Leeds Engineering - From the Great Exhibition to the Great War - and its Distinctive Diversity, 1851 – 1918

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Abstract

This dissertation takes as its subject matter the Leeds engineering industry of the later nineteenth-century up to the First World War. This is a topic hitherto neglected by both local historians of Leeds and academic historians of engineering. The dissertation explains the rapid growth of the Leeds engineering industry after 1850 in terms of the diversification of engineering trades. The chapters, both in their narrative and thematic form, analyse the growth and variety in terms of the main drivers of this change, which included population growth to create a local market, growth and change in widening international and imperial markets, and the innovative energy of Leeds engineers in creating new products and methods which, in turn, created new customers and new markets. Within this, imperial markets, particularly the Indian market, were of vital importance for Leeds Steam Locomotive builders. The growth of Leeds engineering is mapped across the latter part of the nineteenth-century to demonstrate movement and change in the usage of premises in South Leeds. The key factor here was that engineering companies were initially located on smaller plots and relied on their proximity to water for power. But, as they became larger, they needed more land and newer rail access to connect them to customers in Britain and especially the British Empire.

The variety of engineering trades practised in Leeds was recognised at the time as being distinctive of the city, hence I analyse the growth in engineering trades both in quantity of companies and in their diversity between 1850 and 1914. However, my analysis extends to 1918 in order to describe the contribution that this diversity of trades made to Leeds munitions production in the Great War, comparing it to the larger more specialist metalworking city of Birmingham. I also explain, for the first time, how the Leeds engineering managers took charge of local munitions production and further analyse the very important and decisive policy influence they had on national munitions production at a critical point in British history.

Finally, I note that the history of Leeds engineering was, when contrasted with, for instance Manchester, remarkably unrecorded and uncelebrated. My dissertation analyses this lack of celebration and commemoration and suggests some reasons specific to Leeds why this was the case. This is particularly

apparent when I compare the statuary in Leeds, Birmingham, and Manchester in chapter 5, indicating each city's elites' different projection of their city and themselves.

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Chapter 1: Introduction.

James Watt Junior's description of Leeds Engineers(1816): -

> "Men without means and without character."[1]

Meysey-Thompson description of Leeds engineering(1882): -

> "Locomotive engine building has for the last fifty years held a prominent position in Leeds – a position in great measure due to the enterprise and energy of Mr. Kitson, whose labours in this direction have continued for nearly half a century. Of late it has received a further development by the introduction of tramway engines. Another branch of this manufacture, that of agricultural machinery, was commenced in 1860 with the introduction of the steam plough and is now one of the most important industries of the town." [2]

1.1. Overview

My dissertation provides the first scholarly account of the historic breadth and variety of engineering activity in the city of Leeds. I do this first by explaining its rapid growth and its diversification in the period after the Great Exhibition of 1851 and then analysing the city's engineering industry's consequent capacity to make a major contribution to the diverse demands of British military manufacturing during the First World War. Before rounding off the dissertation with a brief epilogue, I suggest some Leeds-specific characteristics to explain why the history of Leeds engineering has hitherto been so little addressed in much of the relevant historical literature. The two contrasting quotations above highlight in the first quote how poorly regarded the quality of early Leeds engineers and their products were by an angry JamesWatt (Jnr) to his father,the 'figurehead' for the steam age and the second quote showing the high level of engineering and commercial achievement evident in the prosperous Leeds engineering

[1] Kilburn-Scott, *E. Matthew Murray Pioneer Engineer: Records 1765–1826*. p.42. James Watt (Jnr.) to Watt (Sen.). This comment specifically references the disagreement between Boulton and Watt at the Soho Foundry in Birmingham and Matthew Murray at the Round Foundry in Leeds concerning an alleged breach of Watt's steam engine Patent by Murray and Watt's jealousy about the superior design and quality of finish achieved (by David Wood) in Murray's Leeds Foundry.

[2] Meysey-Thompson, A.H. *On the History of Engineering in Leeds.* Proceedings of the Institution of Mechanical Engineers. (1882) p.271.

industry of the 1880's written by the important and ubiquitous Leeds engineering figure of Meysey-Thompson.

There is a valuable account of Leeds engineering history up to 1850 in Gill Cookson's*TheAge of Machinery.* In the relevant secondary historical literatureon Leeds civic history, the history of textiles, the history of engineering and that of British industry in general,[3]historiansgenerally pass over the case of Leeds without comment on, or explanation of the substantial growth of engineering in Leeds between 1850 and 1918. However, by bringing together elements of these different genres of history and adding primary sources on engineering history, I provide a narrative to explain the keycharacteristics of the development of Leeds engineering. These developments emphasise the contrast between the early Watt family's personal criticism of Leeds engineers and the Meysey-Thompson quote from 1882 detailing Leeds engineering's diverse and growing contribution to the national engineering economy.

I have structured the thesis to show in this chapter, via detailed maps, the geographical expansion of engineering activities in Leeds across the period 1850-1914. Then, using the Great Exhibition of 1851 as a starting point for expansion of engineering in Leeds Chapter 2 examines the contrasts between the central committee expectations for the exhibition with how it was presented locally in Leeds. This chapter also looks at howa small group of influential Leeds engineers chose to present themselves at the Great Exhibition. Chapter 3 analyses the expansion of engineering in the second half of thenineteenth-century in response to growing local population and widening national and international markets. Chapter 4 explains the variety of engineering activity, in the Hunslet engineering 'hub' in the latter decades of the nineteenth-century, and the early twentieth century.

Chapter 5 describes the variety of engineering trades in Leeds before the Great War and suggests some reasons why Leeds engineering history and its engineers have been uncelebrated. The chapter compares Leeds engineering with that in Bradford and Newcastle upon Tyne; a comparison which identifies Leeds's diversity of engineering trades as distinctive. Chapter 6 reveals the hitherto unacknowledged but

[3]See Chapter 2, p.30-58. Also, literature such as: - Briggs,A. *Victorian Cities (*1963), Fraser,D. (ed), *A Modern History of Leeds* (1980), Hahn, B. *Technology in the Industrial Revolution* (2020).

significant influence that leading Leeds engineers, especially Bernal Bagshawe at Leeds Forge, had in shaping national munitions policy. Chapter 7 shows the level of engagement in wartime munitions production in Leeds and gives it perspective by comparing it with Birmingham.

By structuring the chapters in this way, I establish the three reasons why engineering in Leeds grew and varied across the period that I study: the rapid growth of population and the metalworking and machine-building it stimulated; the widening national and imperial/international markets that presented themselves; and the high level of innovation in Leeds engineering which created new customers and new markets. Many important Leeds engineers, such as Meysey-Thompson, Joshua Buckton, Sir Peter Fairbairn, Thomas Greenwood, Samson Fox and Bernal Bagshawe, appear in this narrative and I suggest reasons why so little is recorded of them in either local civic history or the history of British engineering. Samuel Smiles, a Leeds resident for twenty years and an active author into the 1890s passed over all these men often in favour of those in other places and of other ages. For example, in *Lives of the Engineers* (1862), he gave John Smeaton half a volume, with Rennie (d.1821), then Boulton (d.1809) & Watt (d.1816) and both the Stephensons (George d.1848, Robert d.1859). In his *Invention & Industry* (1884) he praised Murdock (d.1839), Watt's assistant and Watt (d.1816) again as the inventor of the condensing Steam engine. [4]

Chartres &Honeyman in *Leeds City Business*(1993) write that by 1893 Leeds had developed into one of the largest concentrations of industrial activity in the country.[5]They do not, however, discuss reasons for this growth and variety of engineering trades. As a valuable contemporary source, the Leeds Chamber of Commerce recognised in 1893 and again in 1902, that engineering in the city had 'Diversity' and 'Variety' in the many different engineering activities flourishing in the city. Also, at a mid-point in the period, Arthur Herbert Meysey-Thompson -- an engineer and perhaps the only historian of Leeds engineering over the last 140 years -- in his speech to the 1882 Institution of Mechanical Engineers in Leeds described how many and various were its engineering interests. His table from the speech is given

[4] Smeaton, as a Leeds born engineer published much of his work and therefore became better known and connected than many other Leeds engineers.

[5] Chartres &Honeyman, *Leeds City Business 1893 – 1993*. p.14.

in the text below. [6] Whilst the Meysey-Thompson list was not an exhaustive examination of engineering in the city, it shows that he understood Leeds engineering as unusually varied and, in this respect, Meysey-Thompson is an excellent example of the rise of the engineer to public notice and of the growing expertise of the Leeds group of engineers. He was from a well-connected, landed family in the North Riding; very much part of the 'county set' and very well educated. It's a measure of the development of engineering into a profession that Meysey-Thompson's activity as a qualified engineer and director of Hathorn Davey in Leeds was seen as both acceptable and respectable in wider society. The same could be said of Sir Charles Parsons, inventor of the steam turbine who did much of his development work when at Kitsons in Leeds Meysey-Thompson is a figure who was active in Leeds engineering throughout the period and is a key personality in Leeds' rapid response to the munitions crisis in the early months of the Great War; accordingly he appears at multiple points in this dissertation. [7]

Whilst there are works which address the earlier influences on engineering development in Leeds, descriptions tend to miss the period of greatest change -- that of the post-1850 steam-driven expansion. In her recent work on the role of northern textiles manufacture in the Industrial Revolution, Barbara Hahnhas described the nation's long process of incremental industrial and commercial development and mentions Leeds frequently in the years before 1850. [8]However, she touches on engineering only in passing and like Cookson, ends her work at the century's mid-point. The part played by Leeds has only occasionally been addressed in the histories of nineteenth-century British industry and is usually given a role supporting the main actors like Manchester, Glasgow and Birmingham. For example, Asa Briggsgives Leeds its own chapter but only describes the building of the Town Hall in the 1850s.[9] It is not as though Leeds has been written out of the record; it has just never been properly written in! Population growth and commerce, then population growth and industries feeding off each other fuelled engineering growth in the latter half of the nineteenth-century. This growth was encouraged by the

[6] Leeds Chamber of Commerce *Day Books from 1885 -95 and 1895 -1908*.

[7] For reference to Kitsons see: - Kilburn-Scott,E. *Genesis of the Parsons Steam Turbine.* Distribution of Electricity (Vol. XI p.209-16. March 1939.

[8] Hahn, B. *Technology in the Industrial Revolution.* (2020).

[9] Briggs, A. *Victorian Cities.* (1963).

widening markets that became available and were given new energy and breadth by the considerable level of engineering innovation undertaken in Leeds.

Gillian Cookson's *The Age of Machinery* identified Leeds as a fertile seedbed for industrial growth towards the close of the eighteenth-century and described its early development in the first decades of the nineteenth-century based on textile machinery production, comparing Leeds and Keighley. [10] It describes these early days in some detail and identifies textile machinery making as the driver of engineering development. Cookson took the midnineteenth-centuryas a point of national change and decline relative to international competition and particularly one of relative decline of textile machinery making in Leeds. [11] Extending beyond the existing Cookson narrative for the first half of the century, my dissertation gives a description and explanation forLeeds engineering's rapid growth, describes the distinctive diversification of engineering in Leeds in the second half of the nineteenth-century and,using primary sources, I reveal Leeds engineers' influence on national policy and Leeds engineering's quantitative contribution to the war effort in 1914.[12]

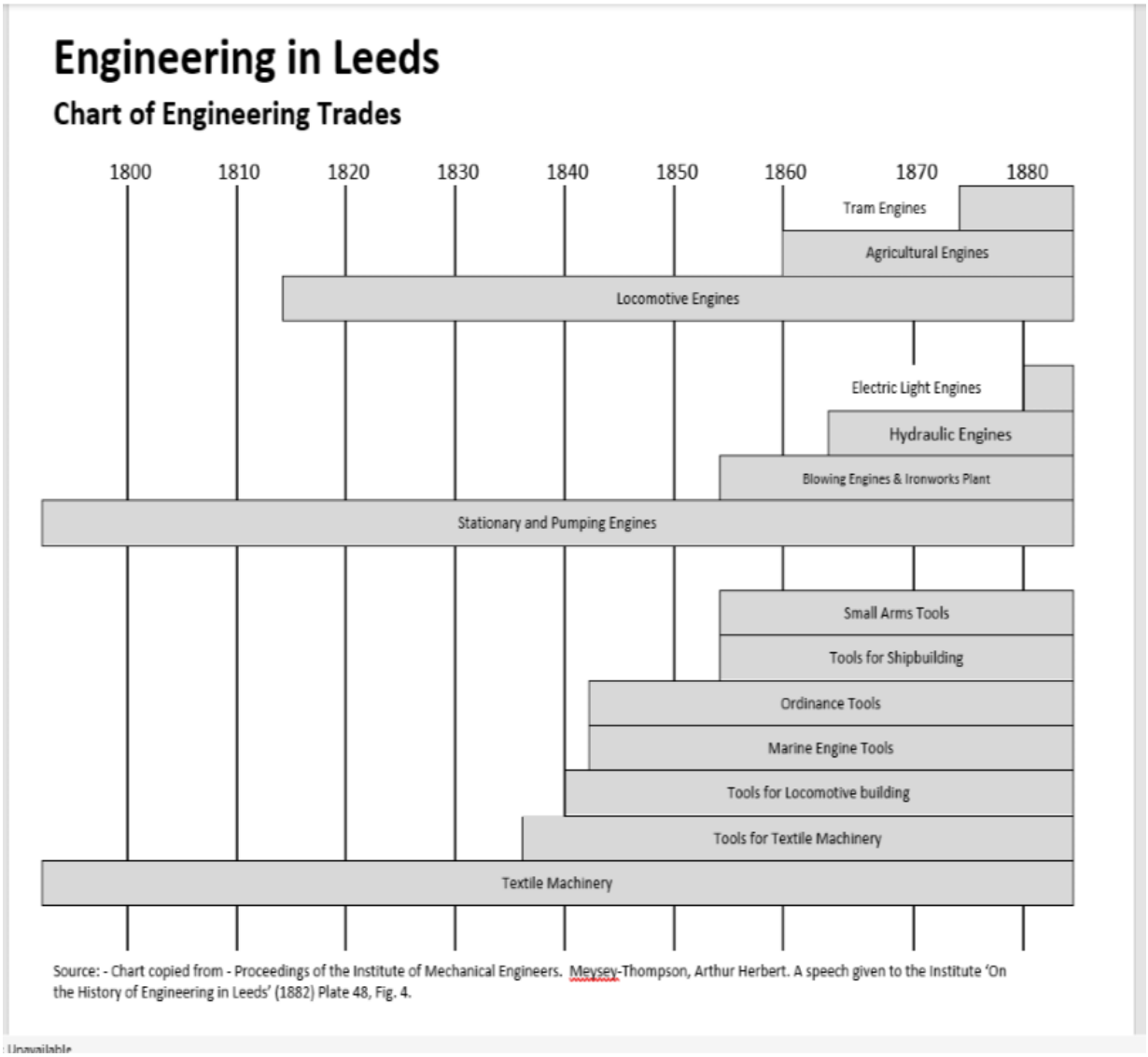
For Leeds engineering, this was not a point in any respect of decline, but a jumping off point for large scale growth, with the rapid expansion of locomotive steam engine manufacture and all its supply chain implications for engineering diversity. With the presence of Taylor Wordsworth in Water Lane and the rapid growth of Fairbairn Lawson, I find no decline in textile machine making as suggested by Cookson but given the rapid growth in other engineering fields, its decline may be described as relative. I take the example of Leeds involvement in the Great Exhibition as a description of a turning point for industry in Leeds and particularly, for engineering. In contrast to Auerbach's *The Great Exhibition of 1851, A Nation on Display*, and its London-centric account of the exhibition's creation, goals and outcomes, I offer a fresh Leeds-based perspective. I do this by using reports in local newspapers that showed how the often London-centric objectives of the exhibition were tailored to local Leeds requirements and sensitivities.

[10]Cookson, G. *The Age of Machinery, Engineering the Industrial Revolution 1770-1850.*

[11]Cookson, G. *The Age of Machinery, Engineering the Industrial Revolution 1770-1850* p.258-9.

[12]Edgerton,D. *Science, Technology and the British Industrial 'Decline' 1870-197*0 (1996) although starting in 1870 reinforces this view of relative decline.

To support the contemporary views from sources which demonstrate engineering in Leeds being 'diverse' and varied, I give brief comparisons between Leeds and both Bradford and Newcastle upon Tyne to highlight the differences in engineering activities between Leeds and towns (later cities) standardly interpreted as 'single industry' locations.



(Figure 1)
From a speech by: -Meysey-Thompson, A.H. *On the History of Engineering in Leeds (1882).*

Data from Meysey-Thompson in Figure 1 above gives a top-level view of the range of engineering activity current in Leeds in 1882 and a clear indication of accelerating diversification during the second half of the nineteenth-century. Here, as Cookson shows, textile machinery was the starting activity along with stationary steam engines for power and pumping. This was followed by Murray's locomotive steam engine. The skills gained by apprentices in Murray's foundry enabled them to develop a variety of engineering products, especially in the latter part of the century.

In spatial terms, engineering activity in nineteenth- century Leeds was located mostly in the Holbeck and Hunslet districts, south of the River Aire. I give below, for orientation purposes, a schematic map of Leeds showing Ward names from 1885.

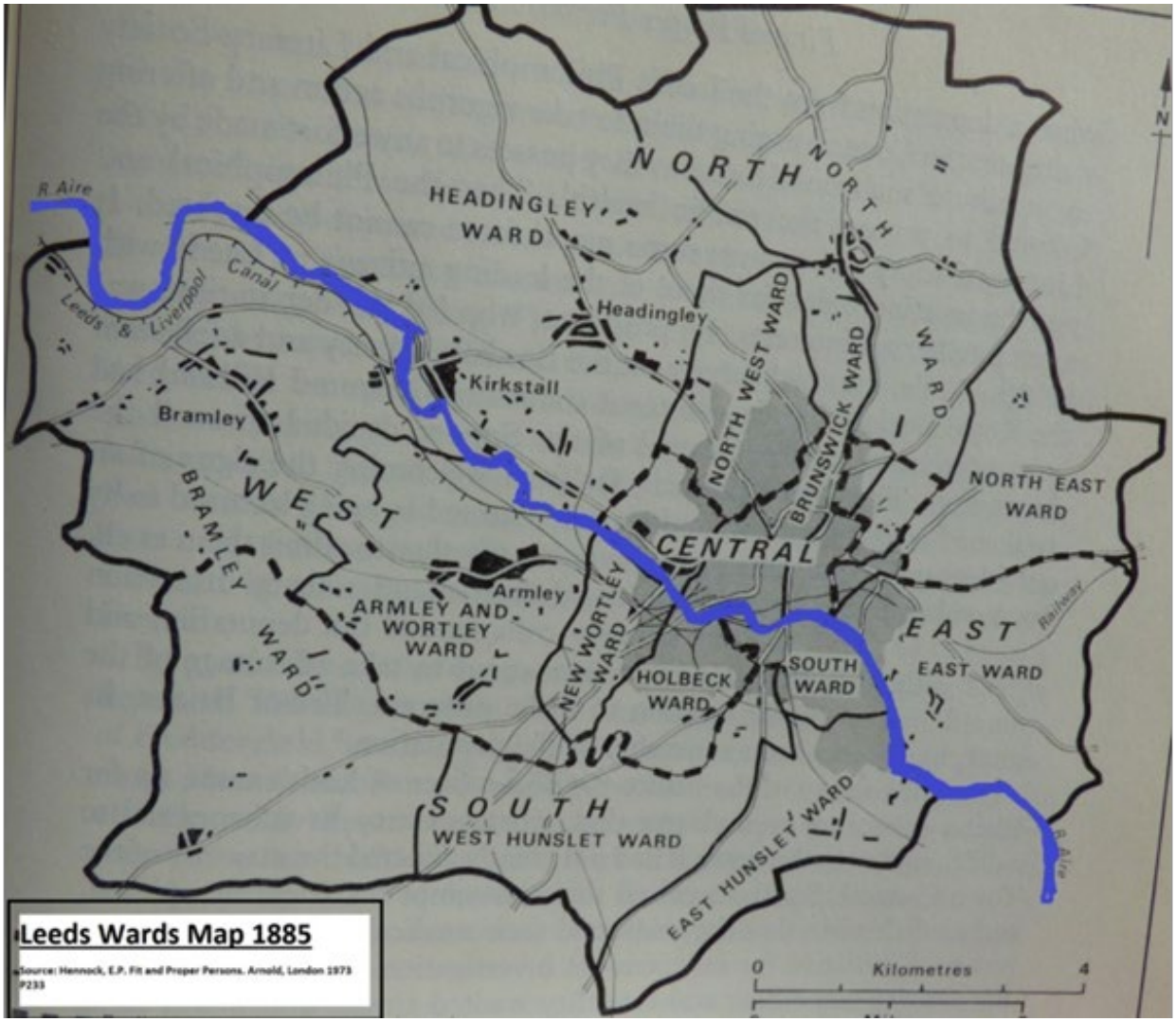


Figure 2**:** Map to show Leeds Wards North and South of the River Aire in 1885.
Source: Hennock, E, P. *Fit & Proper Persons* p.223.

To illustrate the growth of engineering in Leeds and to highlight the development of the 'Hunslet Engineering Hub', I show three maps below. These have been created using the data painstakingly accumulated by E. J. Connell for his 1975 PhD Thesis, *Industrial Development in South Leeds 1790-1914*. Using Rate Book information from the City Council archives, his thesis identifies each industrial premises south of the River Aire, who owned or used it, the industrial use to which it was put and its changing ownership and use across the century to 1914. Using Connell's local map segments and their accompanying building-specific text, I take 1820 to contrast with the much-widened level of activity shown in 1860 and 1900 as a further contrast with 1860, showing engineering growth and movement before the Great War.

I map the appearance of new industrial premises categorised as ‘Engineering’, ‘Textiles’, ‘Clothing’ and ‘Other’, as well as any change in their use and in some cases, their subsequent disappearance over the century. This gives a graphical representation of industrial growth and change in Leeds during the nineteenth-century and highlights the growth and spread of engineering over the century.

The tables and charts below show the general growth of industry in south Leeds where, in the 80 years between 1820 and 1900 (the years analysed in Connell’s 1975 thesis), the number of industrial premises had doubled. In addition, the charts show the rise of engineering sites to a point of pre-eminence (by number), the relative decline of the textile trades, and the first appearance of the relatively new garment trade south of the river mostly in repurposed woollen textiles premises.

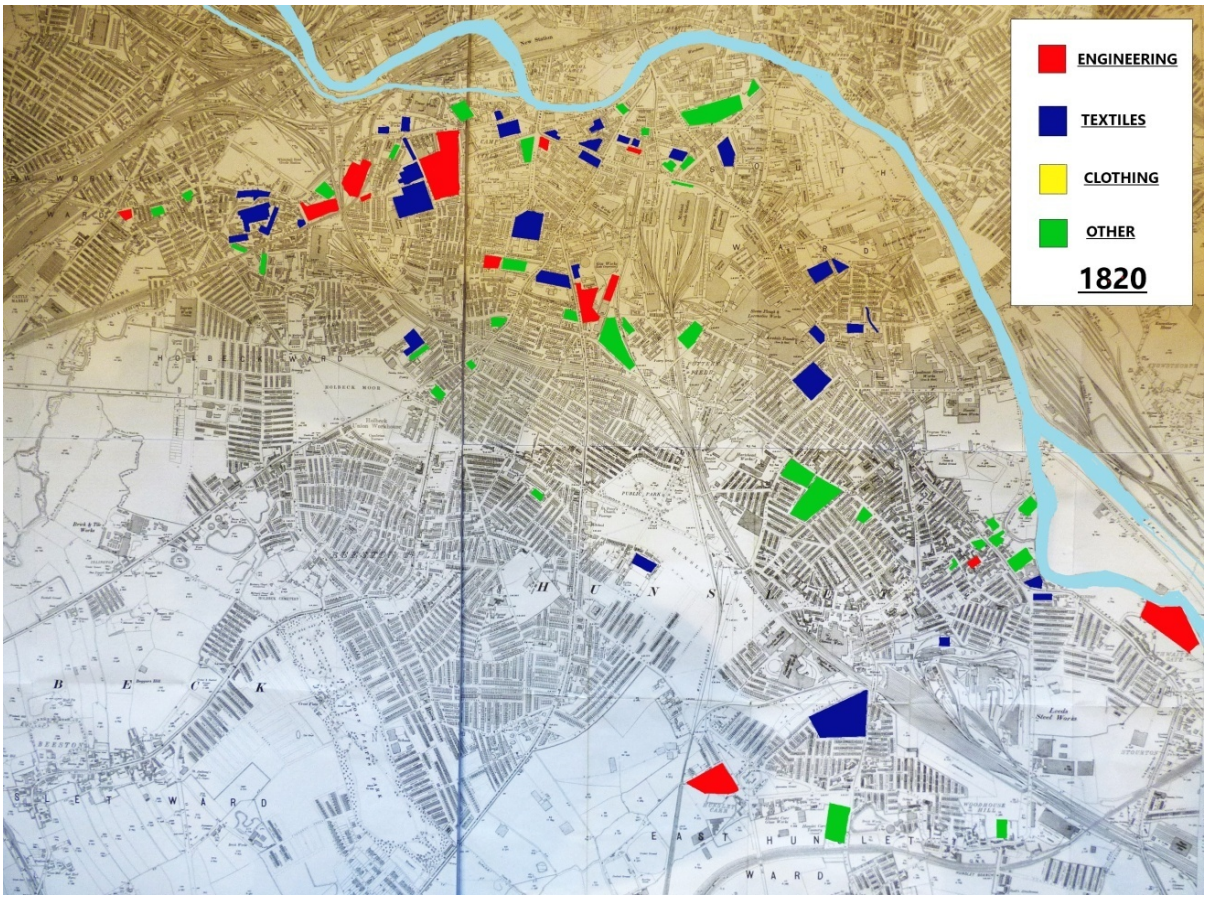


Figure 3:Map to Show Distribution and Usage of Industrial Buildings South of the River Aire in 1820.Data Source: - Connell, E.J. *Industrial Development in South Leeds 1790-1914,* PhD Thesis, University of Leeds, 1975 (using 4 Ordnance Survey maps 1:25,000 1905/6)

The map for 1820 shows a sparse number and a widespread scatter of small industrial premises south of the river. These were set in a largely rural landscape of gardens tofts and pasture. The main use of individual buildings was in textile manufacturing alongside a variety of pottery, glass, brick, chemical and dye works, all of which were small-scale and often exploited the presence of local becks, i.e. Benyons Beck, Balm Beck and the Hol Beck, not always for motive power. Prominent as engineering sites are Gothard's Foundry by the 'Mineral Railway', bringing coal from Middleton to the coal staithe at Leeds Bridge, and Murrays Round Foundry on Water Lane, close to the growing number of Marshall's flax spinning and weaving buildings. The Brewery (shortly to be bought by Tetley) is shown South of Leeds Bridge, but the land to its east is undeveloped and awaits the construction of Crown Point Bridge (in 1842), and the subsequent layout of Black Bull Street, Chadwick Street and Saynor Lane. In 1820, none of the railways existed that the1906 set of maps used as a base. At that time, Leeds was only connected to York by railway, its terminus being at Marsh Lane, off the map to the northeast. The main population centre was the city centre north of the river,and the only significant roads south of the river were Hunslet Road, Hunslet Lane, Water Lane, Meadow Lane, Dewsbury Road and Low Road. Much of the existing machine-making and castings businesses were located north of the river in the school close area, York Street, Mabgate, East Street, and the Bank and Steader areas. Nearly all of these were very small scale.

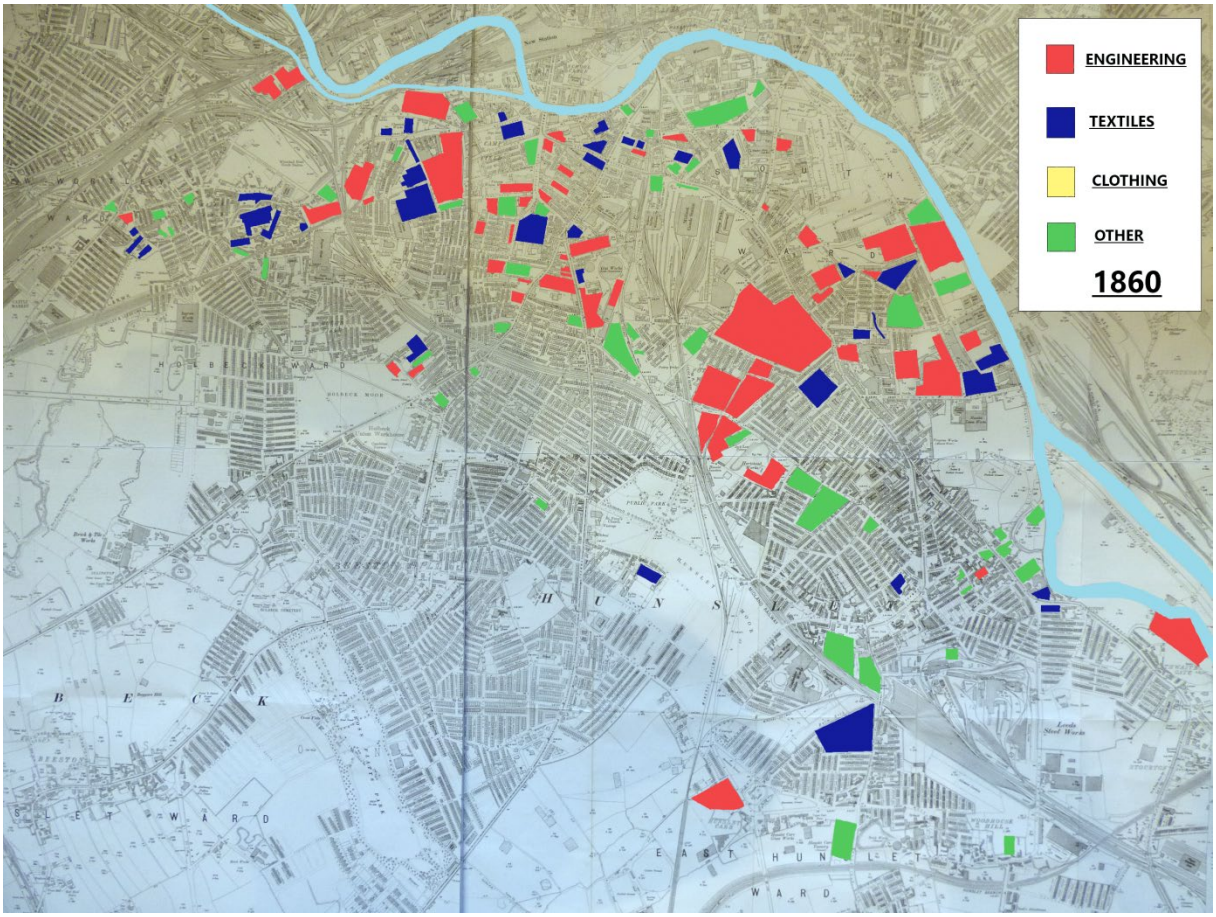


Figure 4: Map to Show Distribution and Usage of Industrial Buildings South of the River Aire in 1860.Data Source: - Connell, E.J. *Industrial Development in South Leeds 1790-1914,* PhD Thesis, University of Leeds, 1975 (using 4 Ordnance Survey maps 1:25,000 1905/6)

Forty years later, in 1860, the physical layout of Holbeck and Hunslet had changed radically. Holbeck had filled up with commercial and domestic premises. Large quantities of housing --largely the classic Leeds back-to-back -- had begun to fill in spaces between industrial premises. The influence of the Crown Point Bridge development can be seen in the eastwards movement of industrial premises. The area around Black Bull Street shows a growing number of industrial premises and many riverside locations had been exploited below Crown Point Bridge. The size of many of these businesses, especially the ones either side of the suspension bridge across the Aire at South Accommodation Road and in the growing Hunslet Road/Jack Lane area, were much larger in acreage than those in Holbeck.This represented the increasing availability of better connected land for more capital-intensive businesses as Leeds engineering exploited the opportunities presented by steam power and the railways. Many of the larger concerns in the flat land of this central area of Hunslet had their own sidings and access to the Midland mainline railway, instead of the original benefit (in Holbeck) of a river or canal-side location. The table below

shows that engineering had, by 1860, outstripped textiles in the area by number of premises, although the occupational statistics for 1861 show that textiles industriesstill employed 28,000 people as compared to 12,000 employed in other forms of engineering.

