it was Webb who declared at this time, 'We may be on the eve of a crisis in the history of the Amalgamated Society if not that of trade unions generally'. At this moment the machine question made a 're-appearance' as an issue in certain districts, with capstan and turret lathes, millers and borers at issue in circumstances reminiscent of the worries that arose over planing machines and centre lathes in the 1840s and 1850s. A feature of the 90s complementary to the Society's 'more vigorous trade policy and a change in leadership' was the emergence of an employers' federation that mobilised employers in the defence of their interests and pursued an unyielding strategy.[22] In the major

engineering dispute that followed, the employers' claimed to be defending their freedom to manage and in so far as this freedom included changed notions of machine shop practice it had already exercised an influence upon the Society. In 1896 George Barnes exercised a greater appeal over the membership than John Anderson because of his stronger understanding of the pressures felt by individual members on traditional methods.

According to Jefferys, one of the changes that marked engineering from the early 1890s and 'affected all sections of the industry ... was the growth of specialisation and standardisation'. But this was not a simple step for engineering firms to take because it required the elimination of skill through, firstly, the breakdown of jobs into simple tasks performed by tools operated by that familiar bogey, the 'handyman'. Secondly, firms had to develop their methods of manufacture, that is alter their workshop practice by a reliance on the use of jigs, accurate machine tools and gauges, so that the interchangeable system of manufacture could be adopted. However, there was a difficulty attached to this process of change and this was the greater suitability of the interchangeable system to some products - bicycles, typewriters and sewing machines for example- more than others where the opportunities for production in quantity were limited. Moreover, the fine tolerances used in steam-engine manufacture was an additional reason for hesitation that underlines a point stressed by Landes: 'Coherent sequences of machines and interchangeable parts are easier to establish in some industries than others'. A 'determining consideration' rests upon the 'degree of precision required'. Where engineering output was assembled from metalwork that had to fit closely together 'interchangeability was costly, and only the achievement of volume manufacture made the effort worth while'. Saul believed that 'when the market was right, interchangeability was aimed for and

achieved from an early date'. He also had reason to believe that Hick Hargreaves 'sponsored' the Corliss-valve engine in Britain 'and in 1867 began making it simply and to a standardized design'. By the close of the 1890s it was certainly the case that the company was marketing a standard range of steam engines. Potential purchasers had a choice of eleven engine layouts based on the three fundamental types of engine: Simple, Compound and Triple Expansion. In the case of the last of these types the company produced the Triple Fxpansion Engine in three versions, the Horizontal Double and Single Tandem Types, and the Vertical Triple Expansion Engine. Within each of the eleven engine layouts the company listed many engine sizes and could in some instances offer a number of 'Extras', such as the Soho Patent Metallic Packings for piston rods and valve. Within each of the eleven layouts the particular power requirement of customers were catered for through an established order of size, power and price. The Horizontal Compound Engine (with flywheel in centre) was available in no less than 23 sizes, ranging from 100 to 1500 IHP. Each size of engine could be produced in five orders of boiler pressure - from 80 to 160lbs. - each order possessing a distinctive cylinder bore and each one costed and priced. At the Soho Foundry that type of engine listed as Horizontal Compound (wheel central) was capable of being produced in 115 forms based on 23 list sizes. In the lists we have proof that bespoke engineering had yielded to the manufacture of a standardised range of engine designs prepared in advance of all conceivable requirements and available off the peg, an arrangement different to that hitherto when designs met the circumstances peculiar to individual power users. In 1896 De Jersey & Co. of Manchester enquired of Hick Hargreaves for the prices of engines required in Russia and the company's response was to provide preliminary price lists of five engine layouts along with 'five separate sheets' of extras and their prices. The prices of the engines included the

provision of such items as Corliss valves and cylinder lagging 'in addition to the other items mentioned on the enclosed specification sheet' and 'in all cases' the cost of flywheels. The quotations were based on the prices of engines as 'delivered at our works', the packing and delivery 'free alongside steamer in Hull to be added at the rate of 7 1/2%'. In addition to the price lists and specifications Hick Hargreaves also despatched to De Jersey & Co. 'two bound copies of Dimensions of Engines'. The company disclosed that it was their intention to present prices in 'enlarged, amended and more complete lists' that would be 'printed in book form ... and interleaved with sheets giving the dimensions of the various parts of the engines and engine houses'. Underlying this innovation was the adoption of a new principle to the manufacture and marketing of stationary steam engines, with implications for the customer so profound that the new principle required careful explanation. Hick Hargreaves wrote in a postscript to De Jersey & Co:

> In sending you these lists we think it well to point out to you that we have modern designs and patterns for a large number of Engines which we have made from time to time, some according to our own ideas and others according to sizes specified to us, which Engines will not fall into the complete and progressive lists such as those we are now sending you. Both as regards price and time of delivery, it is obviously to your advantage as well as our own, that the engines ordered should as far as possible fall in with our existing designs and patterns. We purpose preparing and sending you very shortly a list of these engines, carried out and priced in the same way as the enclosed lists, with the intention that when requiring an engine you should first try and work in one of

these engines, for which we have designs and patterns, as mentioned, and only have recourse to the lists, when you fail to find an engine suited to your requirements.[23]

Of the three types of engine design available to the cost conscious power user, Hick Hargreaves recommended the Compound mill engine. The company's chief engineer, Hudson, believed that the use of Triple and Quadruple Expansion engines was unnecessary because they offered no improvement in efficiency to justify their greater costs. But the company could not ignore the market for such engines the engineering case notwithstanding and as a consequence three of the eleven engine layouts in the 'progressive' price lists were arrangements of the three-stage type working pressures of up to 200 lbs. The Soho Foundry had turned out Triple Expansion engines for several years prior to 1892 when the company found it necessary to issue a 'circular letter setting forth the various points to be weighed' before choosing a mill engine. In 1896, the company reiterated its opinion: 'in the majority of cases the saving of fuel to be gained by the use of even Triple Expansion Engines would not balance the accompanying disadvantages such as extra first cost, greater complications, and consequent risk of breakdown, and that everything considered, a good Compound Engine designed for 120 to 150 lbs. pressure would prove the most satisfactory'. By 1896, the opinion of a majority of power users who had put down Triple and Quadruple Expansion engines had altered, they 'having either experienced trouble, or failed to realise the anticipated economy'. Hick Hargreaves opinion was vindicated as a result of the 'actual working' of the three-stage type and there was now a 'strong and increasing tendency towards Compound Engines working at a high boiler pressure'. The company was able to boast of its Compound Engines of 1200, 1500, and 2000 IHP then 'in hand' or set down at mills in Bolton, Bombay and

214

Calcutta. The experience of this design had 'shown that whilst such Engines have great advantages in the way of simplicity and reliability, they can compete very closely even in steam economy per I.H.P. with the best Triple Expansion Engines, and that they actually afford the least expensive and most satisfactory method of driving a factory, when all the items of expense are taken into account'. By 1905 Hick Hargreaves could justifiably claim that the Compound Engine was the most appropriate steam engine for producing power on land, because the company's sales of this type dominated engine output, the demand for Triple Expansion engines having apparently fallen away to a negligible proportion.[24]

Chapter 7

The Sequel To Incorporation : The 'Re-Modelling' Of The Soho Foundry, 1892 To 1914