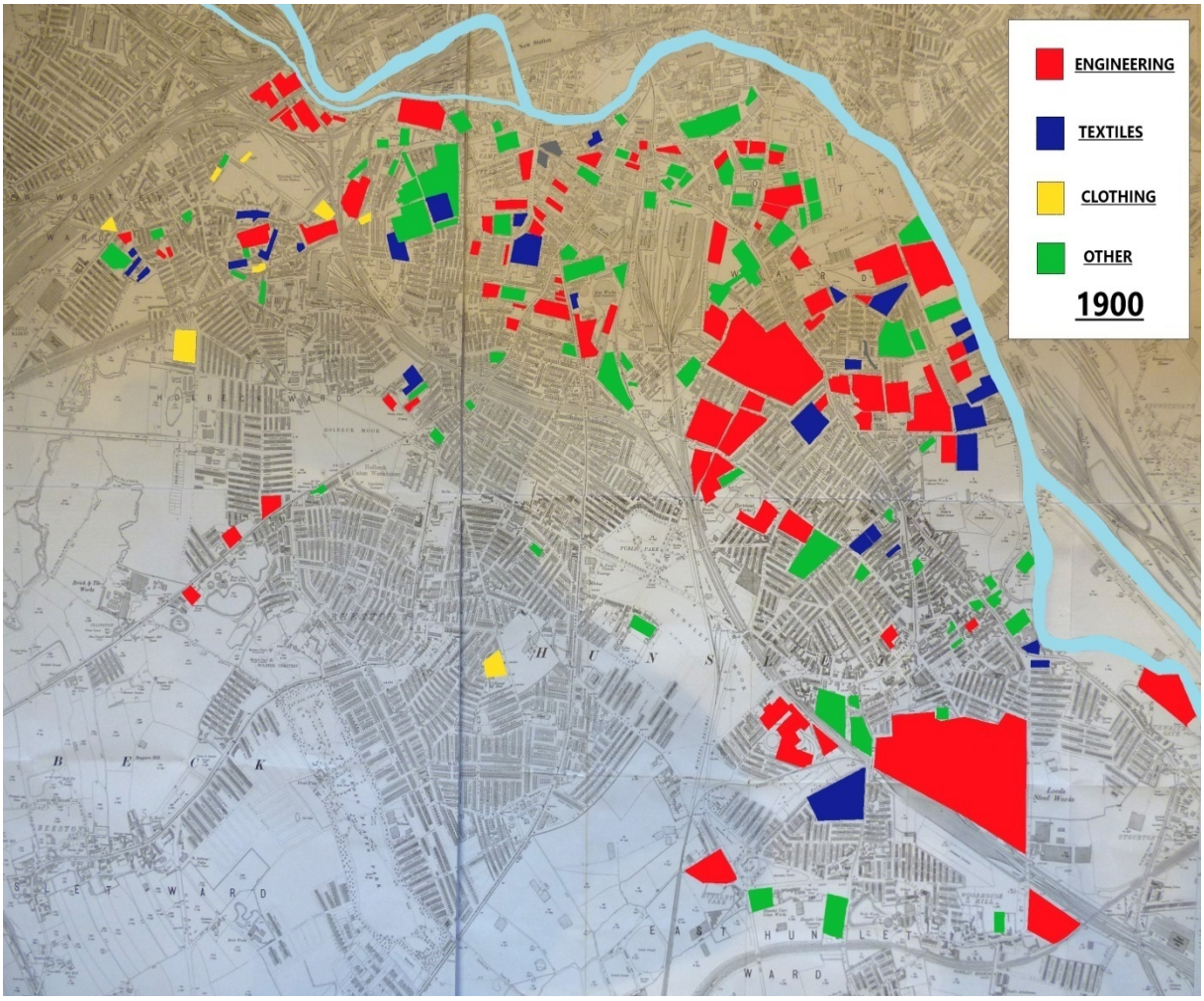


Figure 5**:** Map to Show Distribution and Usage of Industrial Buildings South of the River Aire in 1900. Data Source: - Connell, E.J. *Industrial Development in South Leeds 1790-1914,* PhD Thesis, University of Leeds, 1975 (using 4 Ordnance Survey maps 1:25,000 1905/6)

By 1900, the map shows further engineering development down the eastern side. Notable is the establishment of the Leeds Steelworkson a very large site at Stourton by the Scott family of Newcastle.[13] With Holbeck now fully developed and encouraged by the Hunslet Steam Engine 'hub', much engineering infill had taken place in the South Accommodation Road area. A further development is evident in the western part of the map that shows the appearance of clothing manufacturers. The ready-made clothing industry started on available land north of the river and spread into the northern and eastern suburbs. These firms expanded rapidly north of the river but, as

[13]Established in 1862 by Joseph Ledger and sold to the Scott family of Newcastle-upon-Tyne in 1889.

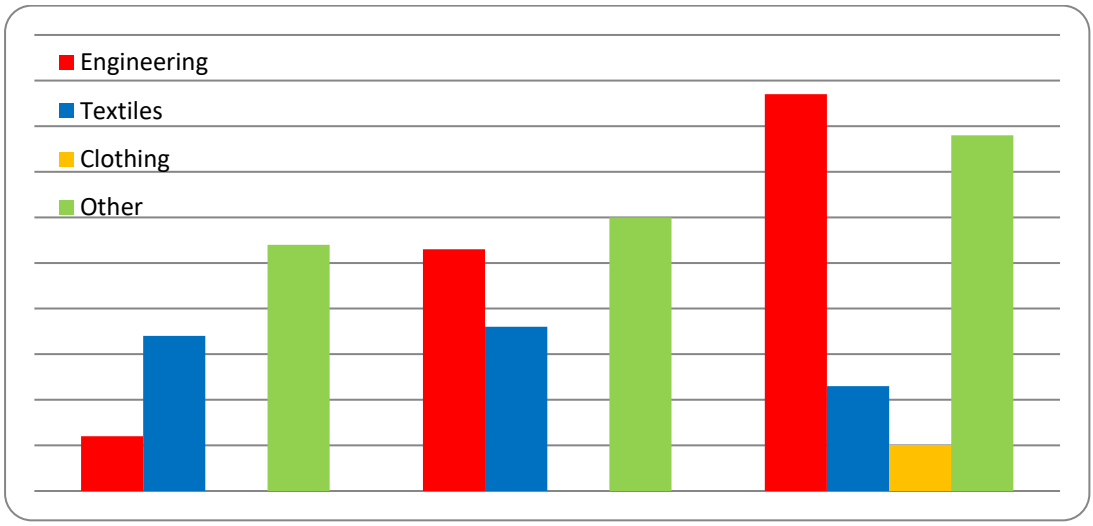
the industry was new and the cost of entry relatively low, they also used and re-used smaller premises south of the river. In some instances, these were based in former textile manufacturing premises.

According to 1901 data, the number of people employed in engineering (28,000) had by 1900 far exceeded those employed in textiles (18,000). Additionally, the number of engineering premises south of the river has absolutely exceeded all other industries.

Also, both maps of 1860 and 1900 show on their northwestern edges the establishment of significant works, including Fairbairn Lawson's Wellington Foundry on Kirkstall Road and the extensive Armley works of Greenwood & Batley next to Samson Fox's Leeds Forge on the south side of the river. Although south of the river Aire and central to Leeds's engineering growth, these premises have not been included in the Connell Thesis.

Industrial Building Usage in South Leeds

(Figure 6)



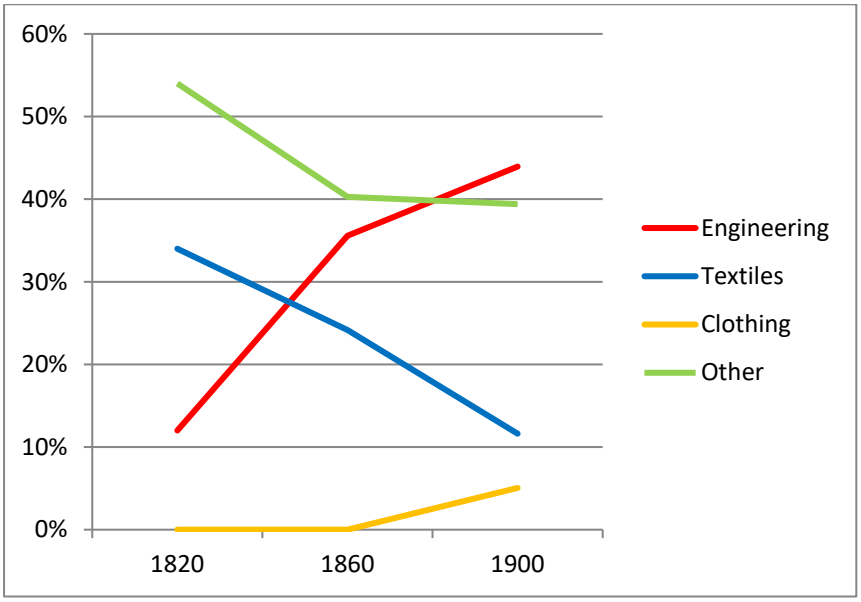
Data tabulated from: -Connell, E.J. Industrial Development in South Leeds 1790-1914 PhD Thesis, University of Leeds, 1975.

Quantity

	Engineering	Textiles	Clothing	Other	Total
1820	12	34	0	54	100
1860	53	36	0	60	149
1900	87	23	10	78	198

%

	Engineering	Textiles	Clothing	Other
1820	12%	34%	0%	54%
1860	36%	24%	0%	40%
1900	44%	12%	5%	39%



According to the map, by 1900 newer, larger firms emerged, supported by several smaller firms that supplied them with castings and other components and benefiting from a large local pool of labour which had by then become very familiar with engineering trades. The maps clearly indicate the movement of engineering industry as growing companies established themselves on newly available land to the east and south. For example, Grimshaw's Nail Works, established in 1867 in Sykes Street (off York Street), moved to larger premises south of the river Aire in Pym Street. Joseph Kaye (lock makers), established in 1868, moved from Kirkstall Road to larger premises in South Accommodation Road on the canal bank in 1884.[14]The 1900 map also shows the arrival of the much smaller, start-up clothing firms which moved into small, available buildings at the western end of Holbeck.

As the Leeds Chamber of Commerce recognised in 1893 and 1902and the Meysey-Thompson list from 1882 and the maps showed the size and diversity of engineering activity in Leeds grew and moved significantly.This provides a strong stimulus for further enquiry into the development of engineering in Leeds in the latter half of the nineteenth-century and to 1918.

It is important to emphasise that my choice of extending my analysis to the end of the Great War is influenced by the rather noteworthy, early and energetic response in Leeds during the war. Leeds engineering responded with a mixture of technical competencies and management energy and

[14]Connell, E.J. *Industrial Development in South Leeds 1790-1914*. PhD Thesis, University of Leeds, 1975. p.180.

enterprise, particularly on the part of Bernal Bagshawe of Leeds Forge who, at an early stage in the war, took proposals to the Central Government. TheLeeds engineer's proposals for organising engineering and munitions precededany structured government response to an industrial war and, as I will show in Chapter 6, the proposals also significantly formed the government's response to the war. [15]

The order of the following chapters provides a narrative framework in which the arguments for Leeds engineering growth and variety are supported by primary and secondary documentary material, and contemporary evidence and opinion. My dissertation starts with the Great Exhibition.I show that despite their small presence there the Leeds engineers managed to expand the Leeds engineering sector in the following decades by producing and exhibiting items – Locomotive Steam Engines, Machine Tools, Hydraulic Pumps, Railway Axles, Bridging Girders and Flax machinery that were in demand in local, national and international markets.

[15]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*. p.24. Also, Scott, W.H. *Leeds in The Great War.*p.182. and *History of the Ministry of Munitions* Vol X, p.80. Scott gives no individual names. The Ministry of Munitions History references Leeds Forge rather than its Chairman, Bernal Bagshawe.

1.2. Literature Review

While Leeds appears in city histories and in histories of textiles, engineering and nineteenth-century British industry in general the history of Leeds engineering is an unexplored area. By drawing relevant detail from these different literatures this dissertation seeks to produce an explanatory narrative for the growth of engineering in Leeds, from its great expansion after 1850, the unusually distinctive character it achieved by the outbreak of theFirst World War, and its subsequent engineering-based contribution to munitions output during the First World War.

Despite covering several historical aspects, city histories, particularly those by Burt and Grady do not address the industrial change in nineteenth-century Leeds. [16] Engineering in Leeds only appears in passing in social histories and several theses which examine issues concerning late eighteenth and early nineteenth-century Leeds, such as the social standing of the town's woollen merchants and broader issues of education, poverty, sanitary development, food supply, civic development and religious affiliations.Local Leeds literature contains many volumes which deal in fine detail with, for example steam locomotives, their design, wheel arrangements and worldwide destinations. Works such as Davies 'et al' *The Monk Bridge Iron Works*, Pease, *The History of J & H McLaren of Leeds*, Redman's, *The Railway Foundry* provide company-specific narratives. These works do not contain a wider appreciation of the growth of Leeds engineering through the nineteenth-century.

Economic historians have also written about Leeds; particularly Prof. Rimmer and his vignettes for the Chamber of Commerce yearbooks in the late-1950s and early 1960s. These gave brief overviews of the history and development of several Leeds industries. Although very useful for this work given the detail they often contain, none of these were worked up into a fuller analysis (although his work on Marshalls Flax Mill and Flax in Leeds is a notable exception). Grady's article*, The Cattle and Meat Trades of Leeds 1780 – 1900* (2000) gives a valuable insight into the leather and tanning trades which, in their turn,

[16] i.e. *An Illustrated History of Roundhay Park*, Burt (2000), *An Illustrated History of Leeds* Burt & Grady (1994), *The remarkable Story of Hunslet*, Burt (2004), *A History of Kirkgate,* Burt & Grady (2016).

provided further opportunities for Leeds engineers. [17] Population growth was a stimulus for this and many other engineering outputs. Rimmer's vignettes on the printing industry in Leeds describe similar opportunities for variety in engineering. [18] The digital access to newspapers has also provided an interesting, if uneven, window into the nineteenth-century world of Leeds engineering.

The history of textiles is bound up with the origins of engineering in Leeds. These early origins are not dealt with in my dissertation, but reference may be made to Barbara Hahn's *Technology in the Industrial Revolution*. Her approach reflects developments in Leeds, which are referenced frequently in the initial stages of the 'industrial revolution'. It is a book about 'systems and networks and the (pre-existing) world that got the machines running'.[19] Hahn's work sets the scene and describes the parameters within which the industrial revolution took placebut her work stops short of the later, post-1850 growth of engineering in the city.

Like Hahn, Gillian Cookson in *TheAge of Machinery, Engineering in the Industrial Revolution, 1770-1850,* takes a similar view of the parameters and the inconsistent progress of change. It is this work that looks in great depth at the development of engineering in Leeds via its origins in manufacturing textile machinery. By taking examples from Keighley and Leeds as centres of this enterprise, Cookson provides a much more detailed view of the machinery suppliers in these two towns. In her introduction, Cookson places textile machinery at the centre of industrial development rather than 'invention' and asserts that this is a much under researched view. [20] Echoing Hahn, Cookson argues that the textile machinery industry already existed but took decades to gather pace, using craft methods for bespoke outputs. [21] The fledgling engineering industry added to the impetus for improvement in techniques and is seen by Cookson as a support for, and an enabler of textile machinery making. [22] Whilst it is true to say that manufacturing textile machinery was the main activity of engineering firms in Leeds (a description not

[17] Grady, K. *The Cattle and Meat Trades of Leeds 1780-1900*. Northern History XXXVII Dec. 2000. p.133-155.
[18] Rimmer, W.G. No.29 *Printing and Printing Machinery*. Leeds Journal 1959 (Journal of the Leeds Chamber of Commerce).
[19] Hahn, B. *Technology in the Industrial Revolution* (2020) p.1.
[20] Cookson, Gillian. *The Age of Machinery. Engineering in the Industrial Revolution. 1770-1850*(2018) p.1.
[21] Cookson, Gillian. *The Age of Machinery. Engineering in the Industrial Revolution 1770-1850* (2018) p.8-20.
[22] Cookson, Gillian. *The Age of Machinery. Engineering in the Industrial Revolution 1770-1850*. (2018) p.29.

yet in general use for the activity), their attention was quickly directed towards the opportunities presented by steam power and the development of 'self-acting' (or 'machine') tools to manufacture accurate goods.

Cookson describes the development of early engineering solely through the prism of those manufacturing textile machinery. In doing so she presents Matthew Murray, who can be rightly regarded as the father of Leeds Engineering almost entirely as a maker of textile machinery even though his lasting legacy is his production of Locomotive steam engines most notably 'Salamanca' (1812) for Brandling's Middleton pit and its mineral railway. Cookson's description of Leeds centres on Murray at the Round Foundry, Stirk at Timble Bridge, Taylor Wordsworth in Silver Street, and Lawson in Mabgate. Whilst this list of textile machinery makers is accurate, it is clear that even by the 1830s, engineering in Leeds was already much broader especially with the arrival of new metals, lubricants and bearings benefitting the growing number of enterprises in foundry work, brass moulding, copper tubing, component making and rolling mills that supplied parts for the widening Leeds manufacturing base. Although detailed documentary evidence for this variety may be harder to find in Leeds at this time it may repay further research. I argue that by 1850 the Leeds engineering landscape looked very different from the one described by Cookson.

Cookson describes engineering at the start of the century in Leeds but suggests textile machinery making as 'winding down' by 1850, thus missing the great acceleration in engineering from the late `1840's onwards. In her first chapter,Cookson includes details from the 1907 census of production, which cites textile machinery manufacture as the single largest branch of engineering in the country and that these manufacturers represented an 'overwhelmingly dominant force in world trade' (almost entirely the 'big 6' in Lancashire; Platts in Oldham being the biggest).[23]By 1907, the next bigger manufacturers were Fairbairn, Lawson, Combe & Reid in Leeds. Despite Cookson's correct assertion of the size of the textile machinery manufacture, she chooses 1850 as a stopping point in her analysis as it, in her view,

[23] Cookson, Gillian. *The Age of Machinery. Engineering in the Industrial Revolution 1770-1850*. (2018) p.11.

represented a decline in textile machinery making in Leeds. She writes of a changed atmosphere amongst machine makers in Leeds, one 'devoid of radical possibilities' and with collapsing personal networks, thus implying decline. [24] I will show that these networks still existed and the transfer of knowledge between firms and across the generations of engineers was further amplified and fuelled by interests in steam rather than solely in textile machinery at a time when the whole of Leeds industry, following the Great Exhibition, was increasingly alert to the huge potential of world and imperial markets.

In a history of nineteenth-century engineering in *Technological Change: The United States and Britain in the 19th Century* (1970), S.B. Saul references Leeds engineering, but only in the context of the national machine tool industry. In *The British Machine Tool Industry 1850* – 1914. (1976) R. Flound explores the Greenwood & Batley archive in great depth, but again only draws out data for machine tools. In the many accounts of nineteenth-century British Industry Leeds has a walk on part behind larger British cities. In Asa Briggs's *Victorian Cities* (1963), Leeds has a chapter to itself, but it concentrates almost entirely on the building of the Town Hall and is scattered with references to Bradford. In Rolt's, *Victorian Engineering* (1974), Leeds is referenced sparsely, for instance, Fairbairn is mentioned in connection with textile machinery, and Fowlers for steam ploughing machinery. In a broad overview of nineteenth-century industrial growth in the UK, none of these references are used to build any larger narrative of engineering activity nationally or specifically in Leeds.

Marsden & Smith's *Engineering Empires* (2005) argues persuasively that imperial power, profit and reach were built through investments in infrastructure and the application of technology, rather than military success.

They use Glasgow as an example of an industrial city and Watt as the source of the steam power that fuelled imperial growth. Though possibly for a Scottish readership, reference to Leeds is entirely absent from the book, where a comparison with Leeds's huge engineering contribution to empire might have been useful for context. Marsden and Smith use Canada as their example of imperial infrastructure

[24] Cookson, Gillian. *The Age of Machinery. Engineering in the Industrial Revolution 1770-1850*(2018) p.258-9.

development, rather than India, where large investments were made in the growing railway network. The growth of the Indian railways proved vital for the expansion of engineering in Leeds in the late nineteenth-century. Leeds engineering sales are discussed below in Chapter 4 and describe a high volume of sales to India. D.R. Headrick's. *Tools of Empire* (1981) emphasises the need for imperial communications infrastructure as a key driver of imperial expansion. The development of steam ships is discussed in 'Part 3: The Communications Revolution' of his book, within which chapter 13: 'The Railroads of India' describes the development of Indian railways, a market opportunity fully realised by Leeds engineering.

Even less has been written about Leeds's contribution to munitions outputs in the Great War and primary sources are, as ever, sparse and piecemeal. *History of the Ministry of Munitions* (1921) in 12 volumes is a very useful source as is Adams's, *Arms and the Wizard* (1978). A rare primary source concerning the creation of the Leeds Board of Management and the setting up of National Shell Factories and the National Shell Filling Factory at Barnbow is Major R. Harrison Archbald's, *Record of the National Ordnance Factories, Leeds 1915-1918* (1919). This may be the only primary source relating to Leeds munitions production. The author worked closely with the Leeds committee, knew them all and made contemporary records of events and actions. Also, but only with specific data about Barnbow is H.R. Gummer's *History and Record of Barnbow Filling Factory* (1919). Drawing some of its data from Archbald, one of the only secondary written sources of information specific to Leeds is W.H. Scott's *Leeds in the Great War* (1923), a valedictory work written in a positive tone covering a wide range of military, medical, social and industrial activities. A chapter in Scott's book is devoted to industrial output and lists Leeds achievements in his Chapter 4. *'Triumphs of Industry' (1923).* [25] Characteristic of the times, he places the sacrifices made, particularly at Barnbow, in a heroic light. Also, he highlights some of the broader engineering contributions made by the web of engineering firms across the city, some of which can be seen or inferred in company-specific records. Chief amongst Scott's highlights is the great triumph

[25] Scott mentions two explosions at Barnbow but in a sub-chapter entitles 'Women's Industry and Courage' the mishaps were glossed over, describing women volunteering to go back into the damaged rooms only hours after the explosions and the Haigh Order of the Day citing this as 'a splendid example of loyalty and determination'- at an un-named location.

of industrial organisation involved in the first National Shell Filling Factory at Barnbow and the National Projectile (shell casings) Factories at Armley and Newlay. Its industrial chapter is short on detail and sometimes inaccurate. I have added to the list of engineering war time activity by referencing secondary, company-specific texts for detail, and primary sources from the Greenwood & Batley archive. Additionally, I have used data from the large series of books on the history of the Ministry of Munitions. Further research at the Public Records Office in the Ministry of Munitions files may repay with more detail of contracts signed with Leeds suppliers, although the massive amount of subcontracting for castings and other parts undertaken by main producers in the 'engineering ecosystem' in Leeds is probably now lost.

As many sources, for example Cookson, use the Great Exhibition as a point of departure for decline, I have taken Leeds's contribution to the exhibition as a turning point for Leeds engineering, using it to describe the beginnings of the expansion of engineering enterprises I have taken details from Auerbach, *The Great Exhibition, 1851: A Nation on Display* (1999) and the Great Exhibition Catalogue to list Leeds's actual contribution to the exhibition. I have also compared Auerbach's description of the London-centric objectives for the exhibition with newspaper reports in the Leeds and West Riding press to describe contrasting local Leeds attitudes and outcomes.

From the White Rose Theses site, I have also relied heavily on Connell's PhD *thesis 'Industrial Development in South Leeds 1790-1914,* (University of Leeds, 1974) and almost a companion piece to it, Ward's PhD *thesis Industrial Development and Location North of the River Aire, 1775-1914* (University of Leeds, 1972). These are both detailed research and I have used much of their information in mapping industrial activity south of the river Aire. Directed at Leeds Industry south of the river Aire, Connell addressed issues in terms of location and the (changing) industrial activity within individual buildings and concluded that the actual pattern of site selection is, generally, more opportunistic than 'theory driven'. The mapping in this dissertation recognises this trend by identifying the arrival of clothing firms in repurposed premises in Holbeck in 1900. In recognising movement instead of change, Connell sought to answer different questions about Leeds than those in this dissertation.

Another excellent portmanteau work on the history of Leeds is provided by D. Fraser (ed.) in *A History of Modern Leeds* (1980) in which luminaries of the Leeds historical cannon, like Grady and Beresford, contributed themed chapters. Ward and Connell collaborated to provide Chapter 6 on "Industrial Development 1790-1914". Whilst the chapter presents a good narrative description of events, it doesn't address questions about why Leeds, and how and why change in the industrial mix came about. Why Leeds came to be the commercial and industrial centre of West Yorkshire rather than, say, Wakefield is left as 'uncertain', despite a suggested list of advantages. [26] Founding and engineering are described as 'existing' in the first half of the century but only feature as large scale in the second half, which is broadly correct but also only a partial explanation. Like Cookson, Ward and Connell identify a relative decline in textiles manufacturing in Leeds in the second half of the century and attribute this to the near disappearance of the flax industry. [27] Like Hahn and Cookson, Connell and Ward identify textiles manufacturing and its technological needs as the impetus for Leeds engineering trades, although they do describe quite high volumes of steam engines manufactured in Leeds during the same time frame. [28] Once again, there is little attention paid to the change in mix of activity and the pre-eminent position of metal working and engineering by the end of the period.

If Leeds had a 'theme' in the second half of the century it would have been 'steam', but any descriptions in literature are very company-specific and fragmentary. Leeds is not a city that has fitted in very well within the literature describing British industry in the nineteenth-century. Christine Macleod's work on patents, their invention of 'heroes' and their subsequent statuary has not featured Leeds. Memorialising in Leeds is sparse and driven by very different motives from other cities. I discuss this lack of commemoration in Chapter 5 and compare Leeds statuary with that of Birmingham and Manchester.

[26] Fraser, D (ed.) *A Modern History of Leeds* (1980). p.143.
[27] Fraser, D.(ed.) *A Modern History of Leeds* (1980).p.158.
[28] Fraser, D (ed.) *A Modern History of Leeds* (1980). p.151-153.

Chapter 2

Leeds Engineering at the Great Exhibition

2.1. Introduction

Building upon Cookson's account of textile machinery-making in Leeds in 1850, this chapter analyses the condition of Leeds engineering at the beginning of the first decade covered in my thesis. [29]Specifically, it shows how the 1850s were the start of major engineering expansion as Leeds engineers, dominant for decades in their local market, responded to changing national, international and imperial circumstances. In this context, I discuss Leeds engineering's emerging potential for diversity in the second half of the century. [30]One key issue that I address is the response from the local organising committee in Leeds to the internationally important Great Exhibition in London of 1851. In contrast to the nationalistic agenda of the London-based Royal Commission and its Executive Committee that organised the Exhibition, I interpret this exhibition as a venue that offered new marketing opportunities to Leeds engineering companies. I, thus, explain how Leeds engineering displays at the Exhibition, although few,were key products of local industry thathelped fuel Leeds's engineering expansion in the coming decades.

Many industrial histories of nineteenth-century Britain pivot around 1850 as a time of change. The historiography on the development of engineering in Britain and Leeds in particular,has often used the Great Exhibition of 1851 in Hyde Park to illustrate this view.[31]Promoters of the Exhibition intended, amongst other things, to show off Great Britain as the pre-eminent'workshop of the World'

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[29] Cookson, Gillian. *The Age of Machinery. Engineering in the Industrial Revolution 1770-1850*. (2018). See Chapter 3 Machine Makers p.111-116.

[30] In Appendix 1 I give a chart showing the engineering legacy of Fenton, Murray & Wood at the Round Foundry and how that engineering skill filtered down across generations and directly into Leeds post 1850 steam-based expansion.

[31] MacLeod, C & Nuvolari, A. *Glorious Times: The Emergence of Mechanical Engineering in Early Industrial Britain C 1750-1850 Brussels* Economic Review Vol52 No.3/4 2009. p.221. Lee is quoted as giving Engineering, though small in 1851 (3.21% of Working population) as the fastest growing activity (9.42%). Here also, Clapham (1926 p.448) is quoted as saying that the rapid growth of engineering can be dated to 'around 1850'. For Leeds: - Rimmer, W.G. *Leeds & Its Industrial Growth.* The Leeds Journal No 12, p.231 'the period of greatest growth was 1840- 60' citing Meysey-Thompson (1882) as a source. Also, in Rimmer on p.231 'During the next seventy years the industry [engineering] grew rapidly.'

but, as the British economy struggled during the late 1840s,there was also concern over British manufacturing deficiencies and poor industrial education in the face of growing foreign competition.[32]In this chapter, I contrast the decline-centred focus of historians such as Auerbach and Edgerton with the upward trajectory for engineering activity in Leeds in the 1850s.

I build on Cookson'sobservations (discussed in Chapter 1.2 above) that reveal a divergence in the interests of Leeds textile manufacturers and their machinery suppliers in the 1840s, as machine-making firms looked to increasingly exploit demand for other engineering products from new, often export, markets beyond textile machinery.

Supporting this view, I argue that the trade directories for 1849 show both a growth in the number of engineering, founders and machine makers of all types in Leeds,with some key Leeds engineering firms also growing in size.[33] Although there were very few large businesses in Leeds,these did employ hundreds of workers and produced textile machinery, steam locomotives, rolling stock and many other products for national and international markets. A measure of the industry's size at this time can be seen in census and occupation details for 1851. The population of Leeds and its out-townships rose from 53,276 in 1801 to 172,270 in 1851 (+ 223%), thus providing a ready local market for the metalwork, castings and machinery needed to sustain a growing town. [34]

By 1851, engineering companies in Leeds employed 7,400 people (almost all of them men); around nine per cent of the working population. This number had doubled in the previous ten years from 3,700 (6.3%) in 1841 and continued torise. [35] Of these, some were making textile machines in firms such as Taylor Wordsworth and Fairbairn Lawson, whilst others were already active in newer establishments employing hundreds of workers in steam-related manufactures. For example, E.B. Wilson's Railway Foundry was quoted in 1851 as employing between 1,200 and 1,300 people.[36]By

[32] Auerbach, J.A. *The Great Exhibition of 1851*.p.10 and Edgerton, D. S*cience, Technology & the British industrial 'decline' 1870–1970* .p.48.

[33] Trade directories for 1850 were unavailable.

[34] Rimmer W.G. *"Occupations of Leeds 1841-1951"* (Thoresby Soc, Leeds 1967) Vol. 50 p.158-78.

[35] Rimmer W.G. *"Occupations of Leeds 1841-1951"* (Thoresby Soc, Leeds 1967) Vol. 50 p.158-78.

[36] *Leeds Times* 21 06 1851.

1849,the Trade Directories show eighty-one firms employed as millwrights, iron andbrass founders and machine makers in Leeds, as well as a large number of craftsmen and journeymen making the main, machinery and components for the textile and steam engine industries,and also household goods, milling machinery, gas fittings and a wide variety of other items. Of these eighty-one firms, only twelve had existed in 1817.Therefore, sixty-nine firms were new to the market with fresh capital and fresh ideas. Thus, although prefaced by a superficially quiet showing at the Great Exhibition, engineering in Leeds was, as I will discuss in the next section, set for a major expansion in the 1850s.

2.2. The Great Exhibition – A Springboard for Leeds Engineering Growth

Widely promoted by Prince Albert, the Prince Consort and housed in Paxton's Crystal Palace -- a building as remarkable as the materials it enclosed -- the Great Exhibition of 1851 was aimed at, and succeeded in, displaying Britain's manufacturing and mechanical prowess and diversity. [37] It did so alongside an extensive array of goods from around the Empire and indeed the world, available for purchase by a growing domestic population increasingly able to afford expressions of personal taste. Interpreting this exhibition is not, however, a straightforward matter. At every stage of its planning, the objectives and meanings ascribed to the Exhibition were changeable and contested, even amongst the organisers on the Royal Commission.[38]

Auerbach, in *The Great Exhibition 1851: A Nation on Display*, argues that what had begun with the idea of 'showing the world that we are the greatest' turned into one of addressing the deficiencies of British design and sales and a display of liberal values of nineteenth-century Britain.[39.] Later, the effect of local committee involvement and the 'selling' of the idea to suit diverse local interests, which stimulated such an immense attendance at the exhibition, added education, personal improvement, entertainment and a social event to the Exhibition's anticipated legacy effects.

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[37] Auerbach, A. J. *The Great Exhibition of 1851.* p.9. The original idea of Francis Wishaw of the Royal Society of Arts but 'galvanised' by the patronage of the prince.

[38] Auerbach, A. J. *The Great Exhibition of 1851*. p.24.

[39] Auerbach, J.A. *The Great Exhibition of 1851* (1999). P.31. Auerbach cites Bell-Knight,C.A. T*he Crystal Palace: Rise, its Decline- its Fall*. p.6-7 and p.31.

Auerbach has suggested that although a bold expression of British manufacture, the Exhibition's inception was actually rooted in a lack of confidence in those manufactures then seen to be in growing competition with other European sources. So, while the Exhibition was lauded domestically as a symbol of 'peace, progress and prosperity' with Britain as 'the most powerful and advanced state, a paragon of liberalism', there were just as many criticisms to balance out the positive hyperbole. [40] Auerbach notes concerns over sales, especially as most of the British exhibits were the product of craft-working rather than mass manufacture, where Britain held a pre-eminent position and an economic advantage. Also, concerns were raised that British education was failing to supply anefficient workforce. [41]Innovation was stalling and since the Napoleonic wars British industry had concentrated on quantity and 'economy' rather than the style and aesthetics suitable for continental consumers who had increasingly learnt to live without British imports.[42]

The organisation of the event was managed by a Royal Commission composed of aristocratic, political, industrial, agricultural and artistic interests. The Commission included the Leeds Mill owner and industrialist, John Gott and politician Richard Cobden of Huddersfield, MP for the West Riding. Much of the organisation work was undertaken by an Executive Committee appointed by the Commission and based in London. [43]

The local response in Leeds

Despite the Royal Commission's objectives for the exhibition, the local Leeds committee adjusted it's reporting of the planned Exhibition's 'vision' to suit more local interests and concerns. A public meeting held in Leeds in July 1850 characterised the exhibition as:

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[40] Auerbach, A. J. *The Great Exhibition of 1851*p.1. Source given as Trevelyan, G.M. *British History in the nineteenth Century & After.* p.295.

[41] Auerbach, J.A. *The Great Exhibition of 1851* (1999). p.10. Auerbach cites Trevelyan, G.M. *British History in the NineteenthCentury and after (1782-1919)* (1937) p.295. Also cited is Henry Brougham in the *Edinburgh Review* of 1824: -" British artisans were the least trained and the middle-class manufacturers the worst educated in Europe."

[42] Auerbach, A. J. *The Great Exhibition of 1851*p.1 and p.10-11.

[43] Auerbach, A. J. *The Great Exhibition of 1851.*p.11.

> one of a number of experiments which the experience of other nations has shown to be capable of giving a powerful stimulus to manufacturing enterprise and as a mode of obtaining a just estimate of the skill possessed by other countries and as tending to promote a friendly intercourse among nations…. It is worthy of universal sympathy and support. [44]

France and Germany had, for many years, held national exhibitions to demonstrate their manufactures and processes and conscious that Britain was behind hand in this respect, Mr. Warrenfrom the London-based executive committee -- then on a tour of local organisations -- attended the meeting from Manchester and spoke loftily and at length, suggesting that the exhibition would:

> open minds to the great truth that extended intercourse throughout the world would tend to the wellbeing of mankind at large.
>
> it would give the richer classes the knowledge of how much they were indebted to the working man
>
> it would give the working man a nobler idea of his own powers and encourage in him the principles of self-respect and self-reliance
>
> The exhibition…. would tend to soften national prejudices, prevent war and encourage brotherly feeling.

In contrast to these remarks made by the Executive Committee, the Leeds audience of working men were also encouraged to contribute to the costs and to attend the Exhibition.They believed this would be their opportunity to observe machinery and processes with which they were unfamiliar, with a chance to improve their working and, thereby, benefit both Leeds industry and themselves. Despite the evident spirit of self-improvement proposed by the speakers, the attendees were wary of the loftier ideals presented at the Leeds meeting. They believed the Patent Law would first need revision especially as they suspected that the Foreman would ‘steal' any suggested improvements in the workplace and present them to the management as his own ideas. [45] Mr. Warren’s remarks, prompted by London-centric concern for social unrest contrast with the tone needed to encourage local firms and people to contribute and attend. [46] Echoing the Leeds meeting, Mr. Richard Cobden M.P., when addressing the Huddersfield Mechanics Institute said:

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[44] *Leeds Intelligencer* 19.07.1850.

[45] Until Patent Laws were changed in the 1850’s anything exhibited publicly in the UK could not subsequently be patented thus creating a risk for exhibitors of novel designs and the exact opposite of the Patent laws in the USA.

[46] Auerbach, A. J. *The Great Exhibition of 1851*.p.129. The Commissions concern over crowd disorder at the Exhibition

> any man or woman who failed to visit it (the Great Exhibition) would, in years hence, feel anything but comfortable under the quizzing questions of their then grown children when asking about the greatest of all the great events which will make the 19th century memorable in the annals of posterity. [47]

Richard Cobden was a key member of the Royal Commission for the Exhibition and was fully aligned with the ideas proposed by Warren. But, having waxed lyrical about the 'perfection' and 'brilliancy' of textiles on display from the West Riding, he directed the Yorkshire visitor to view the textiles on display from France, Austria, the German Zollverein and the USA with a critical eye. Mr. Cobden went on to add the conveyance of knowledge and instruction, improvement of taste, enlargement of views and more liberal feelings towards the family of man as reasons for attending. He argued that the Exhibition was highly illustrative of the science, arts, character, customs and habits of the different nations. Here Cobden, alongside his liberal ideals, identified the main international competitors for textiles and engineering products in a manner which emphasised the difference in approach between the metropolitan and local committees.

The Executive Committee suggested that Savings Clubs be set up locally and on a company basis to enable workers to afford rail travel and lodgings when attending the Exhibition and suggested that special arrangementsbe madeby the Executive Committee with the railway companies for 'bulk discount' fares to London. 'The best sights in London are free' applied as much then as now. The *Yorkshire Visitors Guide* provided a list of all the free sites suggesting trips to the Woolwich Arsenal and (by ticket) to the Limehouse, East & West India Docks. [48]

Aside from appeals to the working man, commercial reaction in Leeds to the opportunities presented by the Exhibition was initially mixed. The local Bradford Committee approached the Exhibition with confidence, its representatives having very clear views about its supremacy in worsted production. Auerbach has shown that Leeds, concerned about a possible decline in its woollen trade, saw the exhibition as an opportunity to refute accusations of backwardness in woollens and 'a possible

[47] *The Yorkshire Visitors Guide to the Great Exhibition*. p.1. (Brotherton Special Collections).
[48] *The Yorkshire Visitors Guide to the Great Exhibition.*p.2*. (Brotherton Special Collections).*

remedy for trade depression'.[49]Sensing Bradford's position as a rival, Martin Cawood, the secretary of the Leeds Committee wrote: -

> Leeds and most West Riding towns were content with plain deal covered with crimson or blue cloth, oak, maple or mahogany oil-cased paper on which to display goods. The Bradford exhibitors have gone to much greater expense and are planning to use 1,500 feet of plate glass to protect and display their goods. [50]

However, by contrast with Bradford, the Leeds committee was, from an early stage, active and influential in other ways. In June 1850 the Leeds Intelligencer newspaper reported:

> The scheme of conditions and limitations drawn up by the Leeds Committee, and the plans for the formation of a local jury, have, at the insistence of the Royal Commissioners, been forwarded by Mr Cawood, the secretary, to all the other committees which have been formed throughout the United Kingdom. [51]

Whilst the London Executive Committee nominally had the final say regarding exhibits, they were heavily reliant on local committees and their 'juries' to decide what to send. In Leeds, in November 1850, there were very many potential exhibitors in the Machinery Section, as shown in Appendix 2. [52] The *Leeds Intelligencer* newspaper reported that there was a total of 57 Leeds firms wanting to display objects in 31 different machinery Categories. [53] Of the manufactured machinery categories, there were 28 firms wanting to exhibit in 13 machinery categories.

A year later, in 1851, Leeds displayed material from 142 companies, of which 46 were from the textile trades and only 6 belonged to the machinery category. Bradford sent outputs from 36 textile companies and, of Bradford's 57 exhibitors, 55 were related to the wool trade. The greater number of Leeds exhibitors reflected the city's much wider commercial and industrial base.

Number of Woollen Manufacturers/Merchants[54]		Prizes Awarded
Leeds	46	15
Bradford	36	11

[49] Auerbach, A. J. T*he Great Exhibition of 1851*. John Gott on p.79.

[50] Auerbach, A. J. *The Great Exhibition of 1851.* Martin Cawood on p.79.

[51] *Leeds Intelligencer*. 06.06.1850.

[52] *Leeds Intelligencer.* 09.11.1850.

[53] For instance, many of these were measuring instruments and gauges. Also, a lifeboat, a walking stick and oars.

[54] *Leeds Times* 21.06.1851. Martin Cawood letter. As a 'sketch writer' he wrote regularly to the Leeds press during the Exhibition.

Any local civic rivalry would be left unresolved by the similar number of prizes awarded to Leeds and Bradford but, in the future, and given Cawood's comments above, it was clear that there were prospects of a steady relative decline in prominence of Leeds Textiles.

As I have discussed earlier, Cookson indicates that, as Leeds machinery makers looked to new markets at this time, users and the makers diverged in their views of products. [55]This chapter will show that Cookson's perception of local decline in Leeds is inaccurate. We will see that, on the contrary, textile machinery making continued to prosper with the growth of major machinery makers, such as Taylor Wordsworth, Fairbairn & Lawson.

(Figure 7.) Textiles at the Great Exhibition. Despite Leeds committee secretary Cawood's concerns over elaborateBradford displays behind plate glass, visitors can be seen here feeling the width of good Leeds Woollen Cloth.

In comparison to the 46 woollen exhibitors and the 81 metalworking firms advertised in the 1849 directory, Leeds engineers were a rather underrepresented group. The catalogue noted only 6 engineering exhibitors from Leeds. This group is perhaps representative of the most progressive and energetic Leeds engineering firms as five of the six went on to exhibit at Paris in 1855 and London in 1862.[56]

[55]Cookson, G. *The Age of Machinery. Engineering the Industrial Revolution 1770-1850*. p.259.

[56]*Leeds Intelligencer* 08.12.1855. 'Paris Exhibition Medal Winners'. Also, a young Samson Fox oversaw the London 1862 machine tool exhibit from Smith, Beacroft, Tannett.

Leeds engineers displayed the following materials in the Machinery Classat the CrystalPalace: -

Kitson, Thompson & Hewitson*	2 Locomotive Tank Engines (Aerolite & Ariels Girdle)
Beecroft, Butler & Co.*	Railway axles, tire bars etc. (Kirkstall Forge)
W. E. Carrett	Steam pump combining a high-pressure boiler & suction pump
Smith, Beacock & Tannett	18' self-acting slide lathe 15" headstocks – self-acting surface and screw cutting motion. Self-acting drilling & planing machine.
J. H. Sadler	Girders as components for bridges.
Lawson & Sons	Machinery for the preparation and spinning of Flax.

* = Prize awarded

The Leeds Committee had thus 'invented' the local jury. This proposal for local juries for each display category at the exhibition wasforwarded to the London Executive Committee which used them as national policy. In an effective reversal of the powers assumed by the London Executive Committee, the fact that only 6 Leeds engineering firms finally exhibited when compared to the 57 wanting to do so a year earlier, was the clear decision of the Leeds Jury.

The Leeds Machinery Jury consisted of: -

Atkinson	(Flax Spinner)
Leather	(Hunslet Engine Co. – Locomotives)
Maclea	(March & Maclea, Machine Tool makers)

These three engineers decided how Leeds engineering was to be displayed at the Great Exhibition and therefore, presented to the world. Although none of the chosen items derived from the Jury members' own firms, they were examples of a similar type and deliberately chosen to display Leeds engineering in its best light. It is difficult to criticise their choice of exhibits given that the goods on display were central to Leeds's engineering expansion during the rest of the century -- locomotive steam engines and associated components, hydraulic machinery, machine tools and structural iron/steel. Of the several textiles machinery manufacturers in Leeds, only Lawson & Sons presented textiles (flax spinning) machinery.

Situated next door to the refreshments room the Machinery Hall was by far the most popular area of the Great Exhibition. Here, Platts of Oldham were the most popular exhibit with a live and loud

display of 15 machines which demonstrated all the processes of cotton manufacture --- from opening raw cotton balls to the final weaving of cotton cloth.

(Figure 8.) Platts of Oldham. Machinery at the Great Exhibition giving a live demonstration of all cotton manufacturing processes (Picture from *London Illustrated News* June 1851)

In his few references to the city, Auerbach is, nonetheless, critical of Leeds, comparing the town unfavourably with Bradford. Leeds is described as conservative and 'backward', the town council split between Anglicans and Nonconformists and their inward-looking arguments creating conservatism & lethargy.In contrast Bradford is lauded as one of the 'shock' cities of the Industrial Revolution, 'a byword for progress'.[57]Auerbach's view lacks balance, missing as it does the many contemporary municipal improvements underway in Leeds,such as the water supply, public libraries and early slum clearance.[58]At this time, Bradford, although smaller in physical and demographic terms was, through its large worsted trade, much wealthier than Leeds.Nevertheless, the ongoing growth in Leeds would, by 1893 when city status was granted to Leeds, far exceed that of Bradford as a commercial and industrial centre. Against any accusation of lethargy, we can note that two Leeds engineering companies were recognised at the Exhibition: Kirkstall Forge was awarded a prize for their manufacture of railway axles and Kitsons for their steam.[59]

[57]Auerbach, A. J. *The Great Exhibition of 1851*p.78-79.

[58]Hennock, E.P. *Fit and Proper Persons.* Water Supply p.205-6, Slum Clearance, p.211-12, Libraries, p.210.

[59]One of the two Kitson steam engines exhibited, 'Aerolite' can still be seendisplayed at the National Railway Museum.

2.3. Change and Technical Development

By the mid-nineteenth-century the several different descriptors used in Leeds'sTrade Directories during the first half of the century had resolved themselves into one as 'engineering', although many older associated names, such as Millwright and Whitesmith were retained, usually for marketing purposes. As engineering developed, one thing is clear -- that it didn't happen in a 'skills vacuum'.[60]Until the introduction of the Yorkshire College of Science's engineering courses two decades later, formal qualifications, other than one's apprenticeship documents, were non-existent. The acquisition of skill came instead with experience working in a relevant job in a specific company. The requirement for skills grewand changed simultaneously. There was always the need for skill and application in 'chipping & filing' to obtain the required finish on castings.But, as self-acting machine tools became more widespread during the second half of the century, the skills required pertained more to designing in the drawing offices, in process planning and control, and in machine setting and adjustment in the workshop to achieve the accuracies and fine tolerances required by ever more challenging metal manufacture.[61] This development of skills was typical of the latter half of the century, as was the emergence of innovators or 'design engineers' such as Parsons, Meysey-Thompson, Kitson and later Royce (of Rolls Royce). [62]

The transfer of engineering skills and experience was alive and well in Leeds and moving from textile machinery to more general metal working and particularly steam engines. Experience spread across the industry and down the generations through family and business connections. I show how widespread and long lasting these connections were in a diagram in Appendix 1. Matthew Murray and David Wood at the Round Foundry were influential in the first quarter of the century. Their pride in their outputs and their passing-on of engineering skills, finish, designs and energy to so many trainees had a lasting influence on the engineering landscape in Leeds. Indeed, further linkages build on these initial connections. John Marshall financed Peter Fairbairn's first premises at Wellington

[60]Hahn,B. *Technology in the Industrial Revolution.* p.15-16.

[61] i.e. Whitworth's development of the 'Thou' (a thousandth of an inch; a typical allowable tolerance being, 'TwoThou').

[62]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918.*p.128-9. Campbell and Meysey-Thompson as 'Consultative Committee' within the Framework of the main committee.

Mills from where Messrs Greenwood & Batley emerged to start their business next door. [63] Smith, Beacock, Tannett at the Round Foundry sent their young apprentice, Samson Fox, to supervise their machine tool exhibit at the 1862 London Exhibition.[64] Whilst at Smith, Beacock, Tannett, Samson Fox met fellow apprentice Robert Sinclair Scott who assisted with family capital in the creation of the Leeds Forge and later became a director of the Leeds Steel Works in Pepper Road. [65] Colonel North, the 'Nitrate King', was an apprentice at Fowler's Steam Plough Works, from where he was sent to Chile to supervise customer implementations. [66] North later became a Trustee of the Leeds Forge Co from where, in the 1880s, Samson Fox sent a young Bernal Bagshawe to the USA to set up his pressed steel rolling stock business in Chicago and Pittsburgh.[67] In addition to the 'tree' in Appendix 1 and contrary to Cookson's assertion that networks were in decline, I suggest the above indicates that the opposite was happening in Leeds.

2.4. Conclusion

At the start of the 1850s, engineering in Leeds had reached what appeared at first sight to be a mature plateau, employing 7,400 people in 1851 (up from 3,700 in 1841). [68] Yet, firms had started to exploit new and growing markets, and some were already positioned, like Kitsons and Fairbairn Lawson, to grow into the large Leeds engineering firms that were to expand in the 1850s in those new market circumstances.

Leeds engineering products went on to supply a local market busy in the manufacture of various materials stimulated by rapid population growth and a national and international/empire market for steam locomotives and machine tools. The themes of growth and diversification in the following chapters will describe the rapid expansion of engineering in Leeds after the 1850's, its growth across

[63] *Leeds Intelligencer* 05.01.1861.

[64] *Proceedings of the Institution of Mechanical Engineers*. Memoirs December 1903, p.920.

[65] Of the Scott Shipbuilding Firm in Greenock.

[66] Colonel John Thomas North, born in Hunslet in 1842 later bought for the town the Kirkstall Abbey estate.

[67] Here Bernal Bagshawe engaged the famous 'Diamond Jim' Brady as sales agent to American railroad companies.

[68] Rimmer, W.G. No.12. *Engineering 1: - The Nineteenth Century*. The Leeds Journal. No.26 (1955). p.230-231.

the remainder of the century and its remarkable variety of output by the start of the twentieth century.

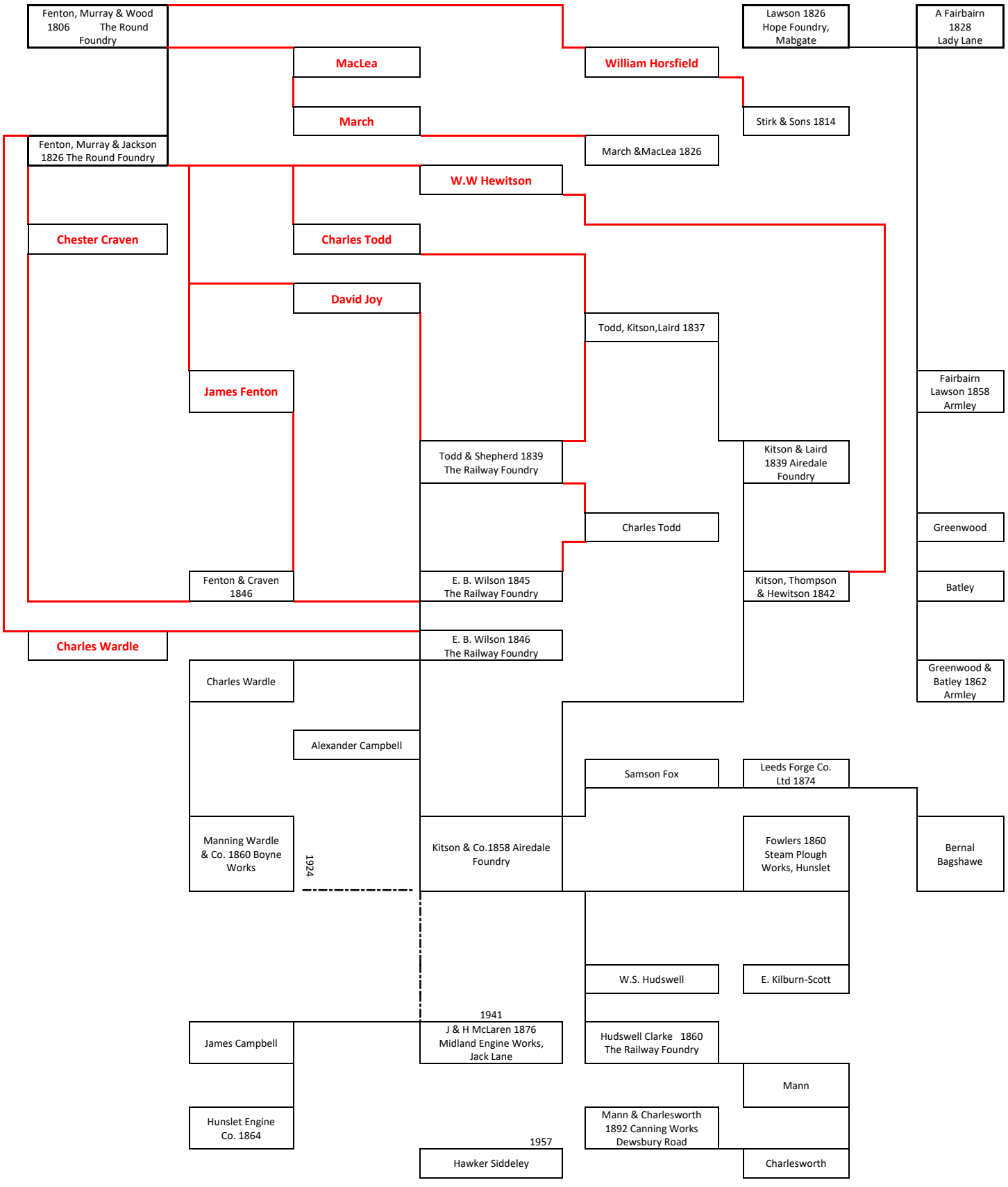
I argue thatCookson's and Auerbach's reference to 1851 asalleged points of manufacturing decline in both Leeds and the nation must be a misunderstanding of the engineering trade in Leeds. For Leeds, the Great Exhibition represented theopposite; it was a starting point for both change and growth for engineering. In future decades there was relative decline in Leeds textiles manufacture but not textile machinery-making. [69] Moving forward from Cookson's 1850 end point, the change in the mix of manufacturing activity in Leedsengineering shows clearly that it had outgrown its now distant eighteenth-century origins solely in textile machinery manufacture. Contrary to Auerbach's view, The Great Exhibition was a turning point for engineering in Leeds in that it helped Leeds engineers towards a greater realisation of changing national and international markets and introduced potential export customers to the possibilities available in Leeds engineering. Although few in number, the engineering representatives from Leeds at the Great Exhibition demonstrated their expertise in Machine Tools and Steam Locomotion; the very areas that were to expand the Leeds engineering sector in the next decade. The potential of the international markets for these goods, in particular, was not lost on Leeds engineers.

[69]Largely due to the rapid decline in flax spinning and weaving in Leeds.

Appendix 1

Dissemination of Skills & Experience in Leeds Engineering

Dissemination of Skills and Experience in Leeds Engineering



Appendix 2.

List of Potential Machinery Exhibitors from Leeds November 1850

No. 2 Section - Machinery

Exhibitors	Sq. Feet	Article	Exhibitors	Sq. Feet	Article
7	283	Models	**9**	**3442.5**	**Engineering & Machinery**
1	1.5	Oars of Boats	**1**	**9**	**Self-Acting Clough**
4	**143.5**	**Washing Machines**	**2**	**186**	**Self-Acting Tools**
1	**33**	**Thrashing Machine**	3	12.5	Chronometers
1	**6**	**Printing Machine**	2	24	Carriage
2	**24.5**	**New Motive Power**	1	15	Hackles & Gills
2	11	Musical Instrument	**1**	**36**	**Flour Dressing Machine**
1	1	Steam gauge	**2**	**7.5**	**Boilers**
2	2	Mathematical Instrument	1	6	Telescope
1	1	Indicator	1	9	Measuring Machine
1	**1**	**Electric Pump**	**2**	**54**	**Agricultural Machine**
1	1.5	Galvanic Machine	1	0	Smoke Burner
1	8	Safe	1	8	Lifeboat
1	300	Wire Work	1	3	Walking Stick
1	**75**	**Machine for Manufacturing Horseshoes**	1	1.5	Sun Dial
			1	**18**	**Steam Pump**

Bold = estimated to be 'actual' machinery items.

13 Machinery categories - **28** exhibitors

Source: - Newspaper - Leeds Intelligencer 09.11.1850

Chapter 3

Leeds Engineering Expansion after 1851

3.1. Introduction

This chapter explains the growth in Leeds engineering after the Great Exhibition up to 1900, the growing prominence of industrialists and the civic infrastructure which supported the development of the self-sustaining engineering 'hub' in south Leeds. Several forms of technical change are documented, for instance, the development of more accurate manufacturing methods like Whitworth's introduction of 'The Thou'in engineering measurement as well as the advantages that increasing sizes and corporate complexities provided to many Leeds engineering firms. [70]

Central to the growth in Leeds engineering was the transfer of skills and knowledge from the innovative work of Matthew Murray and the various engineers that were trained by Fenton Murray & Wood, then Fenton, Murray & Jackson. These former employees moved on to take up positions in engineering companies across Leeds, thereby transmitting their experience down the generations to help create the great steam-powered industrial hub in South Leeds.

3.2. Leeds Engineering Growth

Although few Leeds engineers attended the Great Exhibition, as I showed in the previous chapter, the eventboth gave the world a glimpse of Leeds's industries and gave Leeds entrepreneurs a view of new potential international markets. For Leeds engineers, then, the period after 1851 presented widened horizons, which prompted a new phase of innovation as will be discussed below. Domestic markets had grown organically and locally in Leeds, but also on a national basis. By the early 1850's, Leeds building on its early canal links, was well connected by rail to other towns and ports.In Appendix 1 (Occupational Structure in Leeds 1841 – 1911), Rimmer shows that the population of Leeds nearly tripled between

[70]Whitworth's development of an engineering unit of measure via his screw gauge of the 'Thou', shorthand for a thousandth of an inch; a typical allowable tolerance in British engineering practice being, say 'Two Thou').

1851 and 1901, and the various sectors of industry changed in size and importance, both to service this growth and as a generator of growth itself. Whilst engineering grew in importance from 6.3% to 15.3% textiles saw the biggest decline from 37.8% to 9.3%. The other items (in **Green**) reflect the sort of growth in trades that a rapidly growing industrial town needed and expected. Paper, books and printinggrew from 0.9% in 1851 to 2.7% in 1911 and provided a new market for printing machinery makers in Leeds. [71] Other categories of activities like transport grew from 4.2% to 7.9%, commerce from 1.0% to 5.6%, and professional from 2.2% to 3.6%.

In his article for the Leeds based Thoresby Society, Professor R.W. Rimmer -- a frequent contributor to the *Leeds Journal* with vignettes on various aspects of Leeds industrial history --indicated that engineering employment grew from 6.3% in 1851 to 15.3% in 1901. [72]In his lecture, titled *On the Industrial and Sanitary Economy of the Borough of Leeds* at the 1858 British Association for the Advancement of Science Meeting at Leeds, Baker, a Factory Inspector, described the extent of metal working employment in the Borough at that time as follows: -

(Figure 9) Iron and Machine Making Trades (employment)

		No. Employed	Typical Weekly Wage
1.	Flax & Tow Machine making	2,630	Men 25s – 28s
2.	Tool Engineering & Machine Tool making	1,800	Men 26s – 29s
3.	Engineers, Millwrights, Boiler makers	1,740	
	Steam locomotive making	2,400	Men 28s – 32s Lads 4s - 10s
4.	Various other Smiths Shops	450	Men 12s – 27s
5.	Manufacture of Bar, Plate & malleable iron	2,250	Men 25s – 31s
6.	Various Jobbing Brass & iron Foundries	350	Men 20s – 24s
7.	Hackle & Gill Manufacturing	230	Men 6s – 29s

Total: 12,110

The numbers presented by Baker match those of 1861 (12,208) estimated byRimmer.[73]In contrast to the Great Exhibition, where Leeds engineering was on show to customers, the BAAS meeting in Leeds, which

[71]Rimmer, W.G. *No. 29 Printing & Printing Machinery (1)*. Leeds Journal (1959). p.272-274.

[72]Rimmer, W.G. *Industrial Profile of Leeds.* Thoresby Society Vol 50 1967. p.163. Table 1 Also, the Leeds Journal was the monthly magazine of the Leeds Chamber of Commerce.

[73]Although both may be rather too low when estimating those in Category 3 as a whole and Locomotive engine making

will be discussed in the next section, provided Leeds engineers with an opportunity to describe their industry in detail to an audience of their peers.

By 1900, the very large growth of the Leeds Engineering sector is evident from the Directory listings. [74]

(Figure 10)Quantity of Engineering & Metal working firms in Leeds.

1849	1861	1870	1881	1900
140	122	150	181	260

Source: Trade Directories - *1849 Charlton & Archdeacon, 1861 &70 Whites, 1881 Kelly, 1900 Town & Country.*

Of those engineering firms listed in 1900, only 12 were listed in 1849. The diversity of descriptions in the Trade Directories is also evident and revealing. In 1900, there were 4 consulting engineers, 27iron andbrass founders, 41 iron and tinplate workers, 6 iron masters and manufacturers, 38 machine makers, 9 millwrights, 2 steel manufacturers, 6 weighing machine makers, 21 electrical, 7 gas, 3 locomotive, 7 mechanical, 3 ventilation, 6 toolmakers and 22 whitesmiths and bell hangers. Not wishing to narrow their customer offering, nearly all these firms self-identified in more than one category. [75] For instance, Smith, Beacock & Tannett, makers of heavy machine tools and established in the 1840's still see benefit in advertising themselves as Millwrights. The Victoria Foundry (formerly Murrays Round Foundry) were described by Fentiman in his Historical *Guide to Leeds and its Environs* (1858) as follows:

> makers of all sorts of self-acting tools for the manufacture of locomotives, marine and stationery engines as well as for the manufacture of machinery in general; such tools comprising slide and screw cutting lathes, planing, drilling, boring, wheel cutting, slotting, shaping, screwing, punching, plate bending machines, etc. This firm has done much in establishing the present character of Leeds in this important branch of manufacture. Their tools are exported to all parts of the world. [76]

Joshua Buckton, also heavy machine toolmakers, advertised themselves as machine makers, although McLarens, makers of steam traction engines, advertised themselves as agricultural engineers. Of the 7 gas engineers, Brays was a manufacturer of gas burners and other fittings, whilst Claytons specialised in

in particular with Kitsons, McLarens (steam plough), Manning, Wardle and others all involved in steam locomotion and all employing many hundreds of workers.

Listings from *Leeds & District Trades Directory 1900*, Town & Country Directories Ltd.

[75] The total of 260 has been adjusted to take account of multiple listings.

[76] Fentiman, T. A *Historical Guide to Leeds and its Environs* (Publisher unknown) Leeds 1858.

building large gasholding tanks and later the giant 'Gas Holders' for town gas storage and, therefore, might more properly be described as structural steel engineers. It is evident from the full-page company-specific advertisements in the Trade Directories that the use of such a variety of 'sector' names within engineering were, by 1900, more to do with a need for companiesto associate themselves with a particular market rather than describing themselves accurately. It was also an echo of firms such as locomotive builders, caught between the desire to make standard equipment and the fear of a lossof customersif they did not adapt their product to specific customer requests. The gas and ventilation engineers were more likely to be 'fitters' rather than manufacturers, and the whitesmiths and bell hangers looked like general 'jobbing' makers of almost anything bespoke and small in metal; for instance, a garden gate and a 'butchers show rail' were mentioned as typical items in listings advertisements in Trade Directories.