A new industry like bicycle manufacture might have seized upon standardised manufacture in volume as the most appropriate way of organising production, creating in the process a radically new demand for machine tools, but this was not the case in the major engineering trades where the rewards of interchangeable manufacture were less clear cut because of the personalised nature of demand. Steam-engine manufacture was not a trade where established workshop practices constituted a self-evident anachronism that penalised profitability, a system ripe for displacement by the precise and systematic principles of the interchangeable system of manufacture. Both the new and the classic engineering trades could utilise the latest machine tools, but it was the quite distinct characteristics of the new and classic markets that determined whether or not the latest time-saving machines had an impact on workshop organisation for standardised production. Production techniques at the Soho Foundry did alter from 1892 as the company attempted to specialise in a comprehensive range of engines that could be marketed in anticipation of orders, rather than undertaking engine jobs in response to the peculiar requirements of individual power users. This much is evident from the preparation of Hick Hargreaves 'complete and progressive lists' of engines.[1] But what strategic decisions of the directors lay behind these new lists? Is it conceivable that the new company invested in new machinery and adapted its shop practices to realise the productivity gains offered by improvements to manufacturing, in order to uphold the firm's reputation for milldriving?

In this chapter, the evidence of a re-modelling of the Soho Foundry is discussed for evidence of innovation signifying a recognition of the appropriateness of the principles of interchangeability to a classic engineering trade. Whatever the contribution of the investment programme was to the productive capacity of the firm, the consequence was a successful dividend record. Appendix Ten compares the dividend payments of Hick Hargreaves with those of Greenwood and Batley, the general engineering enterprise, whose 'principal preoccupation' was the production of machine tools from the lightest to the heaviest types. In 1888 the private partnership of Greenwood and Batley was dissolved and a public limited company formed with an initial capital issue of £300,000. After discharging the vendors this issue of shares provided £35,000 to fund a major rebuilding of the works. The initial share issue was followed in 1890 with further calls on shareholders by the issue of preference and ordinary shares, because the company's capital requirements exceeded the finance already raised. In 1893 the capital structure was changed again 'when £20,000 of debentures were issued to the bank as security for the large overdraft which they had granted to the company'. Clearly, this adjustment to the business's capital gearing after the formation of the company reflects the failure to accurately judge the firm's future income flow. Indeed, Floud comments that the 'expansion of the works, and the flotation of the company which the need for finance for expansion demanded, both proved to have been based on incorrect assumptions of the course of future demand'. No such difficulty seems to have disturbed Hick Hargreaves who also arranged with its bankers to fund the company's investment programme through an issue of debentures. It was only when this issue became due for repayment in 1912 that Hick Hargreaves sought accommodation from its bankers and arranged a Debenture Loan Account secured on a further issue of 50 debentures of £1,000 each. Hick Hargreaves financial performance,

as evidenced by its balance sheets, was superior to that of Greenwood and Batley, whose decision to embark upon heavy investment was a misguided one against the background of the previous record of orders. 'In the light of the steady but slow growth in orders up to 1888', observes Floud, 'it is surprising that such heavy investment should have been undertaken at this period, and it is unclear on what evidence an expectation of the type of future growth for which this expansion could cater was based'. On the basis of strategic decisions set out by the directors the company had to operate in the years 1888-91 under an onerous financial burden, with capital expenditure of £104,000 when the total value of the enterprise was £265,000. The incorporation and expansion of Greenwood and Batley saddled the firm with nominal capital of £310,000 'on which dividends had to be paid', the payment of interest to the bankers as holders of the debentures - an issue that ranked pari passu as a first charge - and the debt charges also owing the bankers on the firm's calls for working capital arising from the unremunerative expansion of the works. This expansion of capacity involved departments of the enterprise where payment was deferred or delayed with the result that the company had to bear the financing of contracts, straining the liquidity of the company and driving it to the bankers for accommodation.[2]

Examination of Greenwood and Batley's balance sheets in the period 1889-91 led Floud to conclude that the firm's expansion was 'misguided', causing a credit balance with the bankers to become a debit, necessitating a debenture issue as security for an overdraft already granted and requiring a further overdraft. The policy adopted by the directors from 1893 aimed at restoring profitability to the company was not successful, while the idiosyncratic nature of the 'internal financial management' of the firm certainly offered great scope for

reform. Floud comments that the 'combined result of the financial mismanagement and unwise investment policies of the company, together with the apparent instability of demand for their products during the period from 1890 to 1914, is reflected in the dividend record of the firm'. The management of Greenwood and Batley deserved the damning condemnation levelled at it by the financial press in 1914. The measures employed by Floud to determine the financial success or failure of Greenwood and Batley underline the contemporary opinion that it was a poorly managed and non-profit-earning firm with a 'magnificent reputation' for quality of work, whose 'record as a limited company has been simply disastrous'.[3] By contrast, an examination of Hick Hargreaves dividend record over the same period apparently shows that the directors there accurately interpreted future trends in the market for power and that the re-modelling of the works in the 1890s was the appropriate means to a gainful end. The investment in replacement capital at the Soho Foundry is considered in a later section. Here the annual financial statements of the private company and the changed Particulars of Profit & Loss Account from 1892 are discussed, in order to explore the discrepancy evident between the financial statements of the two firms, that bear witness to the impressive dividend record of Hick Hargreaves & Co.

I

At Greenwood and Batley managerial traits with their origins in the private partnership era endured to afflict the financial management of the public company. Weak customers were accorded 'large credits' and this was particularly true of those customers with which Greenwood and Batley's first Chairman and Managing Director was personally involved. The company's auditors found it 'impossible to keep accurate records of sales and purchases', owing largely to a 'long-standing practice of

paying for supplies by means of cheques received from customers, without passing the cheques through Greenwood and Batley's account'. Another financial eccentricity concerned the Managing Directors, who 'habitually borrowed from the company in anticipation of their salaries'. The company's Chairman came to owe a substantial sum to the company and although exact figures are lacking his indebtedness amounted to over £2,700 in 1894 when he was taking steps to 'reduce his indebtedness'.[4] It is likely that such instances of unconventionality as these were commonplace within even corporate enterprises, because of the profound influence on business organisation of directors and managers who were active in 'family' businesses, either as the grandsons of founding entrepreneurs, or the descendants of those partners who had helped create private partnerships. The financial statements of Hick Hargreaves & Co. Ltd. certainly betray the influence of the directors, with their strong family link to the enterprise.