It is also apparent in the 'Engineer' listings that firms from outside Leeds had set up offices in the 'commercial' streets of central Leeds as agents rather than in the manufacturing districts with the intention to buy machinery from Leeds manufacturers and/or to sell their principal's machinery into the fast-growing Leeds manufacturing machinery market. [77]

3.3. Leeds 'Civic' infrastructure

In line with the growing prominence of engineering in the 1850s, Leeds industrialists were joining the lawyers, bankers and wool merchants in the newly reconstituted Leeds Chamber of Commerce and on the Town Council. [78] Soon, manufacturers like Maclea, March, Marsden, Fairbairn and Barran became Aldermen and Lord Mayors. The Leeds Club had opened in 1846, providing congenial surroundings for the towns civic and industrial elites to mix and discuss the issues of the day. This social network was facilitated by the civic infrastructure being assembled at this time. The BAAS held annual meetings around the regions. [79]Leeds, although keen to host such a prestigious organisation, had nowhere

[77] *Leeds Trades Directory, 1900*.
[78] See Appendix 3 and 4.
[79] Thackray & Morrell. *Gentlemen of Science.* (1984).

suitable to hold large gatherings. This lack stimulated debate in the town council which, pressured by the Leeds Improvement Society and the Leeds Philosophical and Literary Society, passed a motion to build a Town Hall befitting the active and growing industrial centre: 'a noble municipal palace that might fairly vie with some of the best Town Halls on the continent'.[80]

In 1853, Cuthbert Broderick a29 year old architect from Hull won the £200 prize for the best design for the Town Hall. On the 7th September 1858 Queen Victoria and Prince Albert, amidst great rejoicing and pomp, formally opened the finished building which, by then, had gone three times over budget. The main part of the building was named 'The Victoria Hall' in honour of Queen Victoria. As a mark of the rise of the engineers in Leeds society, the Lord Mayor for the year, the textile machinery manufacturer Peter Fairbairn, had the privilege of accommodating Queen Victoria and the royal party at his grand mansion, Woodsley House on Clarendon Road.[81]

Civic dynamism provided a focus for change and raising Leeds's profile. Almost immediately after the Town Hall was completed, as its first public use, it hosted the 1858 meeting of the BAAS, with Meysey-Thompson on the Leeds organising committee. [82]This meeting provided a contemporary record of various descriptions of Leeds engineering. Broderick explained the novel construction of the Town Hall roof to the Engineering Section of the BAAS meeting; James Kitson gave a history of the iron trade in the West Riding; John Marshall gave a local history of flax spinning; and W.E. Carrett (Meysey-Thompson's fellow director) gave a paper on modern appliances for raising water.[83]

The BAAS meeting of 1858 prompted an exhibition of Leeds manufactures in the White Cloth Hall off City Square. In addition to his speech to the BAAS on the 'Leeds Exhibition of Local Industry', Joshua Buckton also described the exhibition in a paper to the Royal Society of Arts.[84] He mentioned the fine

[80]Hennock, E.P. *Fit and Proper Persons.*p.205 and Mitchell, W.R. *A History of Leeds,*p.109.

[81]The Fairbairn family were moved out so the royal household could move in. This was the first time Queen Victoria had stayed in the house of a commoner.

[82]There was a further meeting in Leeds in 1890.

[83]*Meeting Report 1858.* BAAS Transactions (1858) p.182-184 &p.207.

[84]*Leeds Exhibition of Local Industry.* Royal Society of Arts Journal. (08.10.1858.) p.670.

malleable iron and boiler plate produced by the Monk Bridge Iron Works; the axles and 'Naylor's Double Steam Hammer' made by Kirkstall Forge; the famous lathe made by Greenwood & Batley for 'turning irregularly formed pieces of wood' (i.e. a rifle stock) and their endless tape saw (i.e. a band saw, used for cutting bulk layers of cloth, first adapted for use in Barrans clothing factory); a pumping engine by Carrett & Marshall; and a power loom made by Combe (part of Fairbairn, Lawson, Combe & Barbour of Armley). The tone in the report from the local organising committee to their Leeds subscribers was very positive. The report thanked many local people for their time and energy, and declared the BAAS event a success, especially as good cost controlled to subscribers getting nearly half their contributions back. Despite being written for local consumption, the report proves a useful primary source giving an important insight into the local economy when describing the exhibition of local industry:

> But it was a happy idea that the Exhibition should be confined to the Manufactures of the Borough, that distinguishes the Leeds Exhibition from all preceding ones, - and the immense variety of the products of its industrial skill that gave it its principal charm.[85]

The Leeds exhibition was unique to that point in that the whole exhibition contained only objects made in the Leeds area. Towards the end of the report, it stated that the local committee believed that the benefits which it conferred upon the town of Leeds were neither few nor trifling: –

> It brought together the theorist and the practical man, who commonly move in separate and remote spheres. It established friendly personal relationships with many of the distinguished leaders of science, from which the town has already reaped valuable results; and it made known to the large numbers of the most educated class the true position of Leeds as a seat of manufacturing industry and enterprise. [86]

Additionally, in September 1859, the Institution of Mechanical Engineers, established in Birmingham in 1847 by George Stephenson, held its Annual Provincial Meetings in the Town Hall in Leeds. The Institution's archive suggests that Thomas Greenwood read a paper, 'On File Cutting Machinery'. This paper, in the same detailed style of other Greenwood papers, contained fine details on machine set-up, process control and profit, accompanied by many plates and diagrams.[87]This paperwas a typical

[85]*Report of the Local Committee Subscribers to the Local Fund*. BAAS Meeting 1858. (1859). p.11.
[86]Repor*t of the Local Committee Subscribers to the Local Fund.* BAAS Meeting 1858. (1859). p.16 -17.
[87]*Proceedings of the I.M Eng* June 1895. p.134.

example of the detailed process control exercised at Greenwood & Batley during the latter part of the nineteenth and early twentieth centuries and demonstrated a high level of engineering skill and technical competence.

3.4. Expanding Technical Skills

The increasing sizes of engineering firms brought with them a growth in management complexity and a need to delegate to specialised departments.[88] The design and drawing office became much more important as a source of innovative design as firms attempted to move away, often unsuccessfully from customer specifications to standard production design. An example of this is E.B. Wilsons Saddle tank engine. This improvement in innovation and design from manufacturers changed market expectations and created new markets. The growing importance of the drawing office to engineering firms and the technical knowledge associated with it resulted in employers calling for educational institutions in Leeds. Mechanics Institutes had existed for many years providing a general education and a background for 'on the job' apprenticeships, but engineering firms increasingly needed more specific technical skills.

As firms used new materials and developed specific grades of steel, they required technicians with particular mechanical engineering expertise. [89]Thus, as part of the growing civic framework, there was early support from industry across the West Ridingfor the founding of The Yorkshire College of Science (1874-75).The original council included Lister, Salt (textiles, Bradford), Crossley (carpets, Halifax) and Nussey, Lupton (woollens, Leeds), Barran (ready-mades, Leeds) and Fairbairn (engineering, Leeds). Initially, the College offered courses in maths, physics, chemistry, geology and Mining, biology and textile industries, and engineering was soon to follow. [90] Tuition had to be paid for by the students, and courses were arranged as evening and weekend classes so that students could both work conventionally and study outside of working hours. The Yorkshire College was new and keen to expand into engineering

[88]Typical examples of this are Greenwood & Batley's expanded Drawing office and Counting House and Kitsons Drawing Office, home for a time to Sir Charles Parsons to develop his Steam Turbine ideas.

[89] Founded as the Yorkshire College of Science in 1874, merged with the Medical School (founded in Leeds 1831) and Re-named 'Yorkshire College' in 1884, soon part of the federal Victoria University with Manchester and Liverpool.

[90]Textile Industries supported by the Cloth Workers Guild of London.

and Leeds engineering firms were keen to support the College so that their labour became increasingly 'up skilled' and expert.

The 'Counting House' for Leeds' engineering companies also became more complex, not only for the administration of the cash wages for several hundred employees, but also for credit management and cost accounting. [91] More accurate financial management meant that firms were able to carefully calculate 'terms of trade' and adjust credit terms to assure margins while providing competitive offerings. In 1859, Fairbairn Lawson offered a variety of ways for their customers to pay dependent on different insurance arrangements. For instance, they offered FOB (Free on Board, i.e. delivered and loaded onto the ship) at Hull then FOB Antwerp for payment of 3rd with order, 3rd at Hull then 3rd at Antwerp with a 3% discount for cash.[92] As the larger engineering firms in Leeds attempted to move away from bespoke jobs towards standardisation of parts and the increased efficiency through assembly line production methods this brought, they felt a growing need for process control and close task management. Not only did the workers become more specialised, but the apprenticeship skills shifted from basic maths, chiselling and filing to complex machine setting and the understanding of tolerances and their measurement by gauge.

In this period, many Leeds firms had sufficient capital assets to support much more easily, or at least more credibly, their proposals for credit to finance expansion. The percentage of the population engaged in commercial activities grew significantly during the period. Becketts Bank was no longer alone in Leeds and the Bank of England opened a branch in Leeds. [93] Evidence of this greater financial capability can be found at Kitsons, who were able to arrange with Fowlers Steam Plough Co. to finance their setup next door to Kitsons Airedale Foundry in Hunslet in 1859. Kitsons went on to make Fowlers' first steam plough engines until they became properly established. To be financed and kept afloat for years by a

[91]This rather archaic term may not be specific to Leeds but was certainly used at Greenwood and Batley well into the 1920's before being superseded by the more familiar 'Account Dept' title.

[92] The modern equivalent of this is Incoterms which are the standard international terms of trade covering payment for goods and their carriage and the insurance of goods whilst in transit. Also,WYL 365 *Fairbairn Lawson Machinery Order Book 1855-59.*

[93]On the corner of Park Row and Westgate. Now repurposed as a hospitality venue.

sympathetic supplier is a situation that smaller Leeds engine and machinery manufacturers of the 1830s. like Zebulon Stirk, could only dream of. [94]Further, and in clear contrast to the regard in which Zebulon Stirk was held as being 'in trade' and definitely not 'respectable' in the 1830's, the 'occupation' of Engineer was raised to a 'respectable profession' with the establishment of the Institution of Mechanical Engineers and indeed had actually become 'respectable'. [95] This is evidenced by the case of A.H. Meysey-Thompson.[96]

Despite being the younger son of a Baronet Meysey-Thompson chose engineering as a profession, as opposed to the usually acceptable choices of joining the Church or the Army for sons of aristocratic families.Individual engineers like Joshua Buckton presented a paper to the Royal Society of Arts in 1858. In1882, A.H. Meysey-Thompson then a Director at Hathorn Davey in Dewsbury Road, manufacturers of Hydraulic pumping equipment of national standing and engineering expertise presented a paper at the Institution of Mechanical Engineers describing some of the engineering history of Leeds and its development in tabular form (the table in the Introduction). [97]In the same year, his fellow director, Mr Henry Davey, gave a paper 'On Mining Machinery'. Edwin Kitson-Clark (M. Inst. C.E, M.A., F.S.A.) was elected President of the Institution of Civil Engineers (Yorkshire Association of Students) in 1907 and indicated what was required of students by quoting Vitruvius. [98] Later in life, Sir Edwin Kitson-Clark became the President of the Institution of Mechanical Engineers and had also previously presented papers to the institution. Such was the change in educational achievement and professional organisation towards the end of the century in engineering. Within this milieu, it is very apparent that some Leeds engineers had achieved national eminence in their field.

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[94]Zebulon Stirk (d.1851) was a well know Leeds engineer, making steam engines, textiles machinery and managing his own weaving shed. He was rarely out of financial difficulties. Leeds Mercury 1815-1853.

[95]*Leeds Mercury* 23.09.1837. In a rates dispute Zebulon Stirks Yorkshire accent is reported 'phonetically' and his blunt manner described ironically as being from the 'polished gentleman' in contrast to the tone and manners of the Town Clerk, Mr. Kaye and a local barrister, Mr Richardson.

[96]Trust and character of engineers discussed in Marsden & Smith, *Engineering Empire*s. p.8.

[97]Hathorn Davey took over the Carrett business in Dewsbury Road, exhibitors at the Great Exhibition 1851.

[98]Vitruvius: - "Some work up without books in order to be practical – they miss authority and precedent. Others trust to calculation and books and find they have followed a shadow, not reality. A Man must be original and, at the same time, careful of precedent. He requires draughtsmanship; geometry; optics, to understand the effects of the sun; arithmetic for costs and quantities; history for ornament; philosophy, for honesty, and for the avoidance of arrogance and avarice; music for proportion, so as to be able to tune a rope under strain; medicine, for sanitation; law, for rights of water, light, drainage, and equality in contract, astronomy, for natural laws, effects of water and movement of air – and in order to learn these things it is necessary to begin climbing the steps from boyhood."

The leaders of large and growing engineering concerns in Leeds had, through technical education at the Yorkshire College of Science and memberships of professional bodies such as the Institution of Mechanical Engineers,themselves become more professionally expert and specialised. They had become more commercially aware, and able to command large scale capital developments and manage big companies. To both enjoy and emphasise their wealth and status, thesewith newly acquired wealth followed the model that had imitated aristocratic lifestyles. With accumulated wealth,they built in the suburbs of Leeds, where guests could be entertained in the country house manner whilst still within easy carriage ride of town centre social networking and the industrial works that financed this lifestyle. Samson Fox left Leeds altogether and became Lord Mayor of Harrogate as Fairbairn, Marsden, March, Maclea and Barran had done in Leeds. In these behaviours we might see some of the seeds of later industrial decline as family attentions drifted away from profitability and margin. There are few classic 'clogs to clogs' examples in Leeds but, arguably, Kitsons might be one. [99]

3.5 Conclusion

This chapter has shown that,between 1850and 1900, there was a near doubling of the number of Leeds firms engaged in engineering and metal working. This had been facilitated by growth in local population that provided both a substantial local market for metal goods and a labour force; a huge broadening of international and empire markets, and innovation in products to attract new customers and create new markets. That in turn fed the growth of the self-supporting network of firms in Hunslet and Armley making mechanical goods for the world.

The size and commercial momentum provided by the concentration of engineering south of the river Aire supports the description of the major drivers of Leeds growth and diversity in the next chapter. This diversity, first evidenced by the BAAS-associated industrial exhibition which, unlike previous events, was able to fill displays with products solely from Leeds. Innovations created new markets, improved

[99]Weiner, M.J. *English Culture and the decline of the industrial spirit*. p.127: - 'Social prestige was to be found by using wealth acquired in industry to escape it'.

efficiencies and prompted further design ideas. As we will see in the next chapter, in the second half of the century, Leeds engineers made numerous innovations, some famous and influential, others less so.

Appendix 1

Occupational Structure of Leeds 1841 - 1911

		1841	%	1851	%	1861	%	1871 (over 20)	%	1881	%	1891	%	1901	%	1911	%
I	Agriculture	1,543		2,247		2,650		1,789		1,801		2,068		1,675		1,838	
Ib	Animals	22	2.6%	66	2.8%	79	2.8%	86	2.1%	110	1.4%	75	1.3%	0	0.8%	0	0.8%
II	Fishing	3		1		1		4		1		4		1		0	
III	Mines & Quarries	1,082	1.8%	1,798	2.1%	3,439	3.5%	2,764	3.0%	4,063	3.0%	3,210	1.9%	3,829	1.9%	4,897	2.3%
IV	Bricks Glass & Pottery	885	1.5%	1,281	1.5%	1,630	1.7%	1,294	1.4%	2,053	1.5%	2,482	1.5%	3,507	1.8%	3,244	1.5%
	Total I - iv	3,535	5.9%	5,393	6.4%	7,799	7.9%	5,937	6.5%	8,028	5.9%	7,839	4.6%	9,012	4.6%	9,979	4.6%
v	Chemicals & Oils	347	0.6%	748	0.9%	927	0.9%	944	1.0%	938	0.7%	1,578	0.9%	2,024	1.0%	2,545	1.2%
vi	Engineering	3,741	6.3%	7,415	8.8%	12,208	12.4%	13,082	14.4%	18,149	13.4%	21,558	12.7%	28,090	14.2%	33,156	15.3%
vii	Precious Metals	111	0.2%	190	0.2%	299	0.3%	367	0.4%	565	0.4%	806	0.5%	1,149	0.6%	1,430	0.7%
viii	Textiles	22,625	37.8%	28,889	34.4%	28,311	28.7%	17,506	19.2%	22,786	16.9%	22,313	13.2%	18,330	9.3%	20,257	9.3%
ix	Skins & Leather	615	1.0%	1,023	1.2%	1,767	1.8%	2,339	2.6%	3,400	2.5%	3,874	2.3%	3,778	1.9%	3,846	1.8%
x	Dress	4,995	8.4%	9,184	10.9%	9,822	10.0%	9,315	10.2%	16,790	12.4%	30,172	17.8%	34,612	17.5%	39,721	18.3%
xi	Food, Drink, Tobacco & Lodging	2,545	4.3%	4,727	5.6%	5,752	5.8%	6,439	7.1%	8,122	6.0%	10,608	6.3%	13,765	7.0%	16,609	7.6%
xii	Woodworking	968	1.6%	1,546	1.8%	2,078	2.1%	1,957	2.2%	2,638	2.0%	3,063	1.8%	4,117	2.1%	4,501	2.1%
xiii	Paper, Books & Printing	572	1.0%	783	0.9%	1,222	1.2%	1,196	1.3%	2,639	2.0%	4,484	2.6%	6,715	3.4%	8,131	3.7%
xiv	Building	3,148	5.3%	4,179	5.0%	5,665	5.7%	6,768	7.4%	9,138	6.8%	10,525	6.2%	14,725	7.4%	10,189	4.7%
	Total v - xiv	39,667	66.4%	58,684	70.0%	68,051	69.0%	59,913	65.9%	85,165	63.0%	108,981	64.3%	127,305	64.3%	140,385	64.6%
xv	Gas, Water Electricity & Sanitary	34	0.1%	158	0.2%	310	0.3%	487	0.5%	618	0.5%	1,009	0.6%	1,755	0.9%	2,025	0.9%
xvi	Transport	1,756	2.9%	3,483	4.2%	3,910	4.0%	4,782	5.3%	8,108	6.0%	11,400	6.7%	16,102	8.1%	17,083	7.9%
xvii	Commerce	1,073	1.8%	806	1.0%	1,578	1.6%	1,746	1.9%	4,719	3.5%	6,287	3.7%	9,088	4.6%	12,215	5.6%
xviii	Government (Local & National)	238	0.4%	369	0.4%	466	0.5%	636	0.7%	961	0.7%	1,317	0.8%	1,891	1.0%	3,204	1.5%
xix	Defence	370	0.6%	559	0.7%	418	0.4%	509	0.6%	534	0.4%	297	0.2%	519	0.3%	398	0.2%
xx	Professional	1,049	1.8%	1,966	2.3%	2,454	2.5%	2,494	2.7%	4,258	3.1%	5,580	3.3%	6,676	3.4%	7,765	3.6%
xxi	Domestic & other service	6,229	10.4%	7,347	8.8%	9,214	9.3%	8,369	9.2%	13,575	10.0%	14,820	8.7%	15,452	7.8%	15,250	7.0%
	Total xv - xxi	10,749	18.0%	14,688	17.5%	18,350	18.6%	19,023	20.9%	32,773	24.2%	40,710	24.0%	51,483	26.0%	57,940	26.7%
	Total I - XXI	53,951		78,765		94,200		84,873		125,966		157,530		187,800		208,304	
XXII	Others Occupied	5,833	9.8%	5,128	6.1%	4,407	4.5%	6,077	6.7%	9,212	6.8%	12,011	7.1%	10,046	5.1%	8,944	4.1%
	Total I - XXII	**59,784**	100.0%	**83,893**	100.0%	**98,607**	100.0%	**90,950**	100.0%	**135,178**	100.0%	**169,541**	100.0%	**197,846**	100.0%	**217,248**	100.0%
xxiii	Unoccupied	91,842	60.6%	87,918	51.2%	108,783	52.5%	49,211	35.1%	174,657	56.4%	196,588	53.7%	230,898	53.9%	228,543	51.3%
	Total I - XXIII	151,626		171,811		207,390		140,161		309,835		366,129		428,744		445,791	
								119,053	(over 20)								
								259,214									

Source: - Rimmer Industrial Profile of Leeds Thoresby Society Vol 50 1967

Appendix 2

Employment in the Main Locomotive Manufacturing Works in Britain

Railway Workshops (1914)		
Swindon	14,000	
Crewe	7,000	
Stratford	7,000	
Derby	5,000	
Doncaster	4,000	
Horwich	4,000	
St Rollox (Glasgow)	3,000	(1900)
Cowlairs (Glasgow)	2,000	(1895)
Private Constructors (1907)		
North British	8,000	
Beyer Peacock	2,700	
Kitsons	**2,000**	
Vulcan Foundry	1,700	
R. Stephenson	1,200	
Naysmith Wilson	500	

- In 1902 prior to Amalgamation	
Nielsen	3,400
Dubs	2,400
Sharp & Stewart	1,700
	7,500

Source: (ed.) Matthias, P. *Technological Change: The United States and Britain in the 19th Century*
(ed.) Matthias, P. Methuen &Co.,
London 1970.
Chapter 5, *The Market and the Development of the Mechanical Engineering Industries in Britain 1860-1914*. Saul S.B.

Appendix 3

Leeds Chamber of Commerce Occupations of Members

	1851	1860	1873	1880	1890	1900	1910	1920
Industry								
Printing	1	-	-	-	1	2	1	3
Iron/Steel Engineering	4	4	5	6	6	5	4	6
Wool	11	11	12	11	9	11	7	6
Oils/Fats/Soap	1	2	-	1	-	-	1	2
Linen/Flax/Hemp	2	2	2	1	-	-	-	-
Leather/Tanning/Shoes	1	1	1	2	3	4	4	4
Chemicals	-	-	-	-	1	-	1	1
Banking	1	-	-	-	1	-	2	2
Other	3	4	4	3	6	5	7	8
	24	24	24	24	27	27	27	32

Source: *The Leeds Chamber of Commerce*. W.M.Beresford. 1951. p.53

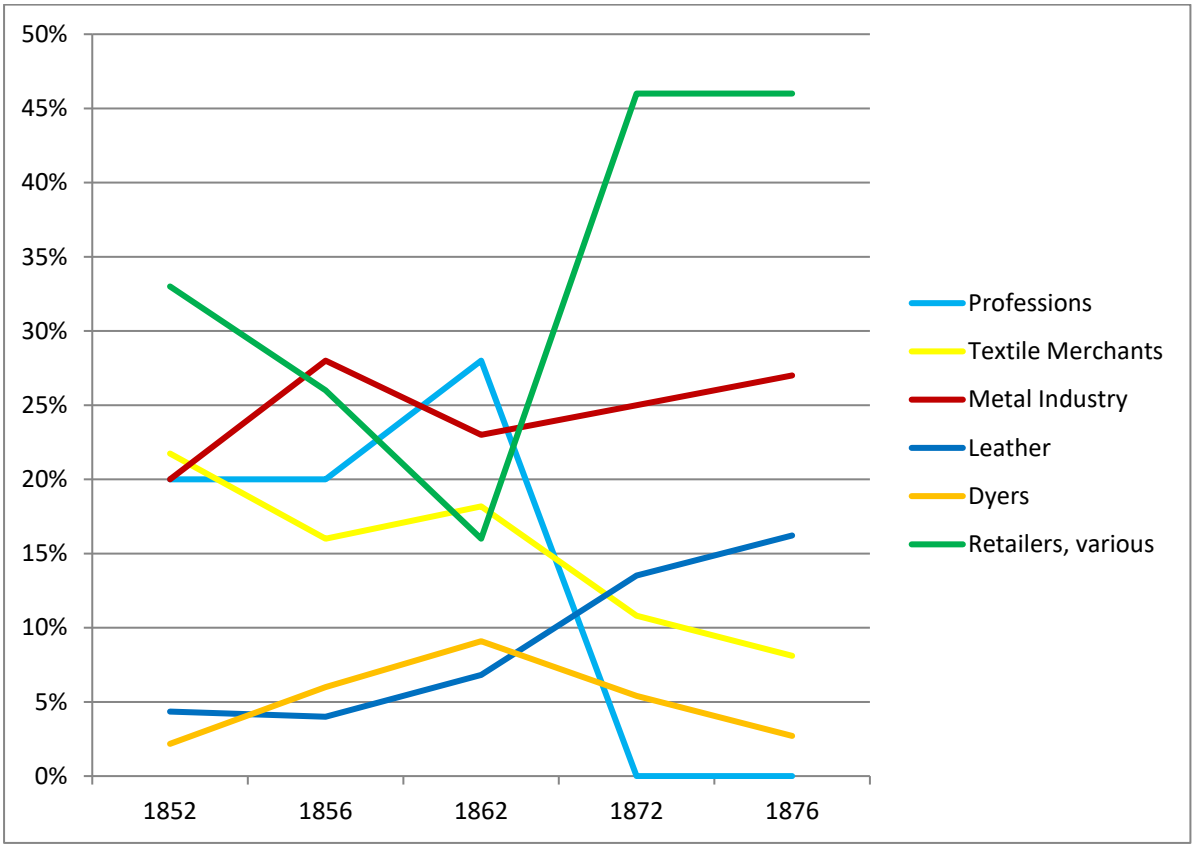
Appendix 4

Leeds Corporation Occupations of Members- 1852 - 76.

	1852		1856		1862		1872		1876	
Doctors	0	0%	0	0%	3	7%	0	0%	0	0%
Other Professions	5	11%	5	10%	6	14%	0	0%	0	0%
Textile Merchants	10	22%	8	16%	8	18%	4	11%	3	8%
Metal Industry	5	11%	8	16%	7	16%	5	14%	6	16%
Metal Industry (Large Firms)	4	9%	6	12%	3	7%	4	11%	4	11%
Leather	2	4%	2	4%	3	7%	5	14%	6	16%
Dyers	1	2%	3	6%	4	9%	2	5%	1	3%
Retailers, various	9	20%	9	18%	5	11%	11	30%	12	32%
Retailers, Food	6	13%	4	8%	2	5%	6	16%	5	14%
	42		45		41		37		37	

	1852	1856	1862	1872	1876
Professions	20%	20%	28%	0%	0%
Textile Merchants	22%	16%	18%	11%	8%
Metal Industry	20%	28%	23%	25%	27%
Leather	4%	4%	7%	14%	16%
Dyers	2%	6%	9%	5%	3%
Retailers, various	33%	26%	16%	46%	46%

Source: - Hennock, E.P. *Fit & Proper Persons*. p.203



Chapter 4

Industrial Change – Innovation and Diversity

4.1. Introduction

Elaborating upon my account in the previous chapter of the significant growth and diversification of Leeds engineering across the second half of the nineteenth-century, this chapter will explain the three main driving forces for that growth and diversity. First, the growing population of Leeds created an expanding local market for metalwork productsand thus, supported the deepening concentration of engineering south of the river Aire in a self-sustaining area. This both attracted and nurtured agrowing skilled population, and which in turn was supported by the co-evolution of civic and educational institutions such as the Yorkshire College. Secondly, growth stimulated by widening national, international and imperial markets for an ever-greater variety of engineering products fortuitously provided broader sales opportunities. Thirdly, aided by the concentration of engineering activity in a specific area south of the River Aire, Leeds engineers developed significant innovation both in outputs and methods which created new customers and new markets for Leeds engineering.

The professionalisation of engineering in Britain across the second half of the nineteenth-century had been assisted by institutions like the Yorkshire College, which had moved engineering from a tactile craft towards a more systematic practice. Trained, skilled and innovative engineers from Leeds also fuelled local enterprise and innovation and attracted engineers from elsewhere to this unusual Leeds engineering environment. Examples of this incoming skilled body of practitioners include the Honourable Charles Parsons at Kitsons Airedale foundry, where he designed and built early versions of his steam turbine, which were sold in 1884 to local firms. [100] Also, in the late-1860s, the sons of the Krupp family of Essen apprenticed at Smith Beacock &Tannett to further their education and practical experience with heavy machine tools and at a similar time, Gottlieb Daimler spent some months at the

[100]Kilburn-Scott,E. *Genesis of the Parsons Steam Turbine*.Distribution of Electricity (Vol. XI.p.209-16. March 1939).

Victoria Foundry. [101]Thus, by the 1880s, Leeds had established itself, both nationally and internationally, as an innovative centre of engineering.

4.2. The South Leeds Engineering Hub.

The early origins of the South Leeds, steam-based engineering hub predate the starting point of this dissertation by about 15 years. The first new locomotive firm to establish itself in south Leeds, alongside the failing Fenton, Murray & Jackson company, was Kitson, Todd & Laird in 1835. James Kitson left the family pub, The Brunswick Arms off Camp Road on the north side of the Leeds town centre, to form the first new firm making steam locomotives in Hunslet, working in collaboration with monied and skilled partners, Todd and Laird. At this time, the Round Foundry was still in operation but making 'stock' engines for Stephenson and steadily losing its skilled people to other local enterprises, such as Kitson and his new business partner and skilled engineer, Charles Todd, who was a former apprentice at Fenton Murray & Jackson. [102]Kitson-Clark suggests that their first intention was to work as jobbing engineers and perhaps do some engine repair work.[103]But, by 1838, they had produced their first steam locomotive, 'The Lion'.[104]

The business grew steadily until the partnership failed and Laird was replaced by Isaac Thompson, a Northallerton iron merchant, and by William Watson Hewitson from Fenton Murray & Jackson. Kitsons grew to be the largest locomotive maker of its time, but there were others clustered around the Hunslet 'engineering hub'. Most influential amongst these was E.B. Wilson at the Railway Foundry. After many changes of partnerships during the 1840s the firm stabilised in 1847 under Edward Brown Wilson. Whilst the domestic, so called 'railway mania' which peaked in 1846 was over, railway companies still needed engines and rolling stock to operate their new lines. Wilson decided to build engines inspired by David Joy's famous 'Jenny Lind' design and created a range of standard engine types. In a departure from the old bespoke design and craft skills approach, Wilson built these engines using common castings and

[101] Rolt, L.T.C. *Victorian Engineering* (1970) p.174.

[102]Fenton MurrayJackson closed in 1843. The site remained unused until 1850 when Smith, Beacock, Tannett moved in.

[103]Sir E. Kitson-Clark. *Kitsons of Leeds 1837-1937 – A Firm and its people by one of them*. p.35.

[104]The Lion can still be seen in the Liverpool Museum.

forging templates. [105] This also meant that,Wilsons could, to some degree, risk making for stock rather than fulfilling specific customer sales orderto improve productivity. The engines were built on a basic assembly line principle in a specially organised erecting shed built over pits and below cranes for easy and speedier access. By reducing the production costs, Wilsons could offer cash strapped railway operators a good deal provided they were willing to put to one side their own more bespoke design ideas. In a further bold move, at least for the times, he also made extended credit terms available.

By 1858, Wilsons Railway Foundry had sold over 600 steam locomotives, mostly of standard design. Wilsons found new markets in industrial premises which were growing larger and by 1854 had designed a range of short wheelbase saddle tank engines that were used to shift material in and around large industrial premises. With further partner and personnel disagreements, Wilsons was dissolved acrimoniously in 1858 and succeeded by Manning Wardle, who used the same site and railway foundry drawings.[106]Two years later, Hudswell Clarke started operations on the other side of Jack Lane from The Railway Foundry and, in 1864, through further dealing by Alexander Campbell -- the E.B. Wilson liquidator -- and another engineer who will later become central to the Leeds engineers munitions plans for the Great War, resulted in the formation of the Hunslet Engine Company. The company occupied the site in Jack Lane for the next 150 years. In cooperation with and partly financed by Kitsons and sharing a Hewitson designed steam engine, Fowlers Steam Plough Works was set up in Leeds, next door to Kitsons in 1859. McLarens, makers of steam traction engines,were also established in Jack Lane at this time.

Best quality wrought iron was available from the Bowling and Low Moor companies south of Bradford and, from 1844 the Farnley Ironworks, which used the same 'Better Bed' ironstone as the Bradford firms, joined Gothards 1772 Foundry at Hunslet Carr as suppliers of premium wrought iron. This, and ready supplies of local coal, invited other engineering firms to the area. In the Introduction to this dissertation, the map of 1860, contrasted with 1820 and then 1900, demonstrated this movement and concentration

[105]Davies, G, Stenton, M, Fitzgerald, R, Kinchin-Smith, R. *Monk Bridge Iron Works*p.13.

[106]The drawings were bought at auction. Wardle knew what he was looking for as the former chief draughtsman at E.B. Wilsons.

vividly. The relative decline in the Leeds woollen textiles industry, as indicated by Cookson, caused by the near disappearance of flax spinning and weaving in the town especially from 1860, reduced the local market for flax machinery and encouraged the search for other (export) markets.[107]Especially as the worsted spinners and weavers of nearby Bradford obtained their machinery from Keighley. The growing size of companies and the realisation of wider markets tempted Leeds engineers to move into the heavy machine tool business. In 1850 Smith Beacock & Tannett started making rolling mill machinery for iron and steel works. Later, Tannett Walker added hydraulic lifting equipment and cranes to their catalogue. Scriven continued to make machine tools and Joshua Buckton in Water Lane moved into ever heavier duty machine tools. Like Greenwood and Batley, Fairbairn Lawson, despite their concentration on textile machinery, also made machine tools, finding a market niche in tools for railway work. Taylor Wordsworth continued making textile machinery in ever greater quantity.

Smith, Beacock & Tannett supplied Samson Fox, their earlier apprentice, with the heavy plant needed to set up the Leeds Forge, which went on to make the world's first pressed, all-steel rolling stock, which transformed the design of goods and passenger rolling stock. Samson Fox, with a lively and innovative cast of mind, made his fortune by designing and patenting his Corrugated Boiler Flue, which with its stronger corrugated cylindrical body enabled engines to go further and faster at higher pressure on the same amount of fuel.Unable to find a domestic market for the larger rolling stock enabled by his invention, he sent his assistant Bernal Bagshawe to the USA to set up factories in Chicago and Pittsburgh and to sell rolling stock to the USA railroad industry. Samson Fox's businesses in the USA and Fairbairn Lawson's establishment of a sales operation in the industrial city of Lille, France provide evidence of the broader view and capital depth of Leeds engineers. [108]

Messrs. Greenwood & Batley, both former employees and partners of Andrew Fairbairn, made munitions and lighter machine tools in great quantity. The further mechanisation in the woollen textiles

[107]Rimmer W.G. *No. 5 The Flax Industry,* Leeds Chamber of Commerce Yearbook 1954. p.177.

[108] The operation survived the German war-time occupation and posted 'catch-up' sales figures for the war years in 1919.

trade in the 1860's saw a great increase in demand for machine tools in the UK. [109] Firms in Yorkshire, in particular, responded to this. Technological and design developments in the USAwere also a stimulus for action. Greenwood & Batley were the first British makers of milling machinery, who sold them to the Enfield Armoury and to Birmingham Small Arms Company.Earlier American imports had been crude and very 'task specific' in their application but, by 1865, milling machinerywith highly versatile rotary cutting action were used in mass production of light and heavy machine tools. In the age of Whitworth's 'Thou' and increased accuracy in all areas of engineering, improved measuring instruments, the turret lathe and twist drills influenced machining significantly. Greenwood & Batley quickly developed a reputation for the quality of their machine tools.

Machine tool-making firms in Leeds, such as Greenwood & Batley,grew across this period, although their growth began to flatten out towards the end of the period. This may have been due to Greenwood & Batley's willingness to undertake more general engineering work; they had a good 'oil department' business making seed crushing machinery and they were still making textile machinery. [110] Uptake of milling machinery in Britain was slow and they sold only 46 milling machines to British users other than armaments firms. Also, along with the sales of machine tools, they engaged in mass manufacture of rifle cartridges, small arms and their components to most of the European imperial armies and, in 1872, they equipped the new Chinese Kiangan Arsenal at Shanghai with the machine tools to manufacture Remington rifles and ammunition. [111] Greenwood & Batley were also involved in manufacturing torpedoes. The Admiralty clearly experienced difficulties with the design and specification of the 'RGF Whitehead Torpedo', which was designed to exacting specifications that prevented other manufacturers from entering the market. Having cut out Greenwood & Batley from the market in 1890, the Admiralty readmitted them in 1896.[112]

[109]Saul, S.B. T*he Machine Tool Industry in Britain to 1914*. Business History, 10:1 1968. p.25.

[110]*Leeds Mercury* 29.05.1890. Wm. Bamford & Sons of Meltham had installed silk spinning equipment from Greenwood & Batley 1885 – 90. Also, Greenwood & Batley had taken over Whithams in Kirkstall Road in the 1889's.

[111]Grant, J.A. *Rulers, Guns and Money*. Harvard University Press, London. 2007.p.29.

[112]Epstein, Katherine C. *Torpedo*. p.41-42.

As late as 1914, Kitsons, despite being specialist steam locomotive makers, still prided themselves on having the skilled workers and machinery to produce any engineering output. [113] This enduring impulse of Leeds engineers to make anything on demand and a concentration on 'institutional' sales to an often capricious Ministry while, at the same time competing with the Royal Arsenal, Woolwich and 'listed' Ministry suppliers may have caused the lack of growth in the last years before the Great War at Greenwood & Batley, but not in the machine tool sector in general. [114]

4.3. Why Diversity?

4.3.1. Population Growth

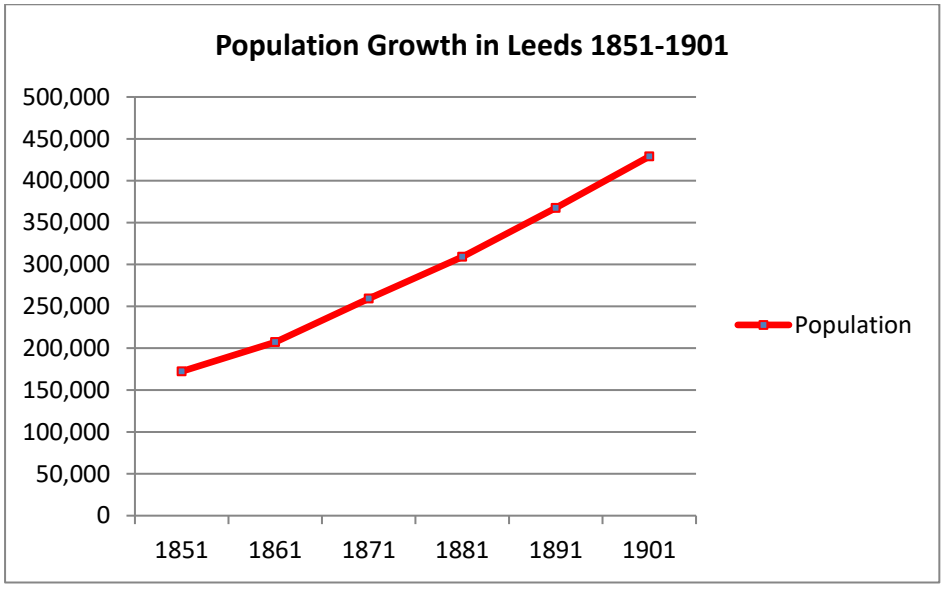
One of the key questions in this dissertation is why Leeds engineering in the later nineteenth-century became so diverse in its operations, in contrast to the more specialist industries in Birmingham, Sheffield and Newcastle. Population growthin Leeds created a wide range of commercial opportunities. For example,the consumption of meat grew. In contrast to the historically larger Wakefield cattle market, which specialised in store cattlethe Leeds market bought cattle for slaughter and consumption. [115] The growing availability of cow hides thus enabled the leather industry to flourish in Leeds and, by 1870, Leeds had become the biggest producer of leather in the country, overtaking Newcastle upon Tyne. This turn of events, and assisted by existing sewing machine makers, led to Leeds becomingthe nation's main centre for heavy industrial and army boots (peaking in 1890).The growth of leather processing also created a market for nails and Blakeys 'Segs' and the machinery to make them along with machinery for cutting leather and heavy-duty sewing. These demands were supplied by Leeds engineers and machine makers, for example Joseph Hall, a Leeds machinery maker specialising in leather processing machinery of all types.[116]

[113]Sir E Kitson-Clark. *Kitsons of Leeds 1837-1937 - A firm and its folk by one of them*. p.171.

[114]Saul, S.B. *The Machine Tool Industry in Britain to 1914.* Business History, 10:1 1968. p.35.

[115]Store cattle are for stock and fattening prior to slaughter.

[116]See Appendix 7.1913 Advertisement for Joseph Hall & Co. showing their wide range of leather working machinery.



Date	Population
1851	172,270
1861	207,165
1871	259,212
1881	309,119
1891	367,505
1901	428,968

(Figure 11) Source: - C.J. Morgan *"Demographic Change"* in D. Fraser (Ed) *A History of Modern Leeds.*

The growth in population also led to an increase in the number of firms making machinery for threshing, food processing and seed crushing for oils and as more houses were built, brick making and stone crushing machinery (see images below).

(Figure 12.) Marsden's Stone Crushing Machinery[117]

(Figure 13.) 1881 Trade Directoryadvert for BrickMakingMachinery.

A similar population-induced development arose with printing in Leeds; the printing industry boomed with cheaper production of paper from wood pulp and the growing demand for all sorts of paper. Newspapers, freed of specific taxes, became more popular as literacy levels increased in Leeds. In the

[117]From the side panel of the Woodhouse Moor statue.

1830s, about 50% of the population could read but, by 1870, just before the Education Act, this had risen to about 80%.[118]With the increased production of 'everything', retailing and marketing became more important, withprinted packaging being central to this venture, as can be seen from examples below.

(Figure 14) Printed Packaging and Poster for Watsons Soap.

As the century progressed paper items became ubiquitous; so much so that under half of the paper used in Leeds was for letter press printing (books and newspapers). In response to this, the number of printers in Leeds grew. There were 42 small operators in 1851 (average of 28 employees), 95 in 1881, and 165 firms in 1911 (average of 49 employees).[119] By the end of the century, Leeds was second only to London as a centre for printing and specialised in high quality colour printing on tinplate, card and paper. [120] Machinery makers followed suit, at first in Otley where it quickly became the main employer and then in Leeds. In 1848, John Oldroyd started his factory. By 1870, six firms were operating, and by 1900, eight firms had begun operations (to Otley's six). These eight firms were operating on a much larger scale than in the 1870s and their market had broadened from the local one. Typical was George Mann & Co. in Elland Road which was employing over 400 people in 1914 and making a profit of £20,000 per year. [121]Adding printing machinery to their 'Sewing Machine Department', Greenwood & Batley also produced their own Patent 'Sun' platen printing machine. [122]The growth of printing in Leeds with the establishment of firms such as Alf Cooks (packaging) and John Waddington (games) and a host of general

[118]Rimmer W.G. *No.29 Printing & Printing Machinery 1.* Leeds Chamber of Commerce Yearbook 1959 p.269.
[119]Rimmer W.G. *No.29 Printing & printing Machinery (2)* Leeds Chamber of Commerce Yearbook 1959.
[120]Fraser (ed.).*History of Modern Leeds*.p.164.
[121]Rimmer W.G. *No.29 Printing & printing Machinery (1)* Leeds Chamber of Commerce Yearbook 1959.
[122]See Greenwood and Batley 1913 advert showing their printing machine. Chapter 5, Appendix 5.

printers provided a solid local market for printing machinery. By 1914, the number of printing machinery firms in Leeds had reduced, but those remaining had grown in size. [123]

4.3.2. Innovation

A characteristic enabler of engineering diversification in Leeds was the capacity to innovate. Initially, Matthew Murray and his successful association with John Marshall enabled a rich period of innovation in textile machinery and more famously, in steam locomotion. His demise in 1826 brought this first phase to a close. By the 1850s, his skilled apprenticessuch as Joy, March and Maclea had moved into other, newer engineering firmsand sparked further innovation in machine tools and steam power. During the first half of the century, innovative change was slow and the direction that innovation took changed. Cookson suggests that innovation in textile machinery continued at a slower pace, whilst innovation in newer steam technology and other machinery gathered pace. [124] During the second half of the nineteenth-century, the market for Leeds engineering became worldwide, firms had grown much larger and engineering people were now of a very different character and skill. Expertise had improved, particularly in machine tools, as evidenced at the Society of Arts Annual Meeting in 1858. During a speech describing the Leeds Exhibition of Local Industry in connection with the first public use of the Leeds Town Hall, Joshua Buckton asserted that:

> In the Machinery room we find a fine collection of engineer's tools, the manufacture of which has now become a most important branch of our local industry, the town of Leeds ranking among the first in the empire in this peculiar branch. [125]

Buckton's assertion above was clearly to his advantage (and that of Leeds). In making it he could not easily have exaggerated this point in front of a knowledgeable national audience of engineers. Also, on display at the exhibition were,a lathe for turning irregularly formed pieces of wood and an endless tape saw' from Greenwood & Batley.[126]

[123]Rimmer W.G. *No.29 Printing & printing Machinery (1)* Leeds Chamber of Commerce Yearbook 1959p.274.

[124]Cookson, G. *The Age of Machinery, Engineering the Industrial Revolution 1770-1850*.p.258-9.

[125]Joshua Buckton's speech to the Royal Society of Arts 08.10.1858 – introducing the Leeds Exhibition of Local Industry. JSA p.670.

[126] The lathe, of interest to the Royal Arsenal for the manufacture of rifle stocks and the 'band saw' soon to be utilised by John Barran.

Diversity in Leeds engineering was also enabled by enhanced technical skill and training. The widespread establishment of drawing offices, particularly at Kitsons and Greenwood & Batley, examined old inefficiencies or shortcomings and designed newer solutions. Such newer design solutions were enhancing the Leeds locomotive industry with refinements in boiler technology and new products such as the steam locomotive tank engine. Similarly innovative were the Scott family's Leeds Steelworks with their innovative 60' (permanent way) rail and Greenwood & Batley with the 'differential cutting lathe' and highly detailed cost engineering of the standard rifle and later, the cartridge.[127]

It is clear when comparing drawings of the Boxer cartridge in 1868 with those of the .303 cartridge in 1914, that the design of the latter had been significantly simplified by using fewer different materials and shaping components differently to employ fewer separate processes. Greenwood & Batley's war-time cartridge department's 'failures' record includes some categories with zero entries. This suggests further association with the Royal Arsenal and the use of 'approved' testing routines, where some categories of failure were eliminated entirely by design changes and newer production methods. [128] It is also apparent from this and his 1868 speech that Harry Greenwood worked on these issues in close collaboration with Mr Davison of the Royal Arsenal, Woolwich.

From 1850, the increasing size of Leeds engineering firms was making it easier for them to invest in innovations. This resulted in many new designs such as David Joys 'Jenny Lind' locomotive. [129]To this, we can add Samson Fox's development of pressed steel railway chassis parts which permanently changed the way rolling stock was built and provided the development groundwork for later pressed steel parts for motor vehicles. [130]Other notable examples of innovation in Leeds include early versions of the torpedo at Kitsons and later Greenwood & Batley to rival the standard 'Whitehead' versionand the idea for a steam turbine to replace the reciprocating steam engine.[131]Kitsons developed the steam

[127]Greenwood, T. Description of the manufacture of the Boxer Cartridge. Institution of Mechanical Engineers 1868. In his notebook of 1864, he gives a very detailed breakdown of each machine, cut, tolerance and timing for the production of a rifle, enabling accurate cost control and scaling of production.

[128]Testing routines and failure records specified by the Royal Arsenal as Greenwood and Batley's customer.

[129]Built at E.B. Wilson in Jack Lane. Designed by David Joy, Chief Draughtsman. 'The new class proved to be so successful that the design was used by Wilson & Co. as their standard design and more than seventy examples were built for various railways.'

[130] Davies, G, Stenton, M, Fitzgerald, R, Kinchin-Smith, R. *Monk Bridge Iron Works.* York Archaeological Trust, 2011.p.15.

turbine while Charles Parsons was employed at the firm. E. Kilburn-Scott, author and engineer and himself an apprentice at Fowlers Steam Plough works and draughtsman at Wilson Hartnell in Leeds, described how Parsons, having patented an early steam turbine design developed this at Kitsons in Leeds where his brother was a manager. [132] Kilburn-Scott wrote: -

> The inventive work of Sir Charles Parsons was on 'virgin soil' and when in 1889 he lost his first lot of patents he straightaway brought out an entirely new turbine having a radial flow and with it in 1892 beat the steam consumption figures of the reciprocating engine. Unlike Watt he was not depending on the work of other inventors.

During his two years at Kitsons, several later versions of his steam turbine design were supplied to local iron and steel manufacturers for driving Brush arc lighting dynamos. [133]

At the start of his ready-made clothing enterprise, John Barran prompted Greenwood & Batley to adapt their band saw into a cloth cutting saw. Here, as with leather, opening a new market prompted the production of different machinery. Barran, with complete serendipity, had come to Leeds from London to work in his uncle's pawn shop in Lower Briggate. He noticed the large amount of clothing being pawned and recognised a market for affordable clothing. Sewing machines had been invented in the United States of America about this time and Barran went into business by bringing together mechanical efficiencies and semi-skilled Jewish immigrant labour that arrived in Leeds after fleeing the pogroms of Eastern Europe. [134]

He made 'ready to wear' clothing in bulk and in 'sets', at first for boys, then for adults. The business boomed and Barren's methods were copied by the many other famous Leeds clothing names like Burtons, Hepworth and John Collier. From the 1870s onwards, employment in Leeds shifted relentlessly towards the clothing industry. Consequently, by 1900, there were five sewing machine manufacturers in Leeds selling to the clothing trade, in addition to the heavy-duty sewing machine manufacture already

[131] Kilburn-Scott, E. Genesis of the Parsons Steam Turbine. 'Distribution of Electricity' Vol. XI March 1939 p.209-16. Also, Epstein, Katherine C. Torpedo, Inventing the Military-Industrial Complex in the United States of America and Great Britain. p.42.

[132] Wilson Hartnell, makers of electric motors in Leeds.

[133] Kilburn-Scott, E. *Genesis of the Parsons Steam Turbine*. 'Distribution of Electricity' Vol. XI March 1939 p.209-16.

[134] Sewing Machine inventor: - Isaac Singer, 1851.

in place for the industrial boot manufacturers, thereby adding further to the diversity of Leeds engineering.

4.3.3. The Widening Market

At the Great Exhibition of 1851, a very small group of Leeds engineers had made strategic decisions to display the specific local metal goods, which both best represented Leeds engineering expertise and which were also best fitted to exploit the growing national and international markets for steam locomotion and power of all types. Although domestic markets were very restricted for independent locomotive makers from the 1850s, various favourable legislative changes were introduced by a succession of industry-friendly UK governments. Perhaps the most significant of these emerged from the demise of the East India Company following the Indian Mutiny (or uprising) of 1857.[135] The British Government then took over the administration of India and a huge imperial market was opened as the British government in India began extending the railway networks to the benefit of British engineering. As Saul notes, 'more was to come with the opening of the Suez Canal in 1869'.[136]

Saul's argument here is amplified later in his work in his contention that, in 1870, Britain accounted for 80% of India's imports. Moreover, the Indian railways were extended under Government contract using money borrowed in London and via a bidding process in which initially only British engineering firms were allowed to enter.[137]Although hardly 'free trade', it is evident that Leeds engineering firms took advantage of these various circumstances: the tables in the Appendices of this chapter show significant volume growth in all the steam engine manufacturers and especially in their 'protected' exports to India.

The table in Chapter 3 Appendix 2 showing employment in railway workshops in 1914 is a good indicator of the volume of work required to keep British domestic railways functioning. However, the whole Hunslet locomotive engine making 'ecosystem' would easily outstrip the North British. With the

[135]Saul, S.B. *Studies in British Overseas Trade 1870 – 1914.* Liverpool University Press. 1960. p.188.
[136]Saul, S.B. *Studies in British Overseas Trade 1870 – 1914.* Liverpool University Press. 1960. p.188.
[137]Saul, S.B. *Studies in British Overseas Trade 1870 – 1914*. Liverpool University Press. 1960. p.198.

widespread increase in import tariffs during the last quarter of the nineteenth-century, all the Leeds engineers began to look towards imperial markets to maintain export volumes. Indeed, it is difficult to see how Leeds engineering could have grown so large without imperial markets, and India in particular.

In 1907, national estimates indicated that 45% of all British engineering outputs were exported. Only 11% of this went to the British Empire, India being the main market. Other key markets in continental Europe were Germany, Russia, France and Belgium. By 1914, the USA textile market was the only such market not dependant on importing British machinery. Standardisation of parts across the textile machinery industry had significantly benefited British manufacturers in this sector. Allegedly, the textile machinery output of Platts of Oldham was equal to the entire output of the USA. [138] Individual Leeds engineering export performance indeed outstripped these national estimates. At a 1913 meeting of the Leeds Chamber of Commerce, Mr F.J. Kitson reported that, of the steam locomotive production in Leeds, 80% was sent to the Empire and India, 15% to other foreign destinations and 5% to domestic customers. Mr. McLaren, of the Midland Engine Works (Traction Engines), stated that 80% of his production was exported; 50% of Leeds textile machinery and 75% of all other machinery were also exported. [139] Unsurprisingly, the Leeds Chamber of Commerce were very much in favour of Free Trade and declared themselves against Chamberlain's 'Imperial Preference' proposals (in 1902) whilst maintaining pressure on government over 'restrictive' foreign import tariffs and, indeed, any factor that lessened profit.[140]

In some instances, however, new business strategies were required for engineering expansion. Due to the vertical integration of domestic railway companies in the UK,Samson Fox could not find an adequate national market for his new pressed steel rolling stock chassis. He, nevertheless,saw an opportunity to trade in the USA and,accordingly,set up factories near Chicago and then Pittsburgh to exploit the growing American market for railway rolling stock and, by producing in the USA, avoided the 'get inside the tariff' that would have been imposed by the USA on these goods had they been imported. [141]Tannett

[138] Mathias, P. *Technological Change: The USA & Britain in the nineteenth Century*. p.142.

[139] Leeds Chamber of Commerce *Minute Books 1909 -21.*

[140] Leeds Chamber of Commerce *Minute Books 1909 -21*. for instance, their comment on the 1911 National Insurance Bill was that the employer's contribution "would prove ruinous."

[141] The young Bernal Bagshawe was sent to America to set up factories in Chicago and Pittsburgh. He contracted the

Walker sent hydraulic dock cranes both to South Wales and New South Wales in Australia. Fairbairn Lawson sent machine tools and textile machinery to India andin 1913, 75% of all the silk spinning and weaving machinery operating in Japan had been made in Armley. Greenwood & Batley made munitions and small arms machinery for all the Imperial European arsenals and specialised in whole factory fit outs, like their contract for the new Chinese Government Arsenal. The local Leeds market of earlier years had become the whole world.

By 1914, the engineering trades of Leeds had taken advantage of national and international markets. These markets were supported by local population growth and Leeds' own technical advancement to produce innovative engineering products made by firms large enough to invest in new products and markets.

4.4. Conclusion

By 1913, the South Leeds engineering hub was thriving with firms both large and small, as evidenced by the Trade Directories listings table shown in Chapter 3 (3.2 Engineering Growth). The number of engineering firms in Leeds had increased from 260 in 1900 to 403 in 1913. The large firms, such as Greenwood & Batley, showed a complex and dynamic outlook, energetically seeking orders and new markets, and reacting to demand and opportunity. Like all firms, Greenwood & Batley sometimes made unfortunate commercial decisions, but they represent an important view of the late-Victorian / Edwardian commercial world and, particularly, the life of engineering in Leeds, where they were not alone in their scale, commercial reach and complexity. [142]Appendix 1 shows the growth in the volume of production at Kitsons, a profile typical of Leeds engineering. Volumes peaked in the 1880s and declined slightly thereafter.

famous railway sales agent 'Diamond Jim' Brady, 'to get inside the tariff'. The phrase used by the *Sheffield Evening Telegraph* 06.04.1904.

[142] For instance, Greenwood and Batley's decision in early 1893, after a brief recovery in profits but persistently reducing annual order value, to have a public issue of shares was unsuccessful coming as it did at the start of the 1893 downturn in trade. See Appendix 6 Leeds Chamber of Commerce Business Cycle 1880-1915.

However, as domestic sales declined sharply, the export trade increased to make up most of the difference. This similar shape is to be seen in the net profit data from Greenwood & Batley in Appendix 2, and in Appendix 4 where the value of total, domestic and export machine tool sales are set out in graphical form. However, in this case, as the Great War approached, domestic sales grew as exports declined. The volume data from Hudswell Clarke can be seen in Appendix 5. Here, volumes grew from the 1880s in line with other local makers, but the influence of domestic sales was more marked in their volume figures than with, say Kitsons. This may be accounted for by their sales of narrow-gauge engines typically for use inside large UK industrial premises. Although the table shows some delivery during 1914-15 of (previously ordered?) engines, the peak during the war is almost entirely caused by their production for the Ministry of War.[143] It will be noted that each company's figures took a serious dip around 1893. Indeed, this may be the reason the Leeds Chamber of Commerce published its 1893 book to distribute to customers to remind them that Leeds was still 'open for business'. The Leeds Chamber of Commerce graphs in Appendix 6 show clearly the major (national) trade depression in 1893. The cause of this was an 1890 crop failure occasioning a failed coup d'état in Argentina and subsequent financial 'panic' in the U.S.A. Whilst the world market was a major opportunity and benefit to the Leeds economy, events in far away places could quickly have damaging local effects and indicates the growing 'globalisation' of commerce and industry.

By the close of the century, Leeds engineering had a thriving export trade, having exploited many national and international markets andhaving developed a momentum which created further growth and even wider variety of engineering trades in the city during the period before the Great War. [144]

[143]For detail see Chapter 6.

[144]The size and diversity of engineering trades in Leeds are compared with Bradford and Newcastle-upon-Tyne in Chapter 5.

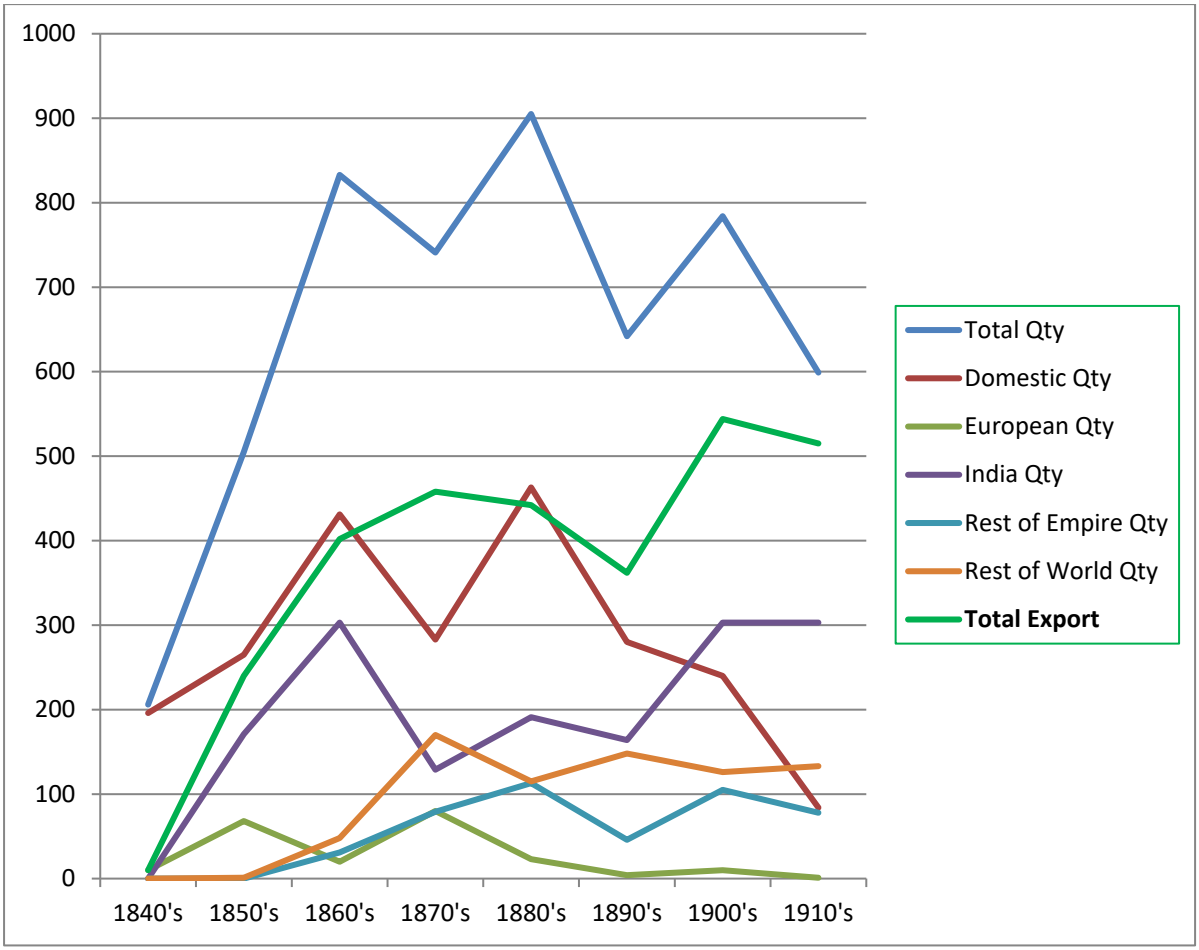
Appendix 1

Kitsons Airedale Foundry

Despatches of Locomotive Engines, Tenders and Trams

1840 – 1920 Totals by Decade

Decade	Total Quantity	Domestic	Total Export	Europe	India	Rest of Empire	Rest of World
1840	206	196	10	10	0	0	0
1850	505	265	240	68	171	0	1
1860	833	431	402	20	303	31	48
1870	741	283	458	80	129	79	170
1880	905	463	442	23	191	113	115
1890	642	280	362	4	164	46	148
1900	784	240	544	10	303	105	126
1910	599	84	515	1	303	78	133
Totals	5215	2242	2973	216	1564	452	741



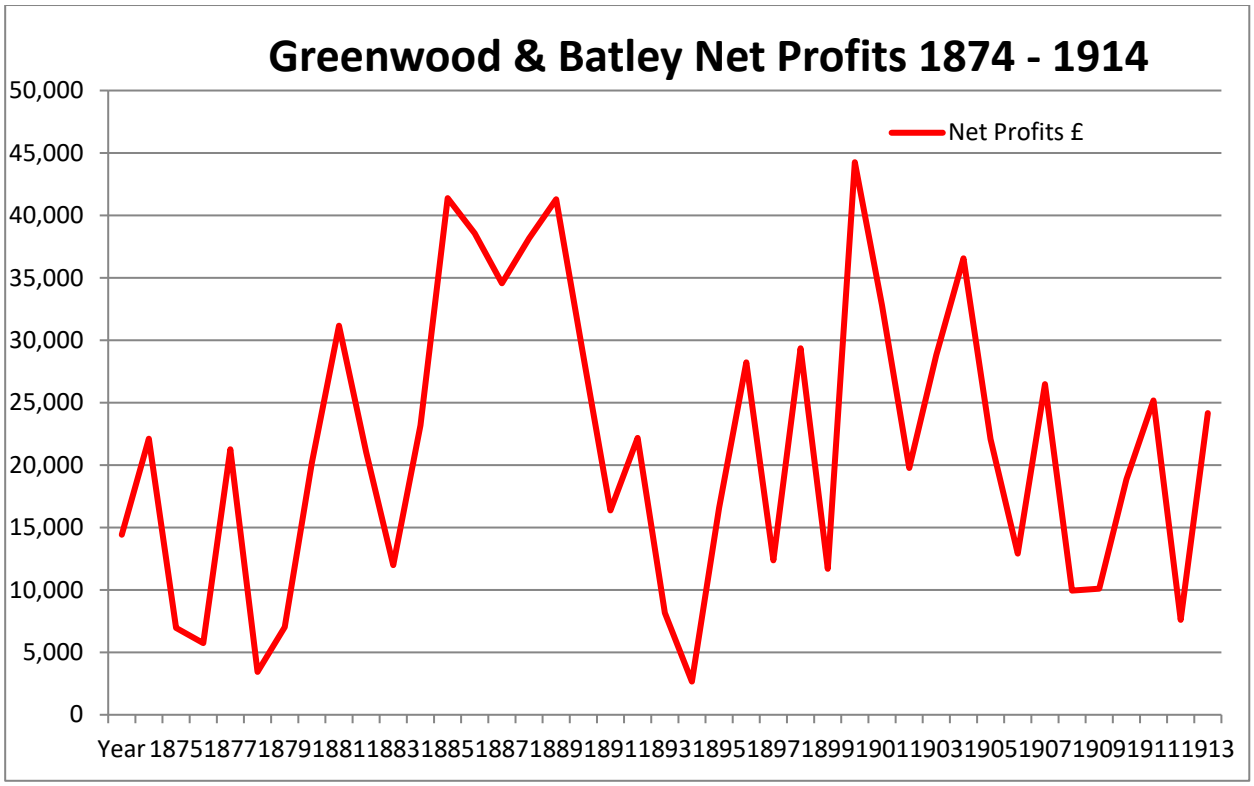
Source data: - Carter, R. *Kitsons Works List.* Industrial Railway Society, York, 1998.
N.B. 1910 figures are distorted downwards by the outbreak of war in August 1914.