Between 1892 and 1913 Hick Hargreaves made net losses on only four occasions, including 1897 the year of the great strike, and was able to declare often substantial dividends in seventeen of these twenty-two years. From 1892 the revised Particulars of Account presents a new arrangement of items, that includes Gross Profit and Depreciation, for example, familiar from the previous series, and new items for Turnover and sums 'available for Dividend', 'Carried Forward' and placed in 'Reserve Fund'.[5] The trade dispute of 1897-98 accounts for the poor trading performance of these years, but thereafter the company consistently generated net profits over a period of several years that closed in 1910. These were years characterised by a 'modest recovery' in prices following the low level reached with the cyclical downswing of the early 90s, a worsening of the terms of trade after the Boer War, and a slight fall in real wages down to 1914. Before the turn of the

century a combination of falling prices and stable wages accounted for a rise in living standards, with strong trade unions effectively squeezing profit margins. There appears to have been 'a marked rise in the share of industrial income going to wages at the expense of profits. The share of wages in the sum of profits plus wages was 52.3 per cent in 1870-4 and 62.2 per cent in 1890-4. But when the trend of prices was reversed in the less competitive environment after 1900 even strong unions could only push up the whole cost and price structure, and prices and profits kept pace with wages'. In engineering, the terms of the settlement that closed the dispute of 1897-98 were 'harsh' for labour and affected 'relations between the employers and the A.S.E.' up to the Great War. The dispute ended with clauses favourable to the employers on matters of wages, piece-work, overtime, the direction of men to machines and the hiring of apprentices. This period also saw the export branches of British industry, including engineering, enjoying 'very great prosperity', with a rate of increase in the volume of exports 'considerably greater' than in the preceding period from 1873 to the close of the century.[6]

In the period 1892 to 1913 Hick Hargreaves average annual gross profit was £18,052, a figure much lower than the average annual figure of £27,703 found for the preceding period, 1879-91, and evidence of a continuing compression of the company's gross profit. We can assume that the company's conception of gross profit did not change with incorporation and that it remained as before, the total sales revenue (turnover), less wage and material costs. This assumption is tenable because of the inclusion of an item for turnover in the Particulars of Account from 1892, and the expression of gross profit as a percentage of turnover. If we apply the contemporary definition of turnover as the value of a company's gross takings, or total sales revenue, before any

deductions are made, then Hick Hargreaves Turnover less Gross Profit should give the cost of the company's money outlays on wages, fuel and raw materials etc. Net profit in the period 1892-1913 was such that the average annual figure came to £10,862, a value slightly greater than the figure of £9,211 for the preceding period, yet depreciation was considerably greater from 1892 and appears to have been particularly heavy down to 1899. Throughout the period of the company's sustained prosperity, the years 1898-1910, the average annual figures for gross and net profits show a pronounced increase over the values for the period as a whole from 1892 to 1913. If the boom period is extended to 1913 to include the poor results for 1911-12, the average annual values remain greater than for the period as a whole, apparently reflecting a sustained improvement in performance arising out of the re-modelling of the works.

The items in the Account for Turnover and Gross Profit are possibly the most significant indicators of the company's performance, inevitably leading the business historian into a consideration of Net Profit and the sums made available for a dividend, or retained as undistributed profit and carried forward. How the item for Net Profit was derived presents a problem that appears to distort the symmetry of the Account. Net Profit, plus whatever was carried forward from the previous year's trading, gave rise to a sum available for distribution as a dividend. From 1899 not all of this sum was divided among shareholders. A portion was either carried forward to the next year's account, or deposited in the reserve fund. The item in the Account for Gross Undistributed Profits was the sum of the values carried forward and placed in reserve. The distortion centres upon Net Profit because this item is consistently less than the sum of Gross Profit less Depreciation. Clearly, there existed an item, hidden from

the Account, that along with Depreciation determined Net Profit. The explanation could lie in interest payments on past loans, plus directors fees and any commission payments made by the company, but why do they not appear with Depreciation in the Account? The annual reports to shareholders provided no answer, because they presented the profit and loss account in terms of what was available for a dividend out of Net Profit, with no mention of either Turnover and Gross Profit or the company's costs. However, the company maintained a General Reserve Fund out of Net Profit from 1899 and it is conceivable that there was already a hidden reserve in existence before then. In the period under review the practice of building up hidden reserves 'by depreciating assets very quickly or by deliberately under-valuing assets' was widespread, and defended on the grounds 'that it was in the shareholders' interest to withhold profits in good times and disgorge them in bad times'. This may not have been a desirable state of affairs, particularly in view of the scope it allowed directors to deceive shareholders of the true financial position of a company, but ethics aside, the implications of hidden reserves for the veracity of financial statements were considerable. It is argued by Marriner that this practice was possibly the 'largest single factor distorting the accuracy of financial statements'. This 'bias' in financial statements came about because not only were hidden reserves created in good times but it was also common for trading losses to be concealed by reversing the procedure and deliberately overvaluing assets or reducing the amounts allowed for depreciation, a practice clothed in secrecy and condoned by the legal system. The natural desire to create a hidden reserve in order 'to avoid violent fluctuation' in a company's disclosed profits or dividends effectively 'rendered statements of "profits" in published accounts highly inaccurate as a measure of "earnings"' and seriously distorted valuations 'of investments, plant, debt, stocks and so on'.[7]

In Hick Hargreaves case the discrepancy between Gross and Net Profits is accounted for by small charges for directors' fees, the occasional commission payment and, more importantly, debenture interest. Prior to the annual report of directors for 1912, the year in which the new Debenture Loan Account was established, no mention was made in the annual reports of debenture interest. In the subsequent annual reports up to 1920, the charge for debenture interest largely accounts for the hidden cost item that together with Depreciation determined Net Profit in the Particulars of Account. If one significant item could be overlooked and omitted from the Particulars were other items similarly treated? Between 1892 and 1901, the sums allowed for Depreciation appear to have moved erratically from one year to the next, exceeding £5,000 in 1892 and '93, falling to nil in 1900, and rising to £2,000 in 1901. It was only from 1902 that the allowance for depreciation became a set charge of £4,000 retained from profit irrespective of the magnitude of Gross Profit.

Depreciation is unique because it is both a provision charged on the expenditure on assets and a reserve maintained from profit for the replacement of assets once they are wasted. The charge for depreciation was therefore capable of defining two distinct requirements within the accounting system and it may have been as a result of this duality of purpose that a General Reserve Fund was specifically established at Hick Hargreaves in 1900. The spectacular growth of this fund in the space of a short period of time raises the question of a hidden fund in existence before its acknowledged creation. The reserve was opened in February, 1900, with £3,372 from the balance standing to the company's credit at the close of 1899. At the next general meeting of shareholders, held a year later in February, 1901, a further sum of £5,000 was added 'to the General Reserve Fund increasing this fund to £15,000'. An occurrence

such as this was inevitable where 'the law did little to ensure the accuracy of financial statements', and when 'it was claimed that auditors were under no legal obligation even to check carefully if items appearing in a firm's books were correct'. But why should the directors of Hick Hargreaves, who were the majority shareholders, attempt to conceal the true state of the company when a reserve fund for contingencies was permitted by the Companies Act of 1856? The answer lies with the outlook and conventions of the directors themselves, who had no difficulty in adhering to the requirements of a company law that was both vague and inconsistent. As Marriner explains, the usefulness of financial statements 'to business historians depends on their accuracy and comprehensiveness and historians should never forget that they were designed only for shareholders not for historians'.[8]

The legislation instead of providing a rigid framework for the instruction of company directors, allowed them to interpret company law as they saw fit, with the result that company balance sheets often presented an 'equation' between assets and liabilities, emphasising the amount of profit available for a dividend. At Hick Hargreaves ordinary meetings shareholders were called 'To receive and consider the Directors Report, the annual statement of accounts and Balance Sheet and the report of the audit thereon'. Not surprisingly, the consideration given to the balance sheet in the directors' report was limited to the net profits arising from the previous year's trading out of which the shareholders might obtain a dividend. Just how comprehensive the reports given at the company's general meetings were is apparent from Hick Hargreaves first ordinary general meeting held in April, 1893.[9] Of the ten shareholders present only two were drawn from the friends of the company, the majority were directors and professional office-holders to the company, who also possessed a shareholding. It was this small