Appendix 2

Greenwood & Batley

Net Profits (to the nearest £)

1874 – 1914



Source: WYL298 Greenwood & Batley P&L Account Ledger

Year	Net Profits £				
1874	14,420	1888	34,557	1902	32,780
1875	22,118	1889	38,165	1903	19,765
1876	6,954	1890	41,296	1904	28,813
1877	5,743	1891	28,721	1905	36,556
1878	21,273	1892	16,368	1906	22,070
1879	3,440	1893	22,171	1907	12,907
1880	7,023	1894	8,161	1908	26,490
1881	20,149	1895	2,660	1909	9,948
1882	31,160	1896	16,576	1910	10,101
1883	21,027	1897	28,234	1911	18,859
1884	11,985	1898	12,366	1912	25,175
1885	23,179	1899	29,356	1913	7,597
1886	41,381	1900	11,684	1914	24,166
1887	38,558	1901	44,260		

Turnover in 1910	Net Margin in 1910
128,175	7.9%

Appendix 3

Greenwood & Batley

Machine Tools Made, by type 1856 - 1900

Machine	Variants Qty	Machine	Variants Qty
Lathe	28	Tapping Machine	2
Planing Machine	13	Screwing Machine	4
Drilling Machine	19	Horizontal Boring, Cutting & Milling Machine	1
Milling Machine	29	Slitting Machine	1
Grinding Machine	17	Turning Machine	1
Shaping Machine	10	Dividing Machine	1
Slotting Machine	6	Screw Making Machine	5
Moulding Machine	1	Rifling Machine	2
Press	4	Profiling Machine	`1
Screw Cutting Machine	1	Cutter Sharpening Machine	1
Stamping Machine	1	Chasing Machine	1
Cam Cutting Machine	1	Bolt Making Machine	5
Wheel & Gear Cutting Machine	4	Twist-Drill Cutting Machine	1
Boring Machine	16	File Grinding Machine	2
Punching & Shearing Machine	6		

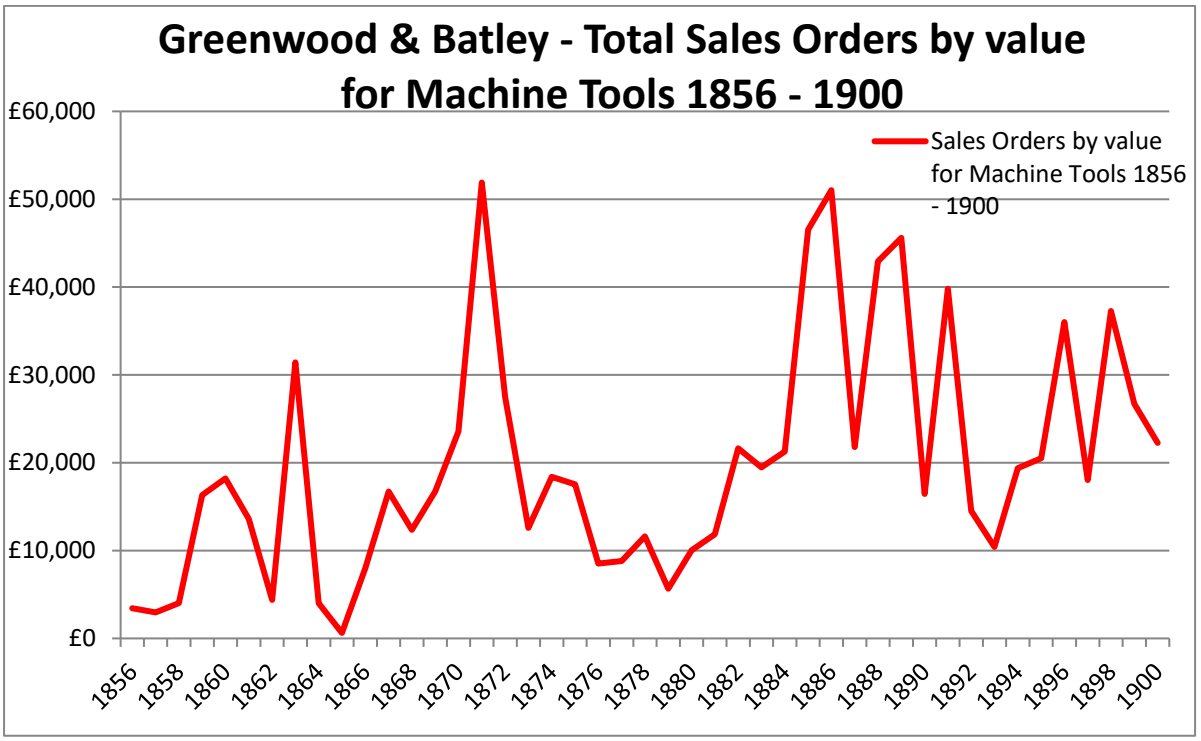
29 Different machines, 173 different variants.

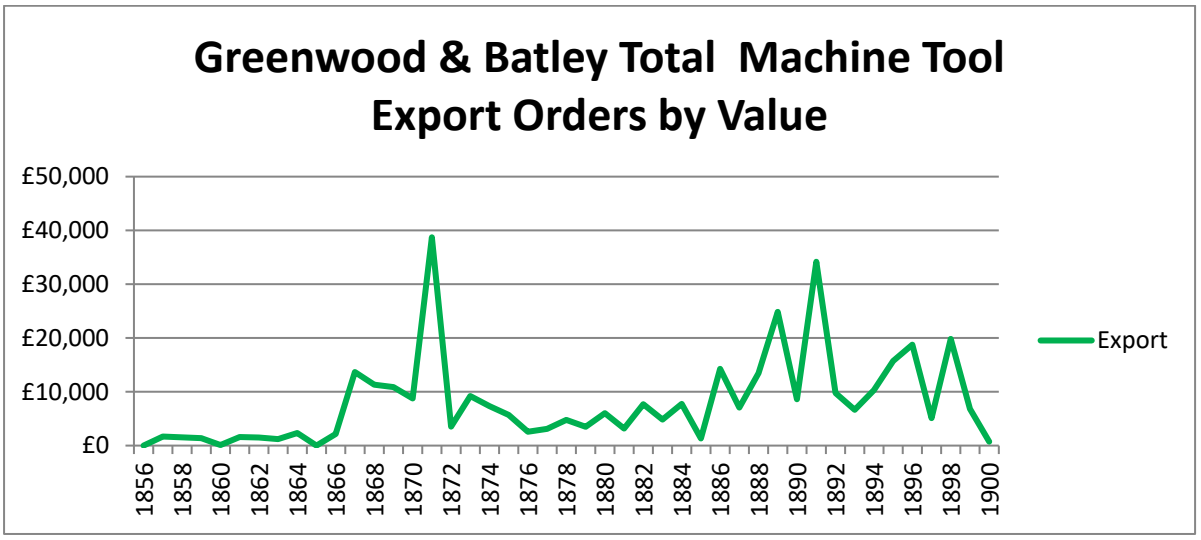
Also worked on and altered: -

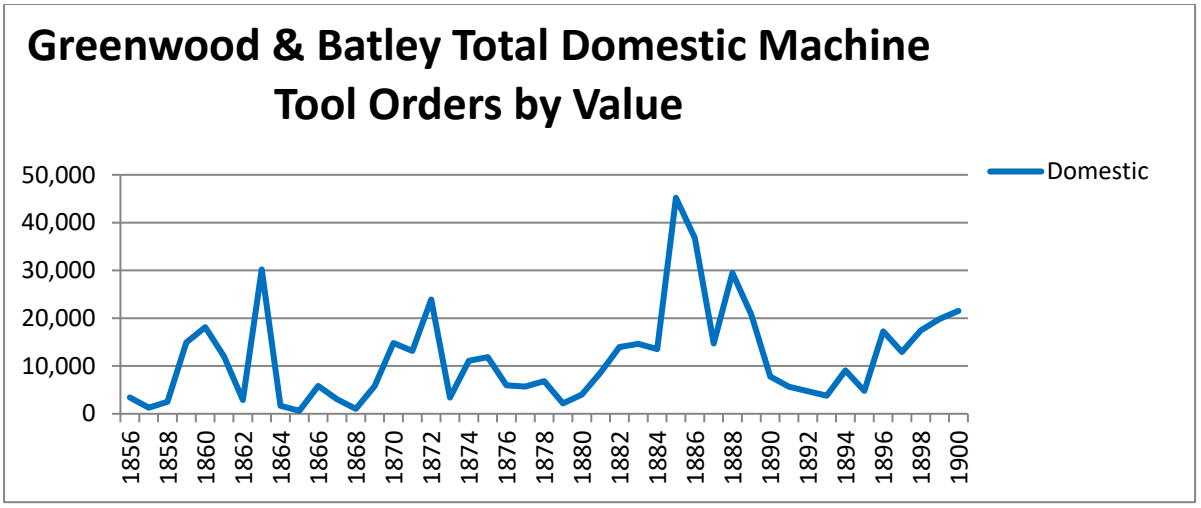
Groove Making Machine	Universal Cutter Milling & Grinding Machine
Sawing Machine	Chamfering, screwing & shaping Machine
Nut & Bolt Making Machine	Gun boring, tracing, rifling & lapping Machine
Threading Machine	Boring, Turning & Rifling Machine
Gear Cutting Machine	

Source: -Flound, R. *The British Machine Tool Industry 1850-1914*
Cambridge University Press,
1976

Appendix 4. Greenwood & Batley – Machine Tool Sales (by Value) 1856 – 1900



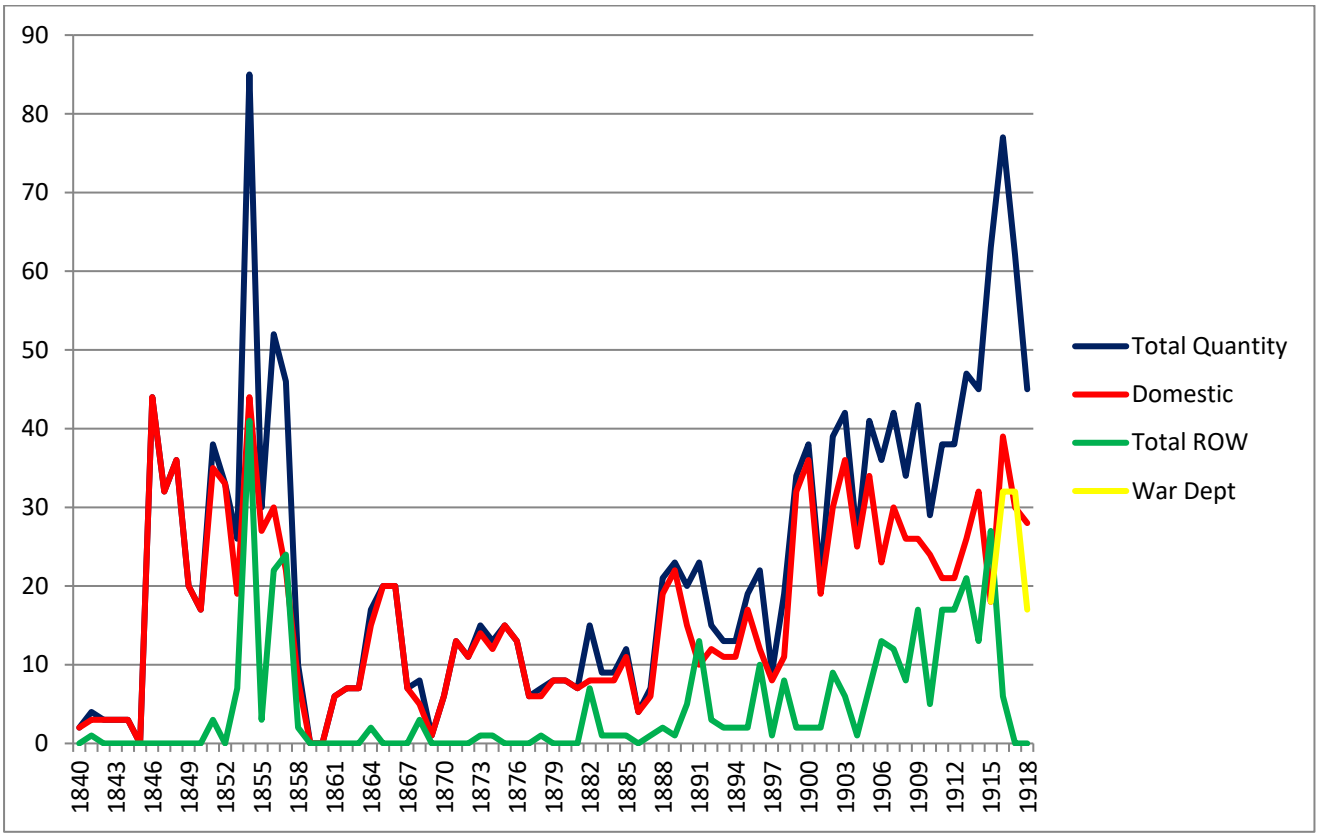




Source: Flound, R. *The British Machine Tool Industry 1850 – 1900*. p.147- 148

Appendix 5.

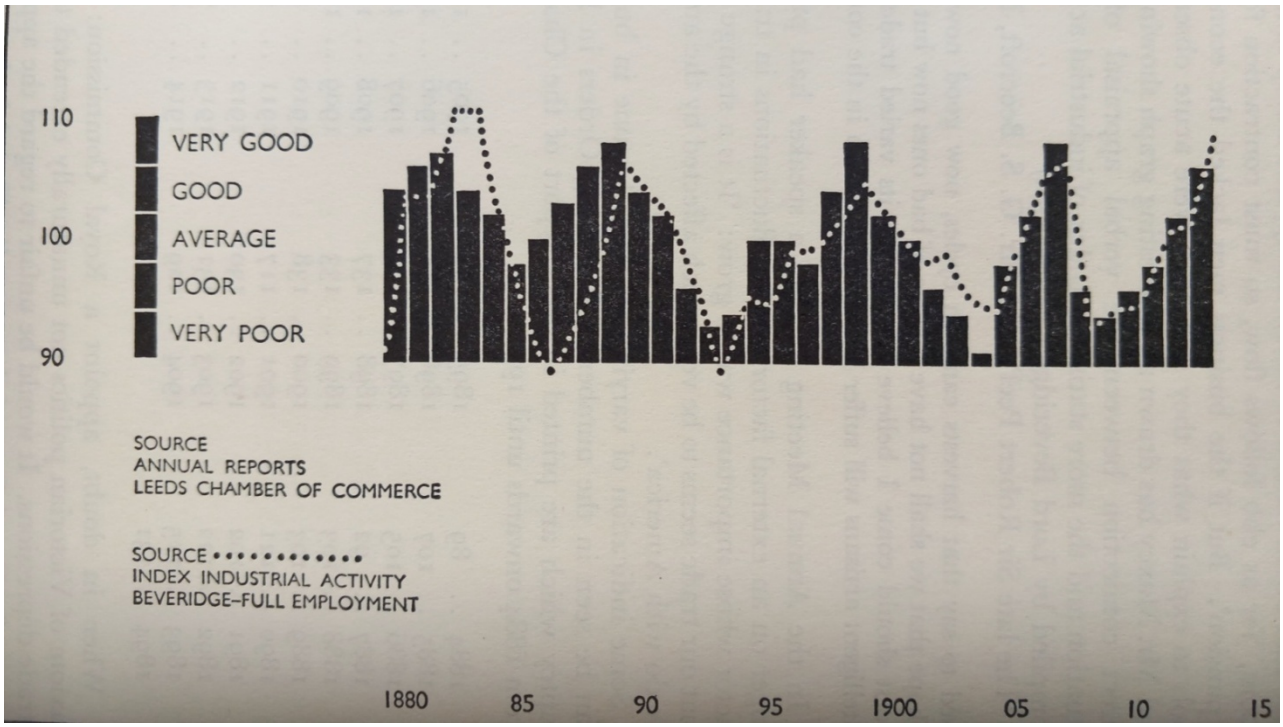
Hudswell Clarke. Production Volume Data 1840 – 1918



Source: Redman, R.N. *The Railway Foundry, Leeds*. Goose & Sons Norwich, 1972

Appendix 6.

The Leeds Chamber of Commerce Business Cycle 1880 - 1915



Source: - Beresford, M.W. *The Leeds Chambers of Commerce*.1951. p.132

Appendix 7

Advert from 1913 Trade Directory for a variety of Tanning and leather working machinery

Appendix 8 Advert for Greenwood & Batley from 1913 Trade Directory.

GREENWOOD & BATLEY,

LIMITED,

Albion Works, LEEDS,

AND AS CARRYING ON THE BUSINESS OF

MESSRS. SMITH, BEACOCK & TANNETT,

AT THE

VICTORIA FOUNDRY, LEEDS,

Engineers and Tool Makers

TO THE

British and Principal Foreign Governments.

Machine Tool Department.—Every description of General and Special Machine Tools for Railway, Marine, and General Engineers. Bolt, Nut, and Screw Machinery. Emery Wheels.

Special Plants of Machinery for the Manufacture of Armour Plates and all kinds of Ordnance; also for Small Arms, Cartridges, and every description of War Material. Coining Presses and Minting Machinery.

Oil Mill Machinery Department.—The "Albion," "Leeds," and Anglo-American systems for extraction of every kind of Vegetable Oil. Presses for making Cattle Feeding Cakes. Seed and Grain Elevators, and Warehousing Machinery. Oil Refineries. Cotton and other Baling Presses. Patent Sack Filling and Sewing Machines.

Textile Machinery Department.—Improved Patented Machines for Preparing and Spinning Silk Waste, Rhea, Ramie, and other Fibres.

Engineering Department.—Frikart's Improved Corliss Steam Engines, for driving Factories, Mills, Electrical Installations, &c.

Electrical Department.—Dynamos and Motors for all purposes, and in all sizes from ¼ H.P. upwards. Installations for Transmission of Power. Complete Tramway Equipments.

Ordnance Department.—Manufacturers of Military Small Arms Ammunition for the British War Department.
Self Propelling Torpedoes (Whitehead's) for the Navy.

Printing and Sewing Machine Department.—Patent Platen Printing Machines. Patent Sewing Machines for making Welted and other Boots. Leather Working Machinery. Cloth Cutting Machines for Wholesale Clothiers, &c.

London Office: **16, Great George Street, Westminster, S.W.**

Chapter 5

Leeds Engineering 1900 - 1914

'One language is common to us all… we can all read a mechanical drawing.'[145]

5.1.Introduction

The last chapter explained the driving forces behind the substantial growth in Leeds engineering over the latter half of the nineteenth-century.In this chapter I will quantify the scale and variety of engineering activities in Leeds during this period and will assess its distinctive characteristics by comparison with Bradford and Newcastle upon Tyne. This chapter will also look at how Leeds engineering, despite being at its zenith in this period with its highly skilled and well-paid workforce, was eclipsed, in occupational terms, by other industrial activity in Leeds.

This chapter will also discuss the absence of national public recognition for Leeds engineering, the shortage of celebration in statuary of engineering and engineers, especially in Leeds itself, and the non-appearance of Leeds engineering in any national spheres of discussion.

I argue that the Leeds engineering elites, with a degree of engrained Yorkshire reticence, did not seek to project a public profile for the city when compared with, for instance, the elites of Manchester who, through the nineteenth-century statuary presented the city as a radical city with a 'world view'. Manchester's statues were of Peel (1850), Cobden (1865), Bright (1865), Gladstone (1901) and later Abraham Lincoln (1919) all of whom were politicians or political thinkers rather than engineers.[146] Birmingham elites, in contrast to Manchester, sought to project a more domestic image; that of having a progressive, well governed local council and commemorated the head of its local political dynasty, Joseph Chamberlain with a Square, a Gothic Memorial and a clock tower all during his lifetime. Leeds (1902), Birmingham (1866) and Manchester (1857) all had their statue of James Watt; a response to

[145]J Hartley Wicksteed, of Joshua Buckton & Co. as President of the Institution of Mechanical Engineersand chairing the meeting inLeeds1903.

[146]Add to this the Free Trades Hall, perhaps the only hall in the country to be named after an idea rather than a person or a place.

Watt's own relentless self-promotion and the liberal view that steam-driven industry was the real winner of the Napoleonic Wars and had 'made Britain great'.[147]

Despite its size and contribution to the national economy,early twentieth-century Leeds engineering remained quiet and uncontroversial both nationally and in Leeds and was usually passed over by news media and any debate outside discrete engineering circles. The diversity in manufacturing and engineering in Leeds had been at least recognised, if made little of, as early as 1858 when Robert Baker wrote:

> For although their freedom from popular tumults depends greatly on their diversified employments, few of which languish simultaneously, yet high wages always consequent on a demand for labour are again consequent on diversified employment, within the same area, which without moral control have often produced in the manufacturing districts of England, outbreaks, expensive alike to individuals and the commonwealth.[148]

Following from Baker's observation and congruent with another downturn in trade, the Leeds Chamber of Commerce Yearbook recorded in 1902:

> The district is favoured by reason on the variety of its industries and the effects of bad trade are never felt to the same extent as in districts which are dependent on one or two industries merely.

It was only inyears of poor trade in 1893 and 1902 that Leeds Chamber of Commerce was moved actively to promote Leeds engineering and its diversity to attract additionalpotential customers.[149] Clearly this was intendedto stimulate trade and tell customers that Leeds was 'open for business' and so diverse that Leeds engineering could meet all kinds of customer requirements.In other years the Chamber of Commerce said and promoted little.

[147]Christine Macleod. *The Invention of Heroes.* Essay in Nature Vol.460, 30th July 2009.

[148]Baker, R. *On the Sanitary economy of the Borough of Leeds.*Journal of the Royal Statistical Society Vol 21 No.4 Dec. 1858 p.434.

[149]These are the only years, 1893 and 1902 that the Leeds Chamber of Commerce produced Year Books until 1913.

5.2. Leeds Engineering – Its Distinctive Diversity of Trades

These early recognitions of diversity in Leeds engineering build towards the 1913Chamber of Commerce Yearbook, which recorded, with a very positive tone in its text, the 62 different aspects of engineering activities in Leeds. I give below the list in the format presented in the yearbook:

(Figure 15)

Gas Burners	Sanitary & Plumbing Appliances	Leather trades machinery	Machine Tools - Testing
Gas Stoves & Cookers	Sawmill Machinery	Degreasing & drying plant	Machine Tools - weighing
Hardware (seamless steel hollowware)	Firewood & fire-lighter machinery	Printing machinery	Machine Tools - Munitions
Spades shovels etc	Cranes	Oil-mill machinery	Perambulators & mechanical toys
Locks	Boilers	Tyres (steel)	Miscellaneous machinery: -
Turret Clocks	Boiler Flues	Portable Railway material (narrow gauge)	Tile making machinery
Wire working	Copper & Brass Tubes	Pumping Machinery	Turbine machines for extracting oil & grease from waste
Boot protectors	Bridge & Structural Steel	Colliery Plant	Chocolate, sweet & soap wrapping machinery
Motor & Carriage Springs	Gas Holders	Agricultural machinery	Paper making machinery
Pulleys	Steel Water mains	Steam Motor wagons	Linoleum making machinery
Nails	Stone & Ore crushing machinery	Generating & electrical plant	Sugar making machinery
Bolts, Nuts, Rivets	Brick making machinery	Locomotives	Grain carrying & elevating machinery
Valves	Woollen & worsted machinery	Railway wagons & carriages	File cutting machinery
Engine packing (i.e. Piston rings)	Flax machinery	Hydraulic Machinery	Turbine pumps & fans
Asbestos covering	Railway wagon & carriage wheels & axles	Forgings	Sewing machines & sack sewing machines
Gas & Water meters	Steel Castings		

The list above helps us to understandLeeds's position as a centre for metalworking, second only to Birmingham. [150] Leeds engineering firms had also changed in shape, with many of them becoming much

[150]Fraser (ed.) History of Modern Leeds p.162.

larger and presenting a wider portfolio of products. The Greenwood & Batley advertisement (see Appendix 5) was typical. By this time, Greenwood &Batley had taken over Joseph Whitham in Kirkstall Road and Smith, Beacock and Tannett in Goodman Street to extend their offerings. [151] Records show that Greenwood& Batley were organised efficiently into specific departments tochannel diversity in designs. Like other large firms in Leeds, they had diversified into the manufacture of electrical equipment and manufactured steam turbines (later employing women in their 'coil winding department')in response to the rise in the electrical power industry. This was not necessarily the case with the smaller firms who still offered bespoke services andmade almost any machine on customer request, therefore, leavingthemselves open to competition from more specialised and efficient manufacturers. The bigger firms were still heavily involved in export markets.For instance, in 1903, as we saw in Chapter 4, 75% of all the silk spinning and weaving machinery in Japan had been made in Armley by Fairbairn Lawson. [152]

Details from the Chamber of Commerce give the following figures: -

(Figure 16) Percentage of Leeds Output Exported, 1914. [153]

Engineering & Machinery	80%
Locomotives	95%
Traction Engines	80%
Textile Machinery	50%
Ready-made Clothing	33%

In dramatic contrast to the 260 firms engaged in metalwork as shown in the 1900 Directory, Kelly's Directory for 1913 supporting the list assembled by the Chamber of Commerce shows that 403 different firms engaged in engineering activities (See Appendix 1).[154] The list from Kelly's Directory for 1913 does not record millwrights (or mill furnishers) as separate enterprises in contrast to 1850 (in Chapter 2). At Fowlers Steam Plough Works in 1914, the staff list had millwrights and electricians grouped together. This would suggest that the increasingly old-fashioned term 'millwright' was used here in a revised

[151]Whithams - where company founder, Thomas Greenwood (father of Harry) had been apprenticed.

[152]WYA (GB205) *Notes on the history of Messrs Greenwood & Batley*. p.2.

[153]Beresford, M.W. (ed.) *Leeds & its Region* p.165 – quotes from Leeds Chamber of Commerce figures.

[154]*Kelly's Directory* lists 439 companies. I have deducted 37 duplicate entries = 402 firms in 66 different engineering trades.

meaning in the context of buildings and machinery maintenance.[155]Unsurprisingly, the numbers from the Chamber of Commerce and those from Kelly's Directory do not quite match, especially as the former was a local listing, and the latter was the product of a sale of advertising space. The figures are not materially different and both clearly indicate a significant growth and a widening diversity in engineering activity in Leeds during the first decades of the twentieth century. This was Leeds engineering at its zenith, with a huge export market for steam related and textile machinery, and a vibrant local market stimulating the production of a wide variety of metal goods.

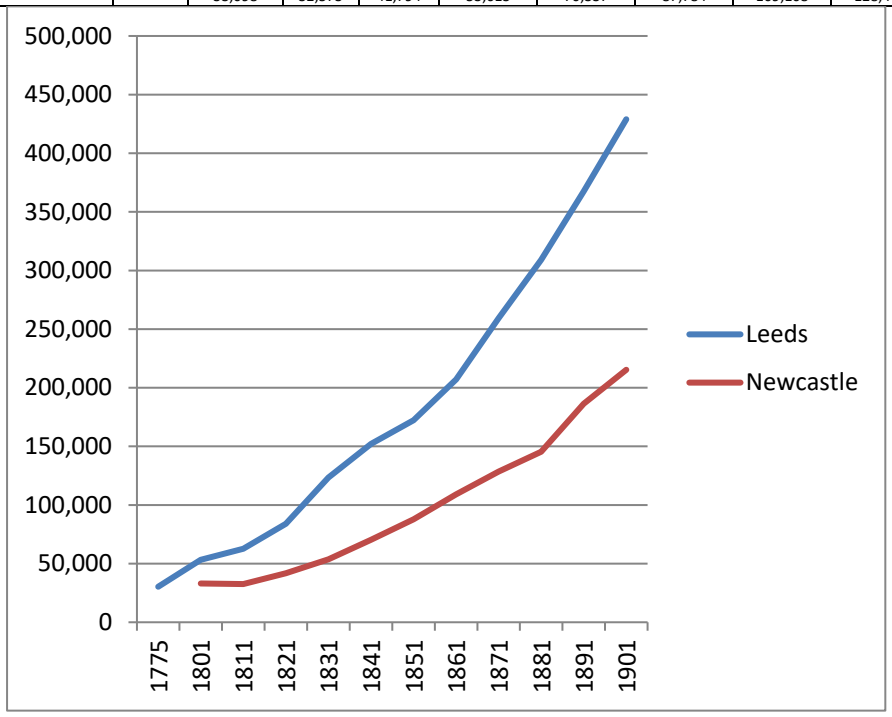
5.3. Engineering in Leeds compared with Newcastle-upon-Tyne

The breadth of engineering activity in early twentieth-century Leeds can be shown as distinctly unusual in comparison to other cities like Newcastle-upon-Tyne and Bradford. In the case of Newcastle, there was a well-developed engineering tradition derived originally from the coal mining industry, where mine owners had over centuries developed efficient mechanical solutions to the problem of digging, boring, moving and transporting coal and slag and draining mines of water. The main activities in the eighteenth-century were the mining of coal and shipping it to London and elsewhere in northern Europe. In addition, the rough handling of rocky coal cargoes wore out wooden ships, quickly stimulating a steady growth in shipbuilding.[156] Given the prominence of shipbuilding, especially after the switch from wood to metal, the trade attracted Charles Parsons to the city (from Leeds) to develop marine versions of his steam turbine. Earlier, the local mining history had influenced thinking in Leeds with the introduction of the Middleton (colliery) railway in 1812 and the collaboration between Blenkinsop (rails), Murray (locomotive steam engine) and Brandling (capital investment as pit owner). They were all from the northeast and steeped in the coal mining industry.

[155]Lane, M.R. *The Story of the Steam Plough Works- Fowlers of Leeds* Table 25.
[156]Colls & Lancaster (eds.) *Newcastle-upon-Tyne – A Modern History.* p.9 -10.

(Figure 17) Population Growth in Leeds and Newcastle-upon-Tyne[157]

	1775	1801	1811	1821	1831	1841	1851	1861	1871	1881	1891	1901
Leeds	30,309	53,276	62,665	83,943	123,548	152,054	172,270	207,165	259,212	309,119	367,505	428,968
Newcastle	-	33,098	32,573	41,794	53,613	70,337	87,784	109,108	128,443	145,359	186,300	215,328



The Leeds engineering trades were, even by 1891, much more varied than those in Newcastle, although the figures from Rowe do not distinguish any trades within engineering associated with ordinance. Admittedly, Newcastle engineering did develop a certain degree of diversity, as evidenced in the Armstrong works. Sir William Armstrong opened the Elswick works in 1847, making iron bridge components and hydraulic cranes (for the Tyneside docks)[158]. The Elswick shipyard opened in 1883 and 84 warships for eight different navies were built there up to 1914, and for ordinance at 'the Gun Works'at Scotswood in 1900. It was said that Newcastle armaments employed 20,000 in 1900 and 25,000 by 1914. [159]

[157]Source: - Census Summary volumes giving current and retrospective numbers at each decade.

[158]See also: - Heald, H. *William Armstrong: Magician of the North,* for more detail on his involvement with Newcastle-upon-Tyne and, via munitions production, the Government.

[159]Forsyth, J. *Scotswood Road.*p.16 – 18. Also, the 1881 census first specified work in Ordinance, sword & bayonet production.

By 1911 the number of people in engineering occupations in Leeds had grown to 33,156 from 21,558 in 1891, an expansion in line with growing company size and the level of diversity described above. The numbers demonstrate that Newcastle, always much smaller in population and diversity of engineering trades than Leeds, was not quite a 'single activity' town. Although military ordinance requireda different set of engineering skills from shipbuilding, both these enterprises werecombined through Armstrong's success in forming a single activity 'armaments' narrative for the town.

5.4. Engineering in Leeds compared with Bradford

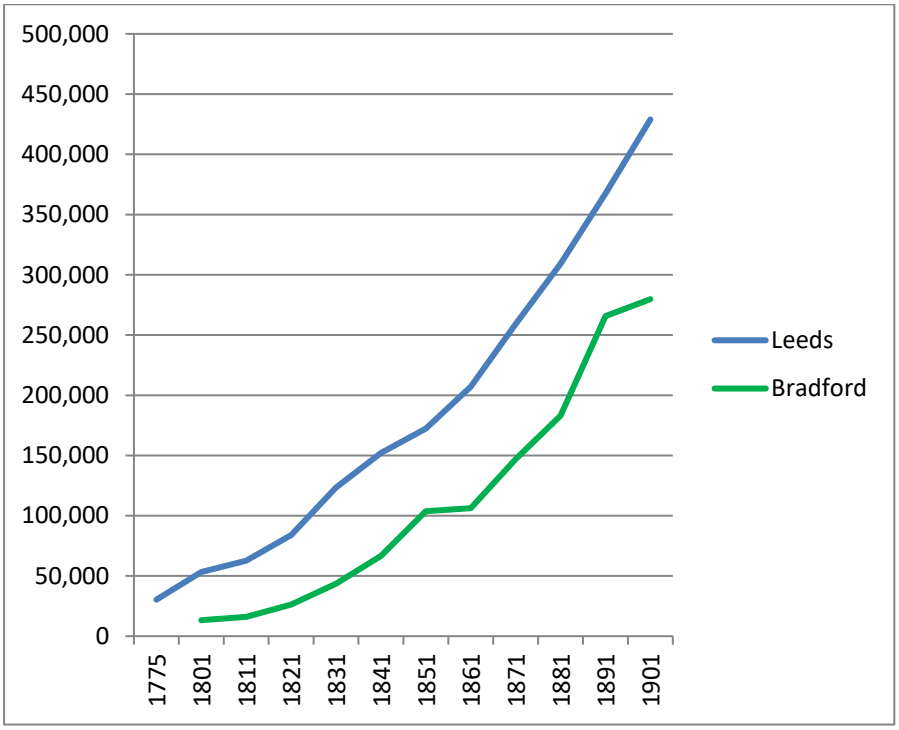
Bradford's industrial base in the nineteenth-centurycomprised of the huge trade in worsted manufacture and its worldwide sale. Engineering trades developed to support these manufactures,but they were much less diverse and more specialised as can be seen in the table in Appendix 4.

While Leeds had, by 1913 66 engineering trades and 402 firms, Bradford in 1908 had well under half the activity with 31 engineering trades and 190 firms (see Appendix 4). Although Bradford could count Low Moor and the Bowling Iron Co. amongst its large metalworking firms, there were few other medium or large sized concerns. Also, some of the engineering trades were specific to Bradford's textiles trade, like the Jacquard Loom Makers, the knitting machine maker and the four loom makers, or were very specialist, like the tap and die maker. The engineering trades in Bradford did not have equivalent local markets to support or the level of population. When comparing Bradford engineering to the main focus of the town we see that, in 1908, Bradford had 853 firms engaged in the cloth trade -- massively more than engineering -- even after allowing for an amount of 'duplication' in the record.

The population differences and growth between Leeds and Bradford can be seen below:

(Figure 18) Population Growth in Leeds and Bradford

	1775	1801	1811	1821	1831	1841	1851	1861	1871	1881	1891	1901	1911
Leeds	30,309	53,276	62,665	83,943	123,548	152,054	172,270	207,165	259,212	309,119	367,505	428,968	-
Bradford	-	13,264	16,012	26,307	43,527	66,718	103,778	106,218	147,101	183,032	265,728	279,767	-



The difference in engineering activity is distinct and by 1901, the population of Bradford was 65% that of Leeds.But the occupational statistics show Bradford moving towardsa predominance of worsted employment. The figures in the table in Appendix 3 show 853 firms engaged in textiles activity in 1908. And even by 1881 the occupational statistics showed a dramatic shift in Bradford towards the cloth trade and particularly worsted manufacture. In 1881, there were 17,789 engaged in Leeds engineering as compared to Bradford's 4,162, whilst in the textile trades employed 18,206 in Leeds and 34,414 in Bradford (See Appendix 4).

Once again it is important to note that the statistics from Census Summary volumes given in Appendix 5 are partial, and the consistency of data collection and interpretation between districts and individual enumerators are sometimes questionable. For instance, Rimmer, using Leeds census returns, has identified 18,149 people engaged in engineering, whereas the national summaries show 14,789. [160] However, these numbers do still allow us plausibly to identify general trends.

The Leeds engineering trades employed many more people than in Bradford in 1881, which supports the trend in growth and diversity seen in the 1913 Leeds figures. Flax manufacture and woollens were holding up well in Leeds at this time, although they were soon overtaken by engineering. Worsted

[160]Rimmer, W.G.*Industrial Profile of Leeds.* Thoresby Society Vol. 50 1967 Table 1. p.137.

manufacture, however, took over in Bradford, with 31.3% of all employees in Bradford working in the worsted trade. The numbers for Bradford engineering firms show a lower level of diversity when compared to Leeds, although these were arguably normal for a town as specialised as Bradford. However, the growing predominance of textiles and particularly worsted in Bradford marks it out as a distinctly single activity town. Leeds was granted city status in 1893 and Bradford later in 1897, which may give an indication of the shifting national prominence between the two new cities.

5.5.Engineering Achievement Celebrated?

By the turn of the twentiethcentury, engineering in Leeds was widespread, large scale and diverse in clear contrast to Bradford. The organic structure of Leeds industry was a powerful source of development. A key factor in the long-term regional pre-eminence of the city was its ability to shift investment into new fields, the interaction between many diverse firms and industries and the support they gave each other.[161]As shown in the Chamber of Commerce tables below, this appreciation applied well to the engineering industry in Leeds and the manufacturing elites who had gained an altogether greater prominence in the city.

(Figure 19) Leeds Chamber of Commerce Occupations of Members

	1851	1860	1873	1880	1890	1900	1910	1920
Industry								
Printing	1	-	-	-	1	2	1	3
Iron/Steel Engineering	4	4	5	6	6	5	4	6
Wool	11	11	12	11	9	11	7	6
Oils/Fats/Soap	1	2	-	1	-	-	1	2
Linen/Flax/Hemp	2	2	2	1	-	-	-	-
Leather/Tanning/Shoes	1	1	1	2	3	4	4	4
Chemicals	-	-	-	-	1	-	1	1
Banking	1	-	-	-	1	-	2	2
Other	3	4	4	3	6	5	7	8
	24	24	24	24	27	27	27	32

Source: Beresford, W.M. *The Leeds Chamber of Commerce.* 1951. p.53

[161]Chartres &Honeyman (eds.) *Leeds City Business 1893-1993.* Their source reference was Ward, M.F. *Industrial Development in Leeds North of the River Aire 1775-1914*. PhD Thesis University of Leeds, 1972. – probably p. 124 – 127 in Ward.

The table above shows the decline in the involvementof woollen trades in the Chamber of Commerce and the rise in the involvement ofmanufacturing. With the reduction of flax owners on the council and the decline of that industry in Leeds points to a dip in the local market for (flax) textile machinery, a point supported by the high export percentages achieved by Fairbairn Lawson.[162]The list of Presidents of the Chamber also indicates strong engineering presence, as follows: -

1900	Mr. E.W Beckett, M.P.	Banking, Parliament & the Law
1901 – 02	Mr. G.R. Portway	Wool Worsted Manufacturers (est.1864)
1903 – 04	Mr. J.H.Wurtzburg	Engineering (Director of Greenwood & Batley)
1905 – 06	Mr. Hyram Barran	Ready-Made Clothing Manufacturer
1907 – 08	Mr. F. Wardle	Engineering – Steam Engine Builder
1909 – 11	Hon. Rupert E. Beckett	Banking & Education
1912 – 13	Mr. J.H. Wicksteed.	Engineering – Heavy Machine Tools (MD at Joshua Buckton)

This list clearly shows the various commercial interests of Leeds supported by professional men, promoted by industrialists and manufacturers, and facilitated by contacts with central government. As we will see in Chapter 6, this familiar and self-supporting community of engineers gathered together very quickly to act positively and promptly when war was declared.

Despite the opportunity afforded by the presence of so much engineering interest on the City Council, this variety of engineering trades was, perhaps for the only time, celebrated publicly during the 1903 Summer Meeting of the Institution of Mechanical Engineers held in Leeds. There were many visits to important Leeds engineering works. Members could take special free tram cars to visit 23 engineering works, each displaying a different engineering trade and a further 16 which were open for special interest visits. As well as opening his own works for visits, Meysey-Thompson, who we last saw in 1882 speaking to the Institution of Mechanical Engineers, was again a fixture on the Leeds organising committee. All these sites displayed aspects of engineering work or the novel use of machinery.
This was as close as Leeds engineering got to celebrating itself on the national stage and in a year when the Institute's President was Mr. J. Hartley Wicksteed, the Managing Director of Joshua Buckton & Co.

[162]Leeds Chamber of Commerce *Minute Books 1909 -21.1913.* 50% of Fairbairn Lawson's textile machinery was exported.

During speeches and toasts over dinner a Mr Maw proposed that Leeds, with the quality of its products and the sterling quality of its citizens had thoroughly earned the position it held in the engineering world. Col. F.W. Tannett-Walker responded with, "one hears a lot about high-speed tools, but I maintain that the best mechanical tool is the workman himself".[163]

Tannett-Walker urged better training, a theme taken up by A.G. Lupton, Chairman of the Council of the Yorkshire College, the development of whose symbiotic relationship with Leeds engineering was discussed in Chapter 3. Lupton emphasised the success of the Engineering Department supported, as it was, by the Institutes local Engineering Committee. It is clear from these remarks that there was a wide engineering population and that Leeds engineers considered themselves a distinct inter-related community supported in the city by its various educational establishments. Their concentration in specific education is evident from the comments made and the leading quote in the chapter which indicates an understanding of a separate set of learning common to all involved in engineering.

Although the Leeds engineers were increasingly skilled and achieved, at least, local prominence, little attention seems to have been given to the important engineering outputs and innovations made in Leeds. The Leeds Chamber of Commerce only advertised Leeds's advantages when trade was bad but by this time Leeds had made more steam locomotive engines than anywhere else in the country, far outstripping all other British producers which, some termed as a 'heroic achievement'. [164] Despite these contributions to the national economy, both in volume and in talent, Leeds and its engineers are entirely absent from both the text and index in the large and richly illustrated coffee table volume celebrating the 150thanniversary of the Institution of Mechanical Engineers, Leeds.[165]

Leeds was not without potential 'industrial heroes' in the Smiles mould, be they inventors, innovators or industrialists but not much was made of them. Even Smeaton and Matthew Murray seemed to have remained largely 'Leeds heroes'. Samuel Smiles, born in Scotland, the editor of the reformist newspaper,

[163] *Proceedings of the Institution of Mech. Eng.* Extract of Minutes: - Notice of Works Visited Summer Meeting, Leeds (1903).

[164] *Leeds Engine Builders* website. p.1.

[165] There is a picture of an invitation to the Institution'Provincial Meeting' in Leeds in 1859, otherwise unreferenced.

The Leeds Times, from 1837 onwards, a Leeds resident until the mid-1850's and the author of *Self He*lp (1859) wrote extensively on inventors and engineers. As we saw in Chapter 1, in his series,*Lives of the Engineers*, he started with civil engineers, gave John Smeaton half a volume with Rennie, then moved on to mechanical engineers like Boulton & Watt and both the Stephensons. In his *Invention & Industry* he praised Murdock,the assistant of Watt & Boulton, with Watt as the inventor of the (condensing) steam engine. Smiles, in his *Iron Workers and Toolmakers* gave an entire chapter to Naysmith, inventor of the iconic steamhammer and one to William Fairbairn of Manchester.

In another chapter, he wrote about Murray, Roberts, Whitworth and Maudsley, all of whom warrant more space. In his description of Murray, he was assisted by information from Mr James Kitson of Leeds and Mr. John Ogden March (Mayor of Leeds, 1863), half of March & Maclea, toolmakers of Leeds and both former Murray apprentices. Here, Murray is credited with inventing the (unpatented) planing machine and the D slide valve. Murray's invention of heckling and gold medal winning flax spinning machinery is listed. Also listed is his improvement to Trevithick's steam engine by giving it a double cylinder, although the fact that at the same time he improved the performance of Watt's condensing steam engine is missed. It is a fair, if brief summary of Murray's work and does give passing mention to his creation of the first working commercial railway locomotive. Whilst this review is not unfair to Murray his innovation is far from emphasised. [166] Rolt, in his book *Victorian Engineering*, moved straight from Trevithick to Stephenson not acknowledging the part played by Watt's condensing engine or Matthew Murray's 'Salamanca' in the development of the locomotive steam engine[167]. Only Kilburn-Scott has acknowledged Murray's contribution to Stephenson. That Stephenson's "Rocket" bears more than a passing resemblance to Murray's 'Salamanca' is explained by Stephenson's visit to Leeds in 1813 to see 'Salamanca' at work and the drawings that Murray sent to Stephenson to assist his design process.[168]

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[166] Smiles, S. *Iron Workers & Toolmakers*. Chapter XIV.

[167] Rolt, L.T.C. *Victorian Engineering*. P.66-67.

[168] Kilburn-Scott, E. *Model of the first commercially successful Locomotive.* 'In September 1813 George Stephenson was in Leeds to see the railway and he also saw the locomotives on Tyneside. His first locomotive [Rocket] was practically a copy of those of Matthew Murray as were others.' Also, in 1815 full line drawings of Murray's locomotive were published in "*Bulletin de la Societé d'encouragement pour l'industrie."* Also, in Bushell, J. *The World's oldest Railway*' p.12-13.

Samuel Smiles, although himself a Leeds resident for a time, hardly emphasised Leeds engineers in his many biographies of eminent Victorians, for example Josiah Wedgewood and J.M.W. Turner. Whilst Smiles gave Murray some detail in a shared chapter, it can be argued the other industrialists and innovators from Leeds, like Kitson, Wilson, Fox, Scott, Joy and Greenwood were more contemporary so less attractive as other 'safe', more historical figures for Smiles to write about even though he was active as a writer into the 1890s. Also, the Leeds men came to 'commercial' prominence after the Victorian statue craze had passed.

Despite the growing prominence of engineers in local elites, as evidenced above, these elites had not celebrated themselves. Statues of Leeds 'worthies' are few and far between. Leeds has, rather conventionally, statues of Queen Victoria**,** the Duke of Wellington and Sir Robert Peel (1852).[169] The Peel statue was an expression of grief by the town council and the newly re-established Chamber of Commerce following his untimely death. Peel, a hero of the Leeds elites,had repealed the Corn Laws in 1846 and Leeds manufacturers were thoroughly, even aggressively, in favour of free trade. [170] Peel's statue in Leeds caught the flood tide of the Victorian craze described in Christine Macleod's work on patents as 'statue mania'.[171] Other Leeds engineers who came to prominence were missed as fashions moved on. If Smiles praised but faintly, a celebratory response from Leeds elites was entirely absent.

The only other statues of note erected in the period were of former Lord Mayors who were significant and well-known engineers, but memorialised for non-industrial reasons,such as Sir Peter Fairbairn in Woodhouse Square and philanthropist, Liberal Mayor, Henry Rowland Marsden on Woodhouse Moor. [172] These were funded by public subscription but not for their industrial or engineering prowess.

[169]Originally placed in Park Row, then moved to the front of the new Town Hall and then removed to Woodhouse Moor in 1937 along with the statues of Wellington and Queen Victoria. The Wellington statue, a gift to the town from Sir Peter Fairbairn. Biographica Leodiensis. p.493.

[170] *Leeds Times* 17.01.1846.Leeds contributed £3,623 to the 'Quarter of a Million League Fund". "The committee of the Leeds Anti-Corn Law Association has great pleasure in announcing the following subscriptions to the above object and earnestly solicit their fellow townsmen who have not yet contributed to do so *forthwith* in order that this Money Demonstration of the energy and determination of the Free Traders of Leeds never to relax their exertions until the Corn Laws and all other restrictions on the import of food are entirely swept away, may be completed before the opening of Parliament". 284 named subscribers are listed, from Marshall & Co. at £1,000 to John Watson at £5 plus sundry others at below £5. It's difficult to find a Leeds industrialist who isn't on the list.

[171]Macleod, Christine. *Heroes of Invention, Technology, Liberalism & British Identity 1750-1914.*

[172]Originally at the junction of Albion Street, Merrion Street and Woodhouse Lane.

Fairbairn's statue was largely in thanks for his time as Lord Mayor and his civic duties, not least of which was the opening of the Town Hall by Queen Victoria. [173] Similarly, Marsden's statue, despite his engineering background was in memory of his mayoralty and in gratitude for his charitable and educational work in Holbeck and Hunslet. The public subscription for the Marsden statue was largely filled by local engineering employees.

Sir Peter Fairbairn, Woodhouse Square

H R. Marsden, Woodhouse Moor

(Figure 20)

Perhaps Smeaton is the only engineer with any current or national profile, although this, given his antiquity, is tending to fade. Some of the others, though local, were clearly deserving of greater acclaim. High on the list must be Samson Fox, inventor of the corrugated boiler flue which revolutionised steam engine capacity, and of pressed steel parts for the construction of railway rolling stock which permanently changed manufacturing methods and was the precursor of pressed steel bodies for motor vehicles.

[173] Queen Victoria and Price Albert were accommodated in Fairbairn's home, the specifically refurbished Woodsley House on Clarendon Road. This was the first time the Queen had stayed in the house of a 'commoner'. n.b. as the royal household moved in the Fairbairn family was moved out for the duration of the visit.

There is also very little mention of Leeds engineering, its firms or its people in local and national newspapers during the period of this dissertation. Prior to 1851 there had been frequent press attention to fires, thefts, disputes and bankruptcies in the engineering trades of Leeds.An example of this is the engineering firm of Zebulon Stirk whose commercial and family vicissitudes were followed eagerly by the press. [174] After 1851 and until the censorship of wartime was applied in 1914, there is little in the press. I suggest there was nothing controversial to write about because Leeds engineering was doing very well. The details in the Appendices in Chapter 4 support this view fully. Also, missing is an appreciation of Leeds's contribution to empire. Marsden and Smith's excellentbook, *Engineering Empires* argues that empires were built on technology and its application through investment in infrastructure more than military conquest. The book, perhaps written with a Scottish readership in mind, centres the arguments on the great city of empire, Glasgow and on James Watt, so symbolic of the steam age. Leeds, a town which made over 19,000 locomotives in the period, more than any other location in the country, and exported most of them to the empireis absent from the text and index. [175]

Leeds elites were not immune from these 'blind spots' either as the City Square redevelopment illustrated. This task was undertaken by Col. Harding in 1902 and presented an ideal opportunity for increasing the profile of the city and celebrating the achievements of Leeds's most prominent industry -- engineering and its engineers. However, Col. Harding's vision for the square was more about civic patronage and classical taste than memorialising Leeds engineers.

[174]35 Stirk related items in Leeds newspapers between 1823 and 1853. *Leeds Mercury* 20, *Leeds Intelligencer* 5, *Leeds Times* 10. Gillian Cookson in *The Age of Machinery,*p.280-282 also has a brief history of the Stirk firm.

[175] Sent especially to India. See Chapter 4, Appendix 1 Kitsons Airedale Foundry – table and graph showing a high volume of Despatches to India.

(Figure 21)
Col Harding, Lord Mayor 1898 **Samson Fox of Leeds Forge**

The statues in Leeds City Square were chosen by the Mayor, Col. Harding to reflect the size and importance of the city and its controlling elites. The effect was intended to show classical taste and demonstrate civic patronage, so a suitably grand equestrian statue was commissioned as a centrepiece. A statue of the Black Prince was available and, despite no connection with Leeds, was installed along with semi naked nymphs (originally holding lamps in honour of the city council's recent electrification scheme) titled ‘Morn’ and ‘Eve’. In addition, there were four statues chosen of local relevance. These were John Harrison, early town benefactor and builder of St. Johns Church; Joseph Priestley, discoverer of oxygen and preacher at the Unitarian Chapel in City Square; Rev. Hook, Vicar of Leeds responsible for the rebuilding of the Parish Church and much educational work; and James Watt. This list was a mixture of ‘negotiations’ in the city council. Harrison was uncontroversial due to his antiquity and obvious benefaction to the city. Hook and Priestley were chosen to placate both Anglican and nonconformist factions in the council; so, Priestley was chosen for his religion more than his scientific enquiry.

Harding paid for the statues of Hook and Priestley, Councillor Boston donated Harrison, and Richard Wainwright, on his deathbed, paid for the statue of Watt. Wainwright saidhe chose Watt to emphasise the strong connection between Leeds and steam engines. No ‘heroes of invention’, nor John Smeaton were celebrated, although Smeaton did feature in an earlier proposal, along with a clothier and pack mule, that was declined. So, even allowing for a reticence to commemorate their living peers the Leeds engineering industry and its engineers were, even at theirpeak of civic pride and the local influence,

were bypassed by the Mayor and Corporation in favour of those with greater antiquity and charitable connection. Richard Wainwright, not a member of the Leeds monied elite but a former engineer himself, might have changed his mind had he realised the angry disagreements between Matthew Murray and James Watt, the famously litigious and inveterate self-publicist, and his son's view of Leeds engineers as "men without character and without means"[176].

Wainwright's view of the prominence of Leeds steam matches the quote from Kirkby below. In T. Kirkby's *Armley through the Camera* (1901), the author has implied, after the manner of Sir Christopher Wren who said, "my monument is all around you", that Leeds engineering did not need monuments because:

> steam is on every sea and on every land… and …. the Samson Fox Corrugated Boiler Flue is now universally used in every Naval and Mercantile Marine and innumerable land boilers. [177]

Is this quotation enough of a Monument? [178] I suggest that Kirkby and Wainwright considered Leeds engineering so ubiquitous and so global that any comment about this obvious fact would be unnecessary.

The only monument in the city, if it can be regarded asone, is the cast iron obelisk over Matthew Murray's grave in Holbeck churchyard where,despite his talent as a mechanical engineer, even he is described as a 'civil engineer'.[179]

[176]Cookson, G. *The Age of Machinery. Engineering the Industrial Revolution 1770-1850.*P88. Cookson'ssource: - Kilburn-Scott, E. *Matthew Murray Pioneer Engineer: Records 1765–1826.*p.42.

[177]Kirkby, T. *Armley through the Camera,* 1901. p.82.

[178]Kirkby, T.*Armley through the Camera,* 1901. P.82-83.

[179]On Matthew Murray's grave: - "The only vestige of beauty in the obelisk over his grave – a construction of cast iron – is that its making was a labour of love by men who had been in his works for years". (Yorkshire Post, Leeds & its history 1926. p.88). Close by are the graves of Murrays apprentices, March and Maclea (both subsequently Lords Mayor of Leeds). Blenkinsop's grave is also his only memorial. Close by the Rothwell church wall it is inscribed: - "Sacred to the memory of John Blenkinsop. Upwards of 23 years steward to the Middleton Estate who departed this life January 23rd, 1831,aged 47 years. Sincerely regretted by all who knew him". Then "The Centenary observed 23rd January 1931". "John Blenkinsop invented the rack railway in 1811 and on a line he builtbetween Leeds and Middleton 4 Matthew Murray locomotives ran from 1812 to 1835. His system was adopted at Newcastle-upon-Tyne in 1813 and Wigan in 1814. These Railways were the first on which steam locomotion was a commercial success".

5.6. Conclusion.

Leeds's engineering had grown and diversified through the exploitation of national, international and imperial markets and, the opportunities provided by growing local markets that demanded new forms of machinery for diverse trades. This was buoyed up by engineering innovations which grew existing markets and created new ones.

However, even as engineering was at its height and, thus, able to make large scale, successful efforts to support the war effort (as we shall see in the following two chapters) it had, in fact, already been superseded in the town in occupational terms by tailoring and the readymade clothing trade. In Chapter 4 Appendix 2 Rimmer's occupational structure in Leeds shows in 1911:

	Employed	
Engineering	33,156	15.3%
Textiles	20,257	9.3%
Dress	39,721	18.3%

The Yorkshire Post publication "Leeds and its History" lists Insured workers in various industries as follows: -

Tailoring	30,837
Blouse & shirt making	1,279
Dress & Mantle making	691
Textiles small wares	510
Total 'Dress'	**33,317**
Woollen & Worsted	8,397
Linen Manufacture	491
Bleaching, Dyeing, making up	1,797
Total 'Textiles'	**10,685**
Engineering (General)	15,085
Iron rolling & forges	2,338
Iron Castings	1,832
Misc. metalworking	1,802
Brass Founding	1,027
Bolts, screws & nails	956
Electrical Motors & switches	306
Brass, copper smelting & rolling	184
Iron & Steel Tubes	150
Engineering (Bridges)	116
Wire & wire rope	115
Total 'Engineering'	**23,911**

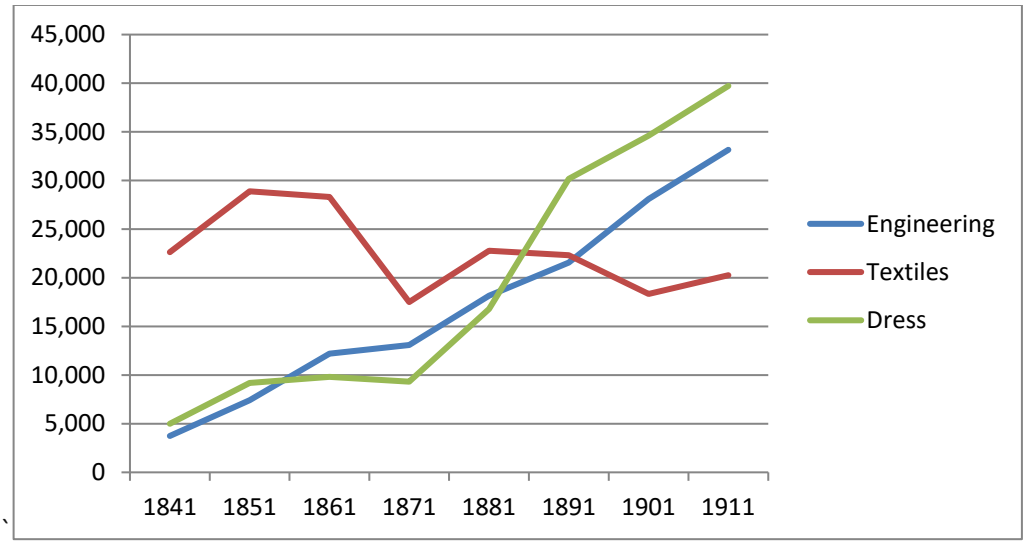
The paragraph groupings in the lists above are my own but whilst the numbers provided by Rimmer and *Yorkshire* Post differ somewhat, they are in broad agreement that 'Dress' had overtaken Engineering as

the major employer in Leeds.[180]The history of Leeds being a local marketplace for woollen cloth, then food, then a nationally important locus for machinery, steam locomotives, tanning, heavy boots and readymade clothing is instructive. The list indicates thatas the next great opportunity came along, Leeds kept reinventing itself. At the zenith of its engineering achievement just before the Great War and the point when Leeds might have become recognised as "the home of engineering", it was already becoming known as the home of readymade clothing instead. The table and graph below illustrate the point. [181]

(Figure 22) Selected Occupational Data – Leeds 1841 - 1911

	1841	1851	1861	1871	1881	1891	1901	1911
Engineering	3,741	7,415	12,208	13,082	18,149	21,558	28,090	33,156
Textiles	22,625	28,889	28,311	17,506	22,786	22,313	18,330	20,257
Dress	4,995	9,184	9,822	9,315	16,790	30,172	34,612	39,721
Total	31,361	45,488	50,341	39,903	57,725	74,043	81,032	93,134

Source:- Rimmer *Industrial Profile of Leeds.* Thoresby Society Vol 50 1967
See Appendix 1, Chapter 3.



Employment in engineering rose consistently across the period as employment in textiles declined. In the 1880s, the decade before engineering overtook textiles, employment in 'Dress' had overtaken engineering and the tailoring trade in Leeds boomed. Dress, i.e. the tailoring trade and ready-mades, first sparked into life in Leeds by John Barran, had overtaken engineering in employment terms by the turn of the century and, despite being not as well paid as engineering and largely north of the river,

[180]*Leeds & its History, 1926* Yorkshire Post Newspapers. 1926 p.70-71.
[181]Details in the table are from: -Rimmer, *Industrial Profile of Leeds.* Thoresby Society Vol.50 1967. Full table in Chap.3 App 1.

became the Leeds signature industry for the next seventy years. Leeds's great engineering history, nearly all physical evidence of which has disappeared, has subsequently become conflated with the 'heritage' world of the steam age and increasingly obscured from general view both physically in South Leeds and in local historical writings and histories of nineteenth-century British industry.

Appendix 1

Kelly's Directory for Leeds 1913

Engineering Activity	Qty
Aeroplane Makers	1 (Blackburns in Telford Terrace, Hunslet)
Axle & Axletree Makers	3 (Kirkstall Forge)
Boilermakers	9
Bolt & Nut Makers	3
Boiler Flue Makers	2 (inc. Leeds Forge)
Boot & Shoe Protectors	2 (Blakeys, Armley & Harry Richmond, Hunslet)
Bottlers Engineer & Machine Makers	1
Brass Finishers	2
Brass founders	20
Brick Making Machinery	3
Cloth Finishing Machinery	2
Clothiers Engineers	1 (Thomas Beecroft, Meanwood Rd. Sewing Machine Manufacturer)
Crane Makers	5
Cycle Engineers	2
Cycle Manufacturers	34
Electric Motor Manufacturers	2 (Greenwood & Batley, Armley. Hartnell Wilson & Co. Kirkstall Road)
Brewers Engineers	1
Civil Engineers	40 (including Mining & Consulting Engineers)
Chemical Engineers	1
Agricultural Engineers	1 (Fowlers Steam Plough Works)
Colliery Engineers	1 (***Fowlers Steam Plough Works***)
Constructional Engineers	2
Electrical Engineers	50
Gas Engineers	7
Gas Lighting Engineers	2
Gas & Oil Engineers	1 (J. Best)
Hot Water Engineers	9
Hydraulic Engineers	8 (inc. H. Berry, Hawthorn Davey)
Lighting Engineers	1 (Stott)
Mechanical Engineers	93
Printers Engineers	5
Textile Engineers	2
Ventilatory Engineers	8
Flanging Machinery Makers	1 (***H. Berry***)
Gas Engine Makers	3
Gas Holder Makers	1 (Claytons)
Iron Founders	16
Iron Manufacturers	5
Iron Masters	4 (***all duplicates of Iron Manufacturers***)
Iron Gate & Fence Makers	3
Iron Bridge Makers	1 (John Butler & Co. Stanningley)
Iron Roof Makers	1
Locomotive Engine Makers	2 (Hudswell Clark, Manning Wardle)
Lock Makers	3
Litho Printing Machine Makers	1 (George Mann)
Machine Tool Makers	4 (***Greenwood & Batley***, J. Buckton, Campbell & Hunter, Scriven & Co.)
Mill Furnishers	8
Oil Mill Machinery Makers	2 (***Greenwood & Batley***, Middletons)
Pumping Engine Makers	1 (Hathorn Davey)

Railway Rolling Stock Makers	1 (***Leeds Forge***)
Railway Wagon Makers	2 (Midland Rail, Sturdy & Sons)
Railway Wheel Makers	2 (Leeds Wheel & Axle Co., Schoen Steel Wheel Co. Bramley)
Riveting Machine Makers	1 (***H. Berry***)
Sheet Metal Workers	1
Steel Manufacturers	5 (inc. ***Kirkstall Forge***)
Steel Founders	1 (Towler, Water Lane)
Steel Castings	1 (Cattons, Hunslet)
Steel Girder Makers.	1 (Barr, Hunslet Rd.)
Stone Breaking Machinery	2
Stove, Grate & Range Manf.	2
Tank Makers	1 (Leeds & Bradford Boiler Makers Co.)
Testing Machinery	1 (Samuel Denison, Moor Rd. Hunslet)
Tool Makers Engineers	1
Traction Engine Makers	1 (***Fowlers Steam Plough Works***)
Tube Manufacturers	1 (Yorkshire Copper Works)
Steam Turbine Makers	1 (***Greenwood & Batley, Armley***)
Woodworking Machinery	1 (Wilson Bros., Victoria Rd.)
Whitesmiths	29

439 company records minus 37 identified duplicate entries = 402 in 66 different Engineering trades (N.B. duplicated company entries identified in bold italics).