225

gathering that heard the Chairman, J. H. Hargreaves, read the directors' report:

> In making this their First Annual Report upon the state and condition of the Company, as required by the Articles of Association, your Board has but little to add to the facts shown upon the Balance Sheet from which it appears that the net profits of the year ending December, 31 1892 amounted to £1776 17 5 and they can but express their great regret that the result of the years trading has been so unsatisfactory.
>
> They attribute this result mainly to the keen competition and the necessarily very low prices at which orders had to be booked during the past year but they are glad to say the present year has opened with brighter prospects and they hope for a more satisfactory result as to this years trading.
>
> The Directors do not propose to divide the small profit earned but to carry it forward.
>
> The Works, Buildings, Machinery, Plant & Tools have all been well maintained and are in thoroughly good condition.
>
> In addition to which the same annual allowance has been made for depreciation as had previously been made by the late firm of Hick Hargreaves & Co.
>
> The stocks of material have been taken at current rates and in precisely the same manner as that adopted by the late firm of Hick Hargreaves & Co.

The auditors' report to shareholders disclosed that they had examined the books and accounts 'of your Company' and attested that the balance

224

sheet was a 'full and fair' statement, exhibiting a 'true and correct view of the state of the Company's affairs'. This statement 'was handed round for the inspection and criticism of the shareholders', who compelled the Chairman to answer 'sundry questions connected with the Balance Sheet'. It was then resolved that the director's report, the annual statement of accounts, the balance sheet and the report of the audit be adopted.

These procedures were in accordance with the requirements of the Companies Acts, 1862 to 1891, under which the firm had been incorporated, but these acts lacked detailed provision as to content and definition of terms for financial statements. If the legislation was incomplete it was not surprising that the balance sheets and profit and loss accounts determined by it were defective. The legal requirements of company law, the 'absence of strict definitions of terms in the acts' and 'accounting conventions' together accounted for the 'many defects' evident in both forms of statement. The legislation called for a full and fair balance sheet to be received by company shareholders, along with an auditors' report, but did not define what was meant by the terms 'full' and 'true', while relegating profit and loss accounts to a position inferior to that of balance sheets. This was unfortunate in Marriner's opinion because profit and loss accounts 'should be more informative than balance sheets', summarising possibly 'a whole year's operations', and displaying 'a record of trading results' from one time period to the next, whereas balance sheets 'tell nothing of movements over time. They only show the relationships of the company to its proprietors and to other parties at one particular moment of time and only at that particular moment: like a snapshot'. It was also true that the legislators 'failed to provide explicit definitions and explanations' concerning the 'format and content of financial

statements'. But this failure did not stem directly from the ambiguity attached to terms and the problems associated with the meaning of profit. The fundamental reason was expressed by Lord Justice Lindley in 1889 when he was considering what constituted profits. He declared: 'There is nothing at all in the Acts about how dividends are to be paid nor how profits are to be reckoned; all that is left, and very judiciously and properly left, to the commercial world. It is not a subject for an Act of Parliament to say how accounts are to be kept; what is to be put into a capital account, what into an income account is left to men of business'.[10]

There are two sources of figures available for a study of Hick Hargreaves financial performance between 1892 and 1920: the annual financial statements of the directors; and the Particulars of the Profit & Loss Account. At the company's ordinary meetings the Directors' Report was read and a balance sheet circulated among the shareholders, disclosing the result of the past year's trading and the effect of either a net profit or loss upon the balance of the profit and loss account. The report revealed how much stood to the credit of the profit and loss account after carrying forward the balance from the previous year, and what sums the directors recommended should be divided in a dividend, put to the reserve, or carried forward. Occasionally, the report referred to the market conditions that had given rise to the trading result. For instance, a low net profit and the inability to declare a dividend might stem from such events as keen competition or weak demand. The shareholders were not appraised of the company's turnover and gross profit, nor was reference made to those items determining the size of net profit. If depreciation was mentioned at all it was in the most general terms. In 1894, for example, the shareholders were told that 'In preparing the Balance Sheet, as will be

observed on examination, ample allowance has been made for depreciation on the same basis as in previous years'.[11] It appears that the major purpose of the general meetings was to consider net profit and the possibility of a dividend, a subject of perhaps over-riding importance to the non-executive shareholders.

The Particulars of Account seem far more informative as they present several items over each accounting period between 1892 and 1920. The very appearance of these financial Particulars, with several columns of figures, some concerning items not mentioned in the annual directors' reports, is both reassuring and stimulating, because figures are self-evidently constant. The difficulty attached to Hick Hargreaves financial statements concerns the inconsistency within the seemingly reliable Particulars of Account, revealed by a discrepancy between the understandably brief directors' reports and the Particulars. The perplexity engendered by two contrasting statements, each of them apparently correct, was resolved once the nature of financial statements as a whole was understood, while the inconsistency of Hick Hargreaves Particulars of Account was explained by methodically working through the figures and referring them to the annual statements.

The Particulars of Account show that Hick Hargreaves paid its first dividend out of the accumulated net profits of three years trading. During 1892 'Keen competition and the necessarily very low prices at which orders had to be booked' had led to an 'unsatisfactory' trading result. The company's financial position at the close of 1893 was 'not altogether unsatisfactory' against the background of a 'great depression in trade, the effect of the coal strike ... & the keen competition, which necessarily means low prices'. The Board could have declared a dividend of 2 1/2%, but chose not to do so because 'a House with whom the company have done a considerable business are in difficulties and as

their indebtedness to the company is £7,148 16 11 and the probability of any of this amount being recovered exceedingly remote your Board feels that they would not be justified in declaring a Dividend'. Trading in 1894 was poor, resulting in a meagre net profit of £571, but this was not disclosed to the shareholders. Instead, the directors were 'glad to be able to state that with the amount brought forward from last year there has been a net profit made of £7,246'. After 'serious consideration' the Board awarded a dividend of 3%, 'leaving an amount to be carried forward of £766'.[12] But the Particulars of Account record a sum of only £466 carried forward and the Account also understates the small amount of net profit achieved in 1894. These initial anomalies within the Particulars of Account are part of a recurring theme within the company's early financial statements as the Board of Directors attempted to put a false view before shareholders that the subsequent Particulars found difficult to accommodate.

It is only from 1904 that the Particulars of Account and the directors' annual reports accord in respect of net profits, dividends and the sums carried forward. That they continue to differ over the size of the General Reserve Fund and, as a consequence, the level of Gross Undistributed Profits, comes as no surprise, as there is good evidence to show that a hidden reserve existed before its declared creation in 1900. In the Directors' Report for 1895 the Board expressed their 'great regret' to shareholders that the trading performance of the company had 'been so unsatisfactory as the figures in the Balance Sheet will show resulting in a loss of £2771 18 7'. Indeed, the Particulars of Account testify that the year's trading resulted in a greater net loss, which was partially offset by the sum standing to the credit of the previous year's account. But the net loss could have been reduced by a further £300 if the total credit balance of £766 had been brought

forward. The Particulars show a net loss of £3,238 reduced to £2,771 by the sum of £466 carried forward from 1894 when, as we saw earlier, the actual amount brought forward was £766, leaving £300 unaccounted for. The balance sheet circulated among shareholders would have confirmed the loss arising in 1895 and may also have shown how it was offset by the previous credit balance of £466. It seems correct to assert that the directors had, at some early date, opened a reserve fund, a fund kept secret, into which was placed £300 of the net profits achieved between 1892-4. At the close of 1895, the directors had no choice but to carry the deficit balance of £2,771 forward to the profit and loss account for 1896, when trading was 'very satisfactory'. A 'net profit of £21,549' was shown on the balance sheet presented to shareholders, allowing £16,200 to be divided in a dividend of 7 1/2% and a 'balance to carry forward of £5,349'.[13] The Directors' Report for 1896 makes no mention of the debit of £2,771 outstanding from the previous year's account, while the Particulars of Account offer a net profit figure of £24,873 for 1896. It is conceivable that the net profit given in the Directors' Report was net of the previous year's debit item, but this, together with the directors' net profit, produces a sum of £24,320, which is £553 less than the Particulars net profit figure. Both statements agree on the size of the dividend paid, a sum of £16,200, but the Particulars of Account understates the sum carried forward in the Directors' Report by £200. For 1896, the Particulars show a net profit of £24,873, and if this sum was used to discharge the debit item of £2,771, a figure of £22,102 ought to have remained available for a dividend. Instead, the figure given in the Particulars is £21,349. Does the conflicting nature of the two statements imply that another surreptitious addition was made to the hidden reserve?

In 1897 Hick Hargreaves made a loss of £8,985 attributed 'entirely' by the directors to the industrial dispute, 'which lasted for six months ... necessarily reducing the output considerably though of course the fixed charges & expenses remained the same'. The directors were, however, confident that the next year's trading would 'show a substantial profit', particularly as the company had work in hand to the value of approximately £145,000. The Board's optimism was borne out by events, because trading in 1898 gave rise to a net profit of £26,775. But on this occasion mention was made in the report to shareholders of the 'adverse balance' standing to the previous year's account. Once this sum of £8,985 had been written off a balance of £17,790 remained for distribution and the award of a dividend of 7% absorbed £15,120, leaving a balance of £2,670 to carry forward to the current year.[14] The significance of the trading year 1898 is that it is one of only three years when the figures of both the Directors' Report and the Particulars of Account are in agreement with each other on the size of net profit, the sum available for a dividend and dividend paid etc. However, the conformity evident in 1892, 1893 and 1898 is not evident in the financial figures for 1899, but the reason for the absence of agreement is apparent.

According to the Particulars of Account, trading in 1899 resulted in a net profit of £31,615, a sum £200 less than that presented to the shareholders by the directors. In their report, Hick Hargreaves had achieved a net profit of £31,815, while the credit balance of £2,670 'carried over from the previous year's accounts' gave a balance of £34,486 'to the credit of Profit and Loss Account'. The sum available for a dividend in the Particulars should be £34,285, but the figure actually given is £34,386, an increase of £2,771 over the Particulars net profit figure. Both statements agree that the dividend of 10% paid

in 1899 absorbed £21,600 from the credit balance of the profit and loss account. As far as the shareholders were concerned, the dividend award left a 'balance of £12,886 to carry forward', and it was at this point that the directors opened the company's Reserve Fund. They proposed 'to place £3,372 as a Reserve Fund and £9,513 to carry forward to the Credit of the current year's account'. These sums together represent the company's gross undistributed profit, but the Particulars of Account show a credit balance of £12,786 and of this £9,314 is Carried Forward and £3,372 placed into the Reserve Fund. Here, gross undistributed profit should equal £12,786, but the figure presented in the Particulars understates that amount by £100. These anomalies, even within the Particulars of Account itself, are understandable when it is borne in mind that company financial statements represent a 'numerical historical record' of past transactions, modified by the perception that hindsight confers. The discrepancies within the annual Directors' Reports disguise imperfectly an item, in this case a reserve fund, that the Board wished to conceal. It was difficult for the directors to change their concept of business, based on ideas formed in the years when Hick Hargreaves was a proprietorship. The directors probably believed that some company matters, particularly those relating to the accounts, should be handled with circumspection and they were clearly assisted in this desire by the vagueness of the Companies Acts. Unfortunately, the flimsy veil of secrecy concealing the reserve fund could not be maintained indefinitely. For one thing, the true state of the company's accounts was distorted by the maintenance of a secret fund and it became absurd to pretend that no such fund existed. The Directors' Report for 1900 showed a balance of £7,044 carried forward to the current year's account. At the next ordinary general meeting held seven months later to consider the half year ending June 30, 1901, the sum carried forward had become a 'credit balance of £6,844 carried over from the previous

years accounts'.[15] From the Tenth Ordinary General Meeting, held in 1901, the annual statement of accounts and the figures presented in the Particulars begin to accord, with only one inconsistency surrounding the size of net profit in 1903. But neither statement can agree on the size of the reserve fund, which, by 1909, had grown to a prewar peak of £35,000. The Particulars of Account consistently understates its true level. However, from 1900 the annual Directors' Reports were presenting 'a true and correct view of the state of the Company's affairs' inasmuch as they identified a reserve fund.

II

Examination of Hick Hargreaves Minute Book reveals that the directors had a strong motive for raising a hidden reserve. It is apparent that from an early date they were considering a costly improvement of manufacturing capacity that would entail the replacement of skilled labour with machine tools. Unfortunately, the depressed trading environment in which the company found itself restrained the ambitious scheme of the directors, who were mindful of the shareholders' expectations of a dividend. At an early Board Meeting in 1892, 'a good deal of desultory conversation' took place 'as to the desirability of re-modelling the Phoenix works or as an alternative of increasing the Boiler Shop at Soho'. Boilermaking was regarded by the directors as an activity crucial to the sales of engines and the Boiler Shop was a department of the enterprise that could not be permitted to fall into disrepair. But no matter how desirable investment in the making of boilers was the phase of the business cycle in the early 1890s did not encourage the directors to invest. The contemporary press comment studied by Nicholas shows that from the beginning of 1891 the level of activity in engineering had begun to decline and by the close of 1892 a

'general tone of depression surrounded all branches of the trade'. Throughout the next year 'the industry was stationary with many shops on short time or partial working while a few firms discharged hands'. Because of what the directors themselves referred to as this 'great depression in trade' and the 'keen competition' arising from it, the Board of Directors was compelled to examine Hick Hargreaves arrangements with the Bolton Iron & Steel Co. Hitherto, contracts for steel boiler plates, bars etc had been placed with this company, but the unsatisfactory level of trade raised the issue of awarding contracts with other firms who had submitted lower quotations. It was decided to allow the steel company 'the option of revising their prices to meet the competition' posed by attractive quotations from elsewhere, the engineering company 'reserving to ourselves liberty of action'. At the same time it was still 'understood that other things being equal the B I & S Co. should have the preference'. The depression did not deter plans 'of the proposed New Foundry' from being considered by the directors, who, after discussing the 'advisability of proceeding with the alterations', resolved to consider the matter at a later date, in order that Percy and Francis Hargreaves could examine the 'existing buildings'. Several months later, at the Second General Meeting of Shareholders, held in February, 1894, the Directors' Report 'strongly' advised 'a re-modelling of several of the shops, to reduce the labor expenses, as well as a complete equipment of modern tools and appliances to keep abreast of the times'. Barely two years after the formation of the company the directors were recommending an investment programme to shareholders and it is difficult to avoid the impression that incorporation of the old company was the first step taken to achieve this desirable 're-modelling' of the firm.[16]

By assenting to the investment programme, the shareholders were assured that they would be placing the company 'in a better position to meet the competition which is daily increasing and which can only be met by the Company availing themselves of labor saving appliances to the utmost extent'. The report to shareholders continued: 'The question naturally arises how best to effect this in the present state of the Company's finances - your Board however thinks that this is a subject well worthy the serious consideration of the shareholders'. At the time that the directors were ascribing the company's unprofitability in 1893 to the scarcity of orders, keen competition and low prices these features of the market were persisting into the current year. Nicholas remarks that engineering 'Work continued from hand to mouth into 1894 where the industry, if not in depression, displayed no great activity'. This combination of weak demand and strong competition for whatever orders were available stimulated the directors' plans for an investment programme, although the actual re-equipping of the works was precluded by the absence of profitability. Hick Hargreaves had entered 1894 'fairly well off for orders', but the directors reminded the shareholders that the company was 'capable of turning out considerably more work' than they possessed, 'and as it is only by keeping the men fully occupied and the machines constantly running that a profit in these days can be expected to be made your Board confidently relies on the cordial co-operation of the shareholders in placing all the orders they can with the Company'. But this appeal was not enough to prevent a poor trading result for 1894, a result so bad that the directors felt unable to disclose the meagre net profit realised. Nevertheless, the shareholders were awarded a dividend of 3% in the Directors' Report for 1894, an award that the Directors hoped would 'commend itself to the judgement of the shareholders'. The coming year seemed to offer little hope of improvement and the directors gloomily confided 'that the

Company commenced the year 1895 with very few orders on hand'. They also reported that the outlook remained 'far from encouraging'. Under these circumstances the investment programme already recommended by the Board could be made to appear even more crucial to the company's future. Once more the shareholders were informed that the directors were 'seriously considering the advisability of re-modelling several...shops with the view of securing greater economy of labour by the addition of labour saving appliances so necessary in these days when to secure orders the price has to be cut down to the barest possible limit'. In truth, the investment programme was undoubtedly underway by February, 1895, when the Chairman delivered the third annual Directors' Report because, referring to the balance sheet, he 'explained that the large balance at the Bank was advisable owing to the contemplated alterations mentioned in the report'.[17]

Hick Hargreaves trading result for 1895 was worse than had been anticipated, with a loss of £2,771 that was again attributed to 'keen competition & the necessarily low prices at which orders had to be booked'. When the Board of Directors discussed the balance sheet on the eve of the Fourth General Meeting 'a good deal of discussion took place as to the unsatisfactory result of the year's trading, but there was no alternative but to accept it & the Directors report was accordingly prepared'. This held out the promise of a favourable result at the next meeting in 1897 and these expectations were borne out, allowing the Chairman to express 'his pleasure at being able to meet the shareholders with such a satisfactory Balance Sheet'. Trading in 1896 had 'been very satisfactory' and it was noted 'that the good results anticipated in the last year's report have been fully realized'. A declared net profit of £21,549 was a pleasing departure from the recent past, particularly as it permitted a dividend of 7 1/2% to be awarded. According to Nicholas,

a revival in home demand, 'initially affecting steam engine, machine-tool, and locomotive building', was recognised by the engineering press as early as February, 1895, and by November 'the trade as a whole had sufficient work in hand to keep well engaged'. This 'revival in home demand' explains the dramatic turnabout in Hick Hargreaves trading performance during the course of 1896. That year, says Nicholas, witnessed a 'flood of new orders on top of nearly full order books', that led to a lengthening of delivery times and stimulated the placing of orders for machine tools and steam locomotives with American firms. Domestic capacity constraints now became a feature of the engineering trade and remained so throughout the period 1896-1900, with British firms in the machine tool and locomotive building trades unable to meet the requirements of clients, as British economic activity gathered pace in a period of growth, culminating in an upper turning-point in industrial production by 1899. In the Summer of 1896 The Engineer was reporting that general engineering firms were marginally better off than machine-tool builders in the sense that they could not fulfil contracts in the times required, while machine tool suppliers, the periodical reported, were 'quite unable to book further orders where anything like early delivery is required'. In the circumstances of a buoyant level of activity, it is not surprising that at the beginning of 1897 the Board had 'pleasure in stating that the prospects of the year...are decidedly favourable and they confidently hope that at the years end they may be able to meet their shareholders with an equally if not better result'. But the engineering dispute of 1897-98 turned a potentially rewarding result into a 'very unsatisfactory' one, a loss of £8,985. However, the company was able to write this adverse balance off and award a substantial divident of 7% out of the large net profit achieved in 1896 through the company's participation in the boom in economic activity. 'Throughout 1897 and

238

1898', notes Nicholas, 'there was overtime working, double shifts, and restrictions on holidays in all branches of the engineering trade'. Prior to the dispute some British machinery buyers were turning to American suppliers, while 'Reports of orders transferred from Lancashire to America occur in the engineering press in 1897 and become general in 1898'. The dispute caused a temporary reduction in orders, but once the dispute was resolved orders increased in volume, with a higher proportion than before flowing to the United States. That is to say, the 'tendency toward placing orders in America increased' with the settlement of the dispute. This 'reliance on the American market in times of high demand' was a significant feature of the years 1896-1900, according to Nicholas, because Britain's engineering trade became satiated with work and 'faced capacity constraints reflected in the very long delivery lags' evident in contemporary periodicals.[18]

The investment programme conceived by the directors in order to enhance the competitiveness of Hick Hargreaves may have been delayed by the poor performance of the company in the early 90s, but it was not renounced or reduced in scale. At a time when remunerative orders were scarce it was understandable that a re-modelling of the works should be recommended as a rational response to a weak market, whose clearly discernible features were the familiar ones of a capital goods industry in depression. But incorporation and the investment programme were part and parcel of the same major design for a restructuring of the business through the creation of a company in order to allow a thoroughgoing improvement of capacity. This restructuring of the firm was a decision of the three sons of William Hargreaves, who wished to secure the prosperity of the business in the long term. The investment programme they advocated to shareholders as a necessary response to the downturn in economic activity possessed greater meaning than was admitted. At

the time it was convenient for the directors to account for projected replacement investment in labour-saving devices as the response to a slump which had rendered profitability elusive. But Hick Hargreaves plight was far from unique. In 1893 the whole engineering industry 'was stationary with many shops on short time or partial working' and many firms had recourse to the traditional remedy of a fall in demand by firing hands. The directors' express desire to substitute labour-saving machines for skilled labour signifies an ambition greater than the immediate response to the slump of the early 90s. The chronology of events seems to bear this out. Not long after the old company was incorporated the state of the engineering trade in mid-1892 was reported to be 'very unsatisfactory', with prices having fallen below cost. Indeed, the engineering press was commenting on a decline in orders that were being booked at lower prices from early in 1891, the year prior to
19
the conversion of Hick Hargreaves. Although it was clearly evident that the level of engineering activity was falling away and a depression was imminent, the old company's conversion was not delayed until a more propitious time. It is therefore conceivable that scant attention was paid to the outlook for contracts, prices and profit because alterations to plant layout and investment in an improved stock of capital equipment were regarded as of over-riding importance, that transcended the course of current economic fluctuations. The pace at which the replacement plant and equipment was actually laid down appears to confirm the impression that the improvement of productive capacity represented a carefully thought-out scheme aimed at securing lasting rewards beyond some future date.

At the close of 1897 when the 'unfortunate Lock-out' was in progress, the directors resolved that the 'proposed alteration to the Boiler shop be proceeded with commencing at first with the 50 ft big
240

bay'. The initial investment in rivetting towers and travellers etc., costing 'roughly' £7,000, was sanctioned, while the 'remainder of the scheme involving a further outlay of say £5,000' was 'left at the discretion of the Directors', who were authorised to proceed with the work and order tools 'from time to time as required'. At the General Meeting that considered the 'very unsatisfactory' result for 1897, the shareholders were informed that their Board had 'taken the opportunity during the strike of making considerable improvements in the various shops as well as buying additional Machinery, all with the end in view of economizing labour and diminishing the cost of output'. By August, 1898, tenders 'for the erection of a New Engine Erection Shop' had been submitted and were discussed by the Board, who postponed a decision in order to allow the Works Manager 'to prepare a tabulated statement showing whether it would be more advantageous to carry out the work ourselves or to let it out'. This key project called for an immediate decision and a 'Special Directors Meeting' was convened once the Works Manager's report was available. His statement showed that by undertaking the project themselves Hick Hargreaves could achieve a saving 'of between £200 & £300' on the 'most favourable of the two [tenders] submitted when quality of materials & workmanship was taken into consideration. It was agreed that the work should be carried out by the Company & that the same should be proceeded with at once'. Within a short time a completely unexpected opportunity presented itself for modernising the shops as a memorandum attached to the minutes explains:

> On the morning of Friday, November 18th 1898 about three o'clock, a fire was discovered in the neighbourhood of the Engine driving the Boiler Shop, Heavy Turning & Fitting shops, the Borough Fire Brigade was immediately summoned but it was not until

considerable damage had been done before the fire was overcome. The damage, which is very serious, involved the temporary stoppage of the three departments named.

At the next General Meeting it was reported that the fire was thought to have originated 'in the Gearing chamber immediately adjacent to the Heavy Turning, Fitting, Electrical & Boiler Departments, which were all more or less disorganised for the time being. No time was lost in re-starting, by means of temporary engines, the machinery rendered inoperative, so as to minimise as much as possible the delay in the completion of several large & important orders in hand at that time'. The directors had 'every reason to believe' that the insurance claim would 'be sufficient to cover the cost of reinstating the Buildings and plant in an efficient manner'. At the same time the shareholders were informed that 'in addition to the alterations & extensions in the Boiler Department mentioned in the last report', the directors had found it 'necessary to sanction the building of a new Engine Erecting Shop, together with the necessary crane, tools & appliances, owing to the limited space which has hitherto been available the increased size of engines & the great expense involved in having to erect such engines in other parts of the Works not specially laid out for the purpose'.[20]

Statistical examination of the annual production of steam engines in the period 1871-1913 reveals that from 1896 there was a significant increase in the size of the engines manufactured by Hick Hargreaves. The Minutes of the Board of Directors show that the re-modelling of the Soho Works was to some extent undertaken in order that engines of 'increased size' could be built more efficiently. Evidence is also offered by this record of the directors attentiveness to the appearance of machine tools of improved design that could fashion the larger engines which the firm had adopted. It is clear that the directors

wished to adopt the latest examples of machine-tool technology for the production of the latest generation of economical engines at competitive prices. 'Considerable discussion and an interview with the Works Manager' by the directors at one of their meetings in 1899 led to the purchase of a number of 'new Machines' being sanctioned at an 'approximate cost' of £7,960. When this major expenditure on machine tools is placed in perspective with the total sum of £13,000 approved for the building of a new Boiler shop and the costs likely to be incurred with the construction of a new Erecting shop, it is understandable why a large balance at the bank had been created to meet 'contemplated alterations'. Good trading results in 1896 and '98 meant that the company's favourable bank balance was not exhausted by these re-modelling schemes. Indeed, it is likely that the bank balance actually increased in size because in April, 1899, a directorial 'discussion took place with regard to the Bank Balance amounting to £ as to whether it should be reduced & if so to what extent and the manner of disposal'. It was agreed that Percy Hargreaves should consult the company's auditors and report his findings at the next Directors' Meeting. At this meeting it transpired that P & J Kevan recommended 'that application be made to Court for permission to reduce the Company's Capital to the extent of £2...per Share, and that One pound per Share be paid off as soon as such permission is obtained and the other One pound per Share at some future time as the Directors may decide'. The directors adopted this recommendation and at an Extraordinary Meeting of shareholders a Special Resolution was confirmed: 'That in respect of each Share in the Company's Capital upon which the sum of £9 has been paid up, Capital be paid off to the extent of £2 upon the footing that the amount returned or any part thereof may be called up again'. This reduction of capital was duly confirmed in December, 1899, by an Order of the High Court of Justice, Chancery

24

Division. If the company was truly well endowed with liquid balances it would have been correct for the auditors to advise a reduction of capital, because such a course was open to any company which had issued partly paid share capital and found itself with all the capital it required. Hick Hargreaves reduction of capital involved a sum of £48,000 and benefited the directors as holders of the largest shareholdings in the company. The magnitude of this reduction in capital may reflect the size of the undisclosed cash balance. It is noteworthy that at the next Ordinary General Meeting held in February, 1900, a sum of £3,372 arising out of the balance of the credit of the profit and loss acoount was placed 'as a Reserve Fund'. A year later at the Ninth General Meeting a sum of £5,000 was placed from the credit balance 'to the General Reserve Fund increasing this fund to £15,000'.[21]

At the same time as arrangements for the reduction of capital were being made another 'discussion took place respecting the completion of the extensions and alterations to the Boiler Shop' at which the Works Manager was again present. It seems that the wisdom of this scheme was debated before an irrevocable commitment was made to it. The directors' decision was to carry through this scheme for a new Boiler department 'in accordance with the original plan and that the various machines...be ordered as they are wanted'. The extensions and alterations to the Soho Foundry's boilermaking capacity affected the future of the company's Phoenix Boiler Works, a separate plant, formerly the Phoenix Steam Boiler Co. Ltd., acquired by Hick Hargreaves on the eve of incorporation. By October, 1899, a buyer had come forward offering to purchase the 'buildings & erections, engine, boiler and all shafting' belonging to the Phoenix Foundry for £2,700, provided Hick Hargreaves cleared 'all the machinery away'. The directors agreed that the Phoenix Works should be 'disposed of' and responsibility for the sale of this

surplus capacity was placed in the hands of the Chairman, who was empowered 'to get the best possible offer'. By the time of the next Ordinary Meeting in February, 1900, the new Boiler department was 'rapidly approaching completion, practically the whole of the buildings being completed & the whole of the new machinery delivered, the bulk of it fixed up & in working order'. The new Engine Erecting Shop 'with its necessary crane, tools and appliances having been completed and in use for some months past'. Moreover, the buildings and plant damaged by the fire of November 18th., 1898, 'have now been reinstated and replaced advantage having been taken to considerably improve that portion of the Works...both an regards the buildings, motive power and plant'. The Board were naturally 'pleased to state' that the claim for loss made upon the insurance company had proved 'sufficient to cover the loss involved'.[22]

In the Summer of 1900 the 'question of re-valuing the Works, Buildings, Plant etc' arose and led to an inventory of the company being made at a cost of £200. The leasehold land and buildings were valued at £34,452 and the valuers were moved to write that:

> On account of your Leases expiring in 32 years from date we consider it advisable for you to deduct an annual depreciation of £1076. 12 . 4 from the Sectional Value we give you of Leasehold Land & Building in order that they may be completely wiped out at the expiration of the said Leases.

The 'fair value' of the Soho Ironworks in 1900 arrived at a sum of £155,242, which compared with the value of £123,915 arrived at in 1890. The valuation of the works and plant in 1900 was taken into consideration at the next General Meeting when the Directors' Annual Report disclosed a substantial net profit of £21,930. This balance to

the credit of the profit and loss account was further increased by the sum carried over from the previous year's accounts and after a handsome dividend award of 10% the directors' were able 'to place £5,000 to the General Reserve Fund, increasing this fund to £15,000'. The Chairman went on to announce the disposal of the 'Branch Boiler Works in Phoenix Street... owing to the completion of the new Boiler Shops...the proceeds of the sale resulting in a deficiency of £732 . 17 . 5 on the value as shown by the Company's Books'. This disclosure led to a statement on the recent valuation of the company's premises, 'the results of such valuation showing an increase of £36,743 . 14. 6 on the value standing on the books of the Company'. The Chairman went on to declare that the directors' proposed 'to deal with this increased value in the following manner, viz, write off the deficiency on the sale of Phoenix Works, £732 . 17. 5 reduce the amount standing as the value of Patent Rights & Goodwill by the sum of £9312 . 17 . 8 and to carry forward the balance of £26,697 . 19 . 8 as a Special Reserve Fund'. This notional 'balance' of over £26,000 was probably an accurate reflection of the amount of the company's hidden reserve only recently disclosed to shareholders. By 1910, following another valuation of the works premises, which apparently revealed 'an increase of £5,474 ... on the value standing in the books of the Company', the 'Special Reserve Fund' was increased to £32,172, while the 'General Reserve Fund', maintained from credit balances of the profit and loss account, stood in excess of £33,000.[23]

The Special Reserve Fund was rarely mentioned in the Directors' Reports to shareholders. No reference was made to it at the General Meeting held in September, 1901, when additional alterations were under consideration by the directors, which a substantial reserve would help to fulfil. By the Spring of 1902 the cyclical movement in industrial production was well into a downswing and the outlook for orders bleak.

Yet the directors were contemplating 'proposed alterations to Millwright Shop, Pattern Shops, Marine Shop etc', for which the Works Manager was called upon to prepare a detailed report. This envisaged the demolition of the existing structures and their replacement with new machining and erecting bays that would possess three 20 and one 50-ton electrically powered overhead travelling cranes. The Works Manager estimated the cost of the electric cranes to be £4,650 and thought the cost of the new buildings would come to £7,255. The provision of small cranes, tramways and lighting would add significantly to the projected expenditure, raising the total cost of the scheme to approximately £13,755. The Works Manager's report was read at a Directors' Meeting held in August, 1902, and afterwards Mr. Dixon was 'called into the room and explained the plans which he had prepared showing the proposed alterations after which on the proposition of Mr. J. H. Hargreaves, seconded by Mr. Harwood, it was resolved that the alterations etc be proceeded with at once'. This project was the latest in a sustained and thoroughgoing investment in replacement plant and machinery. The reward of this re-modelling programme was established before the recovery of the economy from the slump of 1904 to the boom of possibly the 'most ambiguous of cycles... which reached its peak in 1907'. Neither criteria for a major cycle, as stated by W W Rostow, was met by the 'special case of 1907' because in the peak to peak cycle 1900-1907 full employment was not attained, while 'domestic long-term investment was on a depressed scale throughout the upswing from 1904 to 1907'. These features of the Edwardian recovery and expansion in activity suggest that those who took investment decisions at the Soho Foundry were acting on signals peculiar to the market for stationary engines and led to decisions being taken that were contrary to those taken elsewhere in manufacturing industry. Whatever the directors of the company were aware of their response proved rewarding in terms of company

profitability and the dividends awarded to shareholders. The strong trading performance of Hick Hargreaves evident from 1902-03 culminated in the payment of three successive dividends of 10% in the years 1904-05 to 1906-7 and the award of a dividend of 7 1/2%, together with a bonus of 2 1/2%, in the year ending June, 1908. The Directors' Reports also reveal that the General Reserve Fund grew as a result of the company's profitability, rising from £9,714 at the commencement of the trading year 1902-03 to £35,000 at the time of the Nineteenth General Meeting held in August, 1910.[24]

The blessings of far sighted investment in an up-to-date stock of capital were realised in the Edwardian expansion that peaked in 1907. Never again was Hick Hargreaves, engineers, millwrights and boiler makers, to experience such a prosperous time as these years in the first decade of the century. After September, 1914, the General Reserve Fund stood at £10,000 reduced by £5,000 in order that a net debit on the profit and loss account could be offset. This was in contrast to the Annual Report for the year ending June, 1910, which reported that there had been a slight reduction in the reserve to over £33,000, so that the net profit and credit balance from the last account would permit a divident of 5%. The next year resulted in a trading loss, but the substantial reserve allowed a dividend of 2 1/2%. But by 1913 profitability had returned with a net profit of over £5,000 which permitted a dividend payment of 2%, once a further sum of £5,000 had been withdrawn from the General Reserve Fund. Although the Company's trading performance had deteriorated and was variable in its movements on the eve of the Great War, the directors were willing to make dividend awards out of past profits. They probably believed that their enterprise was as well adapted as it could be to generate further high profits, and with them a healthy reserve, whenever the market for

power transmission machinery was buoyant and flourishing. Indeed, when another cyclical expansion reached its peak in 1913 Hick Hargreaves turnover was higher than it had been since the boom of 1908. But after the outbreak of war in August, 1914, the assumptions upon which entrepreneurial decisions had hitherto been based became less valid with the accelerated development of and dislocations to industrial production at home and overseas.

Within a decade of the outbreak of war many of the objects for which the lengthy restructuring of capacity had been aimed were lost as the market for stationary steam engines and auxiliary equipment contracted. It is poignant how in the final weeks of the Long Peace strenuous efforts were made by the company to secure a licence and manufacture the Breguet condensing apparatus, the 'best in the market' according to the Chairman. Visits to Paris and test workings of this engine apparatus convinced the directors that they should 'make the best bargain' possible, even to the extent of a lump sum award in addition to the payment of royalties. On Wednesday July 29th., 1914, 'The Chairman reported that he had closed with the Maison Breguet regarding the patent Condensing apparatus'.[25]