Appendix 2

Occupations in Newcastle 1851 and 1891

	1851		1891	
Occupation	No.	%	No.	%
Food & Drink	3,381	11.0%	5,891	9.5%
Services (Legal etc)	694	2.3%	1,821	3.0%
Shipbuilding	608	2.0%	2,124	3.4%
Building	2,908	9.4%	5,429	8.8%
Clothes & Shoes	4,927	16.0%	7,217	11.7%
Blacksmiths & Metalworkers	2,619	8.5%	4,534	7.4%
Engineers	1,034	3.4%	7,130	11.6%
Horse & horse Transport	960	3.1%	2,761	4.5%
Coal	511	1.7%	1,059	1.7%
Glass, Pottery, Chemicals	1,398	4.5%	893	1.4%
Sea & Boatmen	2,078	6.7%	1,555	2.5%
Agriculture	633	2.1%	500	0.8%
Govt Service	141	0.5%	469	0.8%
Labourers	2,540	8.2%	4,911	8.0%
Teachers	372	1.2%	1,123	1.8%
Domestic Service	5,356	17.4%	9,917	16.1%
Railway Service	427	1.4%	1,678	2.7%
Commercial/Business Clerks	253	0.8%	2,674	4.3%
	30,840	100.0%	61,686	100.0%
Totals quoted in source are incorrect	*38,784*		*78,708*	
	1851		**1891**	
Shipbuilding	608	2.0%	2,124	3.4%
Blacksmiths & Metalworkers	2,619	8.5%	4,534	7.4%
Engineers	1,034	3.4%	7,130	11.6%
	4,261	13.8%	13,788	22.4%

Original Source: - Rowe D.J. *Occupations in Northumberland & Durham 1851-1911*. Northern History Vol. VIII (1973)

Appendix 3

Bradford Engineering

1908

1	Boilermakers	3
1	Brass finishers	7
1	brass Founders	20
1	Clog irons	2
1	Cycle engineer & Makers	1
1	Electrical Engineers	21
1	Engineers - Agricultural	1
	civil	11
	consulting	3
1	Engineers - Mechanical	54
1	Engineers - Printers	2
1	Tool Makers	1
1	Gas Engine Makers	2
1	Gas Fittings Makers	1
1	Iron Founders	17
1	Iron Masters	1
1	Iron Girder Makers	1
1	Iron Plate Workers	4
1	Iron Roofing Makers	2
1	Iron Tank Makers	2
1	Iron Bridge Makers	2
1	Joiners Tool Makers	1
1	Knitting Machine Manuf.	1
1	Machine Tool Makers	4
1	Loom Makers	4
1	Millwrights	6
1	Motor Engineers (car)	3
1	Railway Wagon Makers	1
1	Tap & Die Makers	1
1	Steam engine Makers	2
1	Stove & Range makers	2
1	Textile Machinery makers	3
1	Whitesmiths	18
31		**190**

Bradford Cloth Trade

1908

Finishers	18
Spinners	3
Stuff Manufacturers	156
Woollen Merchants	264
Woolstaplers	23
Woollen Manufacturers	20
Woollen Merchants	59
Worsted Spinners &Manf.	168
Worsted Yarn spinners	77
Yarn Merchants	65
	853

Source: *Kelly's Directory 1908* – Bradford Trades

Appendix 4

Comparative Occupations – Engineering in Leeds and Bradford

Employment numbers in Engineering Trades - National Totals 1881

Source: - National Census Abstracts & Summaries - various years containing data for 1881

	National	**Leeds**	%of Nat.	**Bradford**	%of Nat.
Boilermaker	26,170	688	2.6%	139	0.5%
Bolt makers		173		26	
Brass Finisher		-		-	
Brass Founder		328		122	
Engine & Machine maker	38,481	2,114	5.5%	365	0.9%
Engineer & Engine worker		-		-	
Factory Worker		-		-	
Founder		-		-	
Iron Founders		-		-	
Iron Manufacture (National Qty = 'Other I & S)	200,677	6,331	3.2%	1,549	0.8%
Iron Master		-		-	
Machine Makers		-		-	
Manufacturing or Manufacturing Machinery		-		-	
Mechanics		-		-	
Millwrights	6,940	282	4.1%	60	0.9%
Nail Making	9,603	445	4.6%	11	0.1%
Tin men/Smiths/Tin Plate	32,392	342	1.1%	181	0.6%
Whitesmith	8,212	200	2.4%	107	1.3%
Wire Worker	8,722	82	0.9%	35	0.4%
Fitter	64,663	2,281	3.5%	484	0.7%
Gunsmiths	7,741	10		3	
Ordinance + Swords/Bayonets (+'other')	486	0		0	
Rail Carriage makers	7,512	37		18	
Spindle & Weaving Machine Makers	19,896	1,114	5.6%	1,047	5.3%
Tool Maker	9,162	362	4.0%	15	0.2%
Total employed in Sample in Engineering Trades		**14,789**		**4,162**	
Clothier		-		-	
Cloth Merchant		-		-	
Dying (all cloths)		-		-	
Flax Manufacture (All stages)	12,065	3,501	29.0%	16	0.1%
Linen Manufacture		-		-	
Stuff Manufacture		-		-	
Weaver		-		-	
Weaver - Power Loom		-		-	
Wool dealer & Staplers		136		479	
Cloth manufacture (woollen)	115,808	12,239	10.6%	2,098	1.8%
Worsted manufacture	99,247	1,600	1.6%	31,059	31.3%
Cotton Manufacture		-		-	
Textile Factory Hand		730		762	
Total Employed in Sample Textile Trades		**18,206**		**34,414**	

Chapter 6.

‘Men of Push and Go’ - Leeds Engineers’ Influence on National Munitions Policy

> Present ammunition in equipments and reserve have been held to be sufficient to meet the requirements of the E.F [Expeditionary Force] in the field for 6 months, but unless orders are placed I cannot guarantee that there will not be a deficiency when the first six months of war are over.[182]
>
> When the Shell crisis broke certain gentlemen in this country had already done the work, and that an organisation to produce not only munitions for ourselves but eventually for nearly all our allies had been started.[183]

6.1. Introduction

This chapter presents an account of how the extraordinary diversity of engineering activity in early twentieth-century Leeds enabled the city’s engineering firms to respond so quickly and flexibly to the demands of armaments manufacture during the Great War. To show how this was accomplished by the collective expertise of the Leeds engineering community, I analyse the composition of the wartime engineers on the Leeds Board of Management Committee. I then show how that committee exercised significant influence in reshaping the UK’s national munitions policy in the spring of 1915. The Leeds Committee was officially appointed by the War Office to run the National Shell Factories (NSFs) in Leeds and its linked committee to run the National Shell Filling Factory in Leeds (NSFFs). Furthermore, I show how that committee coordinated the outputs of the wide variety of Leeds engineering firms which served as suppliers of parts and sub-assemblies to the national factories in Leeds. I thus disclose, perhaps for the first time, the effect that the skill and dynamism of Leeds’s engineering management had on national munitions policy at a critical time in the nation’s history.

[182] Adams, R.J.Q. *Arms and the Wizard.* p.1-2. From the Master General of the Ordnance, Major General Sir Stanley von Donop to the Prime Minister H.H. Asquith. 01.08.1914.

[183] Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*. p.28.

The Leeds Board of Management Committeecomprised John McLaren of The Midland Engine works; Bernal Bagshawe of Leeds Forge; Christopher James of Joshua Buckton; Alexander Campbell of Hunslet Engine Co.; and A.H.Meysey-Thompson, a figure central to Leeds engineering throughout the period. [184] The NSFF committee comprised Joseph Watson, Rupert Beckett, Bernal Bagshawe, Arthur Lupton, T.L. Taylor and Major G. Yewdall. The members of both committees had particular skills and experience relevant for the objectives of each committee. I suggest that the presence of Bernal Bagshawe on both committees, with his experience working for Leeds Forge in the UK and the USA (as detailed in Chapter 4), was recognition by the other committee members of his particular energy and skills that could be used to fulfil the objectives of both committees.

My chapter title, using the famous phrasethat Lloyd George coined to describe the sort of men he needed in challenging times to run the new Ministry of Munitions,may be also applied to the engineers on the Leeds Board of Management.[185]They controlled all Leeds engineering outputs for much of the war, and with their forward thinking, energy and clarity of vision, they gave central government a finished plan for the most efficient organisation of munitions outputs. Thisprompt action made an early and profound impact on national munitions policy during the early months of 1915. This chapter reveals the names of, and the parts played by, the Leeds engineers who made this unique contribution to national policy at a critical point in the nation's history. They enabled the nation to transition from, one of 'business as usual' (the first quotation at the head of the chapter) to the second quotation, from Archbald, indicating a planned concentration and efficient use of resources.

Leeds contributed considerably to the Great War through it's prominent metalworking enterprises, second only at that time, to Birmingham, comparisons to which will be compared in this chapter. Leeds

[184] These same committee members also comprised the Leeds National Shell Factory (NSF) committee.

[185]Adams, R.J.Q. *Arms and the Wizard.* P.39 (Footnote 4). A phrase used by Lloyd George on 09.03.15 in a Parliamentary speech about the third Defence of the Realm Act and in support of the proposed Ministry of Munitions. p.39, "men capable of vast exertion, both mental and physical necessary to overcome the vast task before them". Also,The Ministry of Munitions was created by the Munitions of War Act 1915, passed on 02.07.1915 with Lloyd George as the minister of Munitions. Lloyd George had been active in the physical build-up of the Ministry during his earlier membership, within the Ministry of War, of the 'Armaments Output Committee from 31.03.1915 and his tenure as Chairman of the Munitions of War Committee from 08.04.1915 a committee with wide powers prefiguring those of the Ministry of Munitions.

possessed the necessary labour, housing, railway links and the engineering infrastructure for a wide variety of specialisms within a concentrated area where engineering managements knew each other and their firms. As prominent producers of small arms and ammunition, Greenwood & Batley had long established links with the Ministry. Virtually every other medium and large firm had its forge department and steam hammers which could be quickly re-tooled to forge (hot or cold) shells and other parts. This can be seen in the case of Fowlers (Steam Traction works) which closed for a week in September 1914 to reorganise their machinery onto 'a war footing' by retooling the machine shop to enable shell turning. The Leeds Management Committee concentrated lathes and other machine tools for shaping, boring, milling, tapping and threading were concentrated in appropriate locations. The engineering workforce in Leeds was skilled and experienced in operating all these machines. However, initially, skilled men were shown the specific techniques and accuracies of shell production, on a 'train the trainer' basis to provideappropriate supervision as 'dilution' of the workforce with unskilled and female labour progressed. The variety of engineering activity already in Leeds assisted in munitions manufacture. Brass moulders and iron founders were plentiful and firms like Braime who, as experienced copper workers, were able to provide shell components immediately. Like other Leeds firms, they spotted an opportunity to apply better methods, went on to improve the production process and use of materials, and spread 'best practice' nationally.

This chapter will show, first, the Leeds management Committee developed plans for NSFs and NSFFs and put them before national government in a timely manner. Secondly,this chapter will analyse the creation of the NSF and the NSFF. Thirdly,this chapter will compare the Leeds'sbased national Factories with that of Birmingham, which, at the time, was a larger metal working centre. Adding to several incomplete secondary sources, the chapter will also discuss the variety of other Leeds munitions production.

6.2. The Leeds Plan for National Shell Factories

When the UK declared war on Germany on August 4th, 1914, the city of Leeds responded from the first day in terms of recruitment to the army and in its industrial response. According to print media and the patriotic public, the war was expected to be short; to be 'over by Christmas'. [186]The Leeds Chamber of Commerce believed that the declaration of war would cause widespread unemployment with the dislocation of international trade. In the event, this situation was very short lived as military contracts arrived in Leeds by mid-September 1914.

During the first seven months of the war, the War Office, under Lord Kitchener, had been grappling with the issue of increased production of munitions in response to ever-changing, but always growing, military estimates. Armaments requirements before the war, aside from shipbuilding for the Admiralty, had been the preserve of the War Office and Master-General of the Ordnance, who placed orders with the Royal Arsenal, Woolwich and sets of listed suppliers largely supplying small arms and ammunition. [187] The manufacturing capacity at Woolwich and these listed suppliers had proved adequate for pre-war requirements and forecasts. The quote by Von Donop at the head of the chapter suggests that the War Office sought to maintain its control via the pre-war framework. Listed firms had been given leave to extend their works but were always variously short of machinery, labour or raw materials. Ever larger orders were placed but delivery consistently failed and by spring 1915, it was clear that urgent change was required. The War Office had at an early stage split the country up into 'manufacturing regions' with controlling local committees to explore the possibilities of more general armaments manufacturing. As part of this move, in early March 1915, the War Office organised exhibitions of shell typesto stimulate interest in their manufacture, one of which was in Leeds.[188]

At the Associated Chambers of Commerce Annual Meeting in London on March 16th, 1915, its President the West Riding carpet magnate Sir Algernon Firth, and Vice President the Hon. Rupert Beckett, the

[186]Kaiser Wilhelm II told his army the war would be over 'before the leaves fall'.

[187] Firms on the official Ministry of War list as regular approved suppliers.

[188]Adams, R.J.Q. *Arms and the Wizard.* p.4. Also, when the Ministry of Munitions was created (26.05.1915) the 38 local boards were organised into 12 areas.

Leeds banker said, on behalf of the meeting that member firms would "co-operate heartily and to the fullest possible extent in producing the munitions required".[189] Hearing of the speech, Kitchener invited Firth and Beckett to a meeting on the 18th. At the War Office Firth stated, perhaps overenthusiastically: 'I am more than certain that I could get sufficient supplies [for the war] from the West Riding alone'. [190]Whilst clearly rhetorical, these remarks at least illustrate the enthusiasm of British engineering to get to work on the munitions issue. However, the point was made about national engineering resources and their management. On March 20thRupert Beckett invited Leeds industrialists to a meeting with him and Sir Algernon at the Queens Hotel in Leeds, where the Leeds Management Committee was formed. [191]

It comprised: -

Mr. John McLaren. (Head of the Midland Engine Works, Jack Lane, Hunslet)[192]
Mr Bernal Bagshawe. (Chairman of the Leeds Forge Co. Ltd, Armley)
Mr A.H. Meysey-Thompson. (Director at Hathorn Davey, Sun Foundry, Dewsbury Road)
Mr Christopher James. (MD Joshua Buckton & Co. Well House Foundry, Meadow Lane)
Mr. Alexander Campbell (Hunslet Engine Co. Jack Lane, Hunslet)
Also present was Fred Kitson from the Leeds Chamber of Commerce.

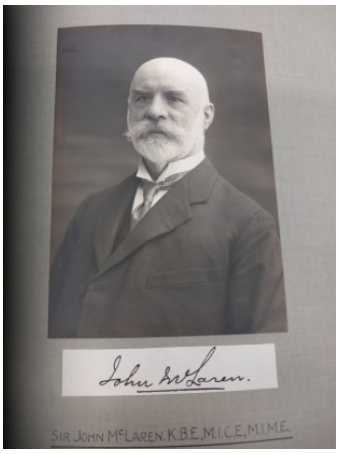
All the above were experienced engineers and experts in organising manufacturing operations with existing knowledge of machinery requirements and sources of supply. They split the work between them as follows[193]:

Bagshawe	Finance and Organisation
Campbell &Meysey-Thompson	Consultative Committee
McLaren & Campbell	Equipment for a 6" shell shop.
James	Equipment of 9.2" projectile factory

Both Meysey-Thompson and Campbell were, by this time, of senior years, hence their largely consultative roles, whereas Bernal Bagshawe was in his fifties and very active in business. Earlier in the dissertation, we saw that Bernal Bagshawe had been sent to the USA to set up and run new factories for Samson Fox. Here was an experienced manager familiar with start-ups and demonstrably someone who knew how to 'make things happen'.

[189]Scott, W.H. *Leeds in the Great War, A book of Remembrance'*. p.173.
[190]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*.p.19 Firth to Kitchener 18.03.1915.
[191]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918.*p.128-9.
[192]Later to be knighted for his services in this role.
[193]Mr Ben Day was later appointed Secretary to the Board. Ben Day was Best Man at Bagshawe's wedding and a close friend.

(Figure 23) Leeds Board Members. [194]

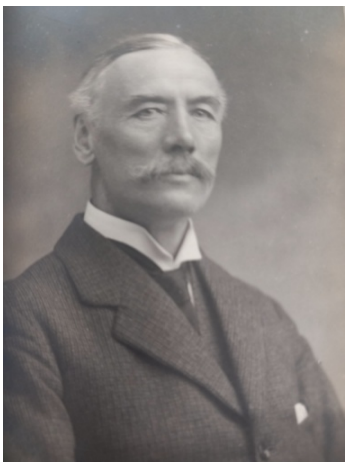


John McLaren

Bernal Bagshawe

Christopher James

Alexander Campbell



A.H. Meysey-Thompson

On March 24th this committee met Major-General Donop -- Master-General of the Ordnance (MGO) at the War Ministry -- and suggested initially that Leeds engineering concentrate local energies on making machine tools for munitions.But after the meeting, this view was changed to address the whole process of shell manufacture from forging to finished shell. [195] On April 22nd Major General Sir Percy Girouard -- Director-General Munitions Supply at the War Office -- arranged for this committee to visit the Royal Arsenal at Woolwich and, on 29th April, accompanied by managers from local engineering firms, they also visited the Vickers Armstrong Elswick works[196]. The result of these visits was a change of policy from the initial plan for a cooperative local engineering group to a single new factory but, as early as April

[194]Scott, W.H. *Leeds in the Great War.*p.174. Photographic portraiture from Archbald, R.H. *Record of the National ordnance Factories, 1915-1918.*

[195]On April 13th the local Leeds committee was reconstituted as 'The Leeds Munitions Committee' which was identicalto the later 'Leeds Board of Management'.

[196] This company was derived from the William Armstrong company of Newcastle-upon-Tyne.

23rd, Bernal Bagshawe at Leeds Forge had already started clearing space and adapting his presses to make 18-pdr shell cartridges. [197]

Four days after the Elswick visit, on May 3rd, the Leeds Committee forwarded a draft scheme of control for a 'National Factory' to the War Office, Munitions of War Committee and on May 13th, Government sanction was given to proceed with arrangements. [198] The Munitions of War Committee recorded that 'it should be put into operation at the earliest possible moment'. [199]

It was further approved by the Army Council on May 20th.Bagshawe used the carriage shop at Leeds Forge which was already cleared of machinery and filled with lathes which, as we saw above, had been gathered in advance by Bernal Bagshawe to produce 18-pdr shell. This resource was to produce 20,000 shells per week. Later, the buildings at Leeds Forge were extended toenable increasedproduction of 40,000 shells per week. [200] This scheme, outpacing arrangements made in other districts, was the first in the country and was used by the MGO as a model plan for all future factories. [201] On May 14th Firth sent a circular to all Chambers of Commerce recommending the 'Leeds Plan' and, later in May, the War Office printed a leaflet giving full details of the Leeds Plan in *National Munitions Factories: A Working Model.* [202]

Orders for the Leeds site were changed frequently by the Ministry of Munitions and the Leeds board members had to react quickly to these changes, a situation which is illustrated by the comparison later in this chapter with Birmingham's munitions outputs. Notwithstanding that Leeds was planned to make heavier, but fewer shells, I suggest that the clarity of control of Leeds engineering management compared to the less efficient, more physically distant management structure in Birmingham led to

[197]*History of the Ministry of Munitions* Vol.X, Chapter IX. P80 Also, Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918. p.22.*

[198]*The Dundee Herald* of 15.05.15 has a different date: 'At a meeting of Leeds engineers yesterday afternoon[so May 14th] Maj. Gen. Sir Percy Girouard [of the War Office Armaments Output Committee] announced that, subject toratification by the Government, it has been decided to establish in Leeds a national factory for the making of war munitions, chiefly shells.'

[199]*History of the Ministry of Munitions.* Vol.I Part III, Chap. IV. p.73.

[200]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*. p.27.

[201]Scott, W.H. *Leeds in the Great War*. p.182. Also, *History of the Ministry of Munitions* Vol X, p.80.

[202]*History of the Ministry of Munitions.* Vol.I Part III, Chap. IV. p.73.

Leeds being chosen for frequent changes in shell size and with its various engineering trades close at hand the difficult task of repair and manufacture of gun barrels.

6.3. Leeds National Shell/Projectile Factories

Under the 'Leeds Plan', the first two heavy shell factories set up in Leeds were at Armley Road (Leeds Forge Ltd) in August 1915. This was followed by expansion at the Newlay site opened in March 1916 and a later development in Hunslet (Goodman Street) in June 1916. [203] These were managed by the Leeds Board of Management. The History of the Ministry of Munitions, a primary source, references The Leeds Forge Co. (so chiefly, Bernal Bagshawe) as the source of the initiative and successful establishment of these factories. [204] Together with three other firms -- Austin Motors in Birmingham, Du Cros in Acton Vale, and Rees Roturbo at Ponders End --, as the 'heavy shells group', they were expected to produce 104,500 heavy shells per week of calibre 4.5-in and upwards. A great strength of Leeds as a munitions producer was its supply of skilled and useful unskilled labour on a local basis without the need for much transport or any housing.

(Figure 24) Output of Empty Shell fromNPF's

Leeds (Armley, Newlay & Hunslet combined)

	1915	1916	1917	1918	Total
4.5-in H.E	37,300	105,200	1,500		**144,000**
6-in H.E		167,700	394,100	430,400	**992,200**
8-in H.E			8,600	5,200	**13,800**
9.2-in H.E		66,600	191,800	172,900	**431,300**
12-in H.E			100	6,500	**6,600**
15-in H.E		1,400	4,600	1,300	**7,300**
	37,300	**340,900**	**600,700**	**616,300**	**1,595,200**

Source: - *History of the Ministry of Munitions* Vol VIII Part 2 Chap 4 Appendix II p.238

Labour in NPF's

[203] The opening of the Goodman Street site was delayed by the sinking of a vessel bringing specialist tools to make 15" shells from the USA. Extra time was needed to adapt locally available lathes for the purpose.

[204] *A History of the Ministry of Munitions* Vol I. Part III Chap IV, P.71

Leeds (Armley, Newlay & Hunslet combined)

	Men & Boys	Women	Total
1915	1,320	670	1,990
1916	1,940	820	2,760
1917	942	1,390	2,332
1918	681	1,658	2,339

Source: - *History of the Ministry of Munitions* Vol VIII Part II Chap V Appendix 3 p.241-244

Figure 25 shows the extent and speed with which the 'dilution' policy in the NPFs was possible in Leeds, as unskilled men were 'combed out' for the front to be replaced by unskilled and up-skilled women. In addition to this, Leeds engineering management constantly refined processes to be more efficient and less laborious whilst women were increasingly being trained up the skills ladder to work on more complex machining processes.

Leeds was spared two of the difficulties encountered by other engineering 'groups'; that of labour and housing. A housing census was undertaken in Leeds in summer 1915and 1,919 houses were found to be vacant of which 1,516 were at a rent at or below 10s per week, with lodging house said to be 'ample'. [205] The labour relations in Leeds at that time were described in the Ministry of Munitions labour survey as,'old fashioned' in as much as the employers, nominally in Limited Liability companies, were still largely patriarchal in their views and many knew their men and were known by their men from generation to generation. Although far from immune from industrial conflict, Leeds proved self-supporting in munitions workers throughout the war, by far the greatest number coming from Leeds itself and its immediate surroundings. The women employed in increasing numbers across the war years in Leeds were described in the Ministry of Munitions labour survey as 'of a very superior type' drawn from the wives of mechanics, domestic servants and women employed in the textile trades so already very familiar with factory work. [206]

[205] *A History of the Ministry of Munitions* Vol VIII Part II Chap III, p.81.

[206] 'A Very superior type ', is a detail from a labour survey conducted by the Ministry of Munitions.*A History of the Ministry of Munitions* Vol VIII Part II Chap III, p.82.

In March 1916 the Leeds Forge Factory achieved a record weekly output of 10,128. The table in figure 24 shows the quantity and variety of shells turned out from Armley, Newlay and the additional factory in the former Tannett Walker works in Goodman Street. This variety of calibre and quantity contrast with the higher quantities of smaller calibre shells produced in Birmingham. Tannett Walker sought to produce 15in and 9.2in shells. Later in 1916 contracts were stopped due to over-supply butaltered and restarted in 1917 because of shortage. In addition to this, when Ministry requirement changed, the NPFs were administratively altered to ROFs to produce artillery Gun Barrels. This was a complicated process involving further changes in machinery. Because a single metal cylinder could not withstand the high pressures involved in the explosive ejection of a shell, the gun barrel was made up of a complex set of steel and steel wire layers. The Goodman Street works produced 200 18-pdr gun bodies per month until the Armistice. Consequently, machinery in the 15in shell shop in Goodman Street was dismantled and new machines were installed to enable the re-lining and rifling of 18-pdr artillery pieces which were rapidly wearing out on the Western Front.

After visits to the Woolwich Arsenal to find out how the process was carried out, the first gun was delivered from the Goodman Street factory, re-lined on May 18th, 1917, and two months later, 2 per day were completed. The Goodman Street works quickly achieved the target capacity of 150 repaired, and 200 new guns per month. An increasing daily rate saw a record 208 delivered during February 1918. By this time, the Leeds factory had become the main location for gun barrel repair. [207]Up to the Armistice nearly 2,500 guns were relined. Additionally,60-pdr guns, 8-in and 9.2-in Howitzers were re-rifled and 18-pdr recuperators manufactured.[208]

The guns were tested in a specially built proofing range in a quarry at Meanwood with the sand butts 200 yards from the firing point. Given the date, rather surprisingly this was the first range set up for the

[207]*History of the Ministry of Munitions* Vol X, Part I. Chapter V. p.78.

[208]The 'recuperator' is the hydro-pneumatic recoil system. In this system, the gun barrel is mounted on rails on which it can recoil to the rear, and the recoil is taken up by a cylinder which is similar in operation to an automotive gas-charged shock absorber and is commonly visible as a cylinder mounted parallel to the barrel of the gun, but shorter and smaller than it. The cylinder contains a charge of compressed air, as well as hydraulic oil, in operation, the barrel's energy is taken up in compressing the air as the barrel recoils backward, and then is dissipated via hydraulic damping as the barrel returns forward to the firing position.

use of NOFs and served as a model for other sites around the country. In all, 4,884 guns were tested and 20,000 rounds fired, giving Meanwood residents an idea of the noise in France.

Following the German offensivesin the spring of 1918, the Ministry of Munitions required Leedsto produce gun carriages.Work was underway to create a gun carriage shop at the Goodman Street site, but this was halted by advances at the front. In the meantime, the site undertook a large amount of other engineering work making brass bushes for fuses and tens of thousands of parts for minesinkers. During shell production at Goodman Street employed 1,591 men and 916 women and when the switch was made to gun barrel production the site employed 1,253 men and 740 women. The table in Appendix 3 shows the primary munitions engineering sites in Leeds into which a host of other contractors fed components and sub-assemblies.

6.4. Leeds National Shell Filling Factory

On April 23rd, 1915, with Lloyd George in the Chair of the Ministry of War, the National Munitions Committee discussed the creation of shell filling factories. The Leeds Board had already expressed its views, which were approved, and the Boards in Liverpool, Glasgow and Gloucester were invited to follow the Leeds example, which became official Ministry policy. [209] In May 1915,the Leeds Committee were asked by Lloyd George at the newly formed Ministry of Munitions to make arrangementsfor all the West Riding 'loading of shell' -- filling the shells with high explosives and shrapnel in addition to manufacturing shells and fuses, cartridge cases and ammunition boxes.[210]With his committee brief of finance and organisation, Bernal Bagshawe examined issues around logistics and efficiency and decided that an entirely new site be built for cartridge and shell filling in line with the earlier national recommendations. [211] Joseph Watson went to the Ministry to make the proposal to fill all West Riding shell production in a single, purpose-built works.

[209]*History of the Ministry of Munitions* Vol. VIII, Part I. Chapter II. p.42.
[210]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*. p.52.
[211]Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*. p.53.

The Leeds shell filling factory was approved on May 20th and had its own controlling Board that reported to the Ministry of Munitions. Its members were, Mr Joseph Watson (Chairman), Mr T.L. Taylor, The Hon. Rupert Beckett,Mr Arthur G. Lupton, Mr Bernal Bagshaweand Maj. G. Yewdall. [212]

Watson, Beckett, Lupton and Yewdall were members of the Leeds Club which was, since 1846, a locus for social and business interactions amongst the local Leeds elites. Beckett was the link to the Chamber of Commerce and Bagshawe, as Chairman of Leeds Forge, was the link to the engineering community and Leeds Board of Management. Watson was the link to the munitions industry. They all had a role to play, they all knew Leeds and they all knew each other. Leeds engineers had reacted very quickly to the situation. In August 1915, the Leeds Munitions Committee acquired from Lieutenant Colonel Gascoignea 400 acregreen field site at Barnbow near Crossgates, close to the Northeastern Railway lines. Before Christmas, the facility had begun filling shells. [213] In April 1916, the first Amatol plant was completed to fill 4.5in shells. Output soon rose to 6,000 shells per day. Further buildings were erected to enable the manufacturing of shell cartridges (mostly for the 18-pdr 'fixed' ammunition). Another Amatol plant and a box factory for packaging were also added. With its 13 miles of wide gauge railways, 33 miles of water mains and 60 miles of steam and hot water pipes, the site quickly took on the look of a small town and became one of the largest undertakings of its kind in the country. [214]

As can be seen from the table in Appendix 1,the production of shells of all sizes up to 6", both high explosive and shrapnel, increased rapidly at Barnbow. At its height, over 16,000 people were employed on the site, 93% of which were women. These numbers declined somewhat in 1917-18 as greater efficiencies in production were introduced by local management. It was the largest National Shell Filling Factory in the country and contributed 19% of all domestic shell output, as can be seen in the table in Appendix 2. In addition to the shell filling activity at Barnbow, a further 36,000,000 breach loading cartridges were filled (for bigger calibre shells as a propellant charge) and another 19,250,000 shells

[212]Later to be ennobled as Lord Manton for this role. Joseph Watson – "Soapy Joe" of the Watson Soap factory, Whitehall Road. A major producer of soap and a rival to Lever Brothers with his 'Matchless Cleanser - the housewife's friend'. He was asked to head the committee as he already had contacts in the armaments industry through his sales of soap manufacture by-product, glycerine.

[213]Lieut.-Col Gascoigne of Lotherton Hall, Aberford. Local landowner and a long-time member of the Leeds Club.

[214] Amatol is a combination of Trinitrotoluene (T.N.T.) and Ammonium Nitrate in varied proportions around 30-70%. Also, Scott, W.H. *Leeds in the Great War, A book of Remembrance*. p.182.

were completed with fuses and packaging for the National Shell Filling Factories, Barnbow was the largest producer and the most cost efficient. This may be, in part due to the rigorous application of the 'dilution' policy, described above in Chapter 6.1.

6.5. Shell Production in Leeds and Birmingham

There was much early activity both in the Government War Office and nationally to support the war effort. Local committees also proposed local schemes to the War Office, for instance, the local Committee for Leicester proposed a cooperative scheme where local firms moved part manufactured material around. But this was superseded by the 'Leeds Plan' developed from March 16th to May 20th, 1915. In the first few weeks of the Ministry of Munitions, local effort had been formalised into 38 local boards in 11 geographical areas covering the whole country, including all of Ireland. Leeds was prominent nationally and within the Yorkshire Area (III). Birmingham was similarly prominent in the Midlands Area (IV) as the largest metal working area in the country and as a district already producing munitions via its several War Office 'listed' firms.

As elsewhere in the early part of 1915, discussions were underway in Birmingham about how best to organise local munitions production.On April 25th,Sir Percy Girouard addressed a meeting in Birmingham advocating a cooperative scheme amongst local engineering firms and a National Shell Factory on the 'Leeds Plan'. Both schemes were adopted. The Birmingham start with the National Factory was sluggish, hampered by a lack of clarity about local powers and delays at the War Office. Also, half of a very large Russian contract with Vickers for two million 18-pdr shell and 3 million fuses had been let to the Wolseley Motor Co. who, with their extensive presses, had offered 30,000 shrapnel shells per week between April and December 1915.[215] This caused difficulties in acquiring labour for the National Factory, causing further delay. Also, the Birmingham Small Arms Co. was building a new factory to increase its output of .303 rifle cartridges which also needed additional labour. Vickers reduced the Wolseley requirement to 630,000 18-pdr shells and the National Factory was in progress by July in

[215] *History of the Ministry of Munitions* Vol II. Part II. Chapter X. p.97.

railway premises in Washwood Heath. Unlike Leeds, the management was physically distant, so the best efficiencies were never achieved, and commercial relations with contractors across the area were said to be 'informal and irregular',leading to delay and inefficiency.[216]

Despite this, the National Factory continued its production with few changes of contract and, at its peak at the end of 1917, Birmingham produced 34,350 shells per week from the National Factory, cooperative contractors and direct contractors. Appendix 1 shows that Birmingham, given its metalworking pre-eminence, produced many more shells than the Leeds sites. However, Birmingham made the lighter calibre shells whilst Leeds made the heavier ones. Additionally, and in part because of the flexibility of management at Leeds, shell manufacture was frequently altered and later in the war turned to gun rifling, repair and manufacture. The Leeds Board also managed the largest and most cost-efficient National Shell Filling Factory in the country at Barnbow.

6.6. Munitions Production in Leeds in Non-National Factories during WW1.

The distinctively broad variety of engineering trades in Leeds was a significant benefit to UK munitions production. Castings and other components were readily at hand and Leeds benefitted especially from firms experienced in working with different metals such as copper and brass. The main secondary source for this area of activity is Scott's *Leeds in the Great War,* especially Chapter 4, "Triumphs of Industry". The book is written for a grieving Leeds readership keen to be reassured that 'it was all worth it'. In that vein, Scott is both triumphalist and vague. The achievements of the National Factories are rightly featured, and some headline numbers borrowed from Archbald and Gummer.

[216] *History of the Ministry of Munitions* Vol II. Part II. Chapter X. p.99-100.

(Figure 26) Output of .303 Mk VII S.A.A (1914-18)

Kynoch	2,373,811,000	31%
Birmingham Metal & Munitions Co	1,477,924,000	19%
R.O.F	1,465,175,000	19%
Greenwood & Batley	705,025,000	9%
Kings Norton Metal Co.	582,430,000	7%
Rudge Whitworth	316,392,000	4%
G.C.F 2	298,750,000	4%
G.C.F 1	218,463,000	3%
Eley Bros	209,455,000	3%
Nobel's	131,305,000	2%
UK Total	**7,778,730,000**	89%
Imported from USA	**952,126,000**	11%
Grand Total	**8,730,856,000**	

Source: *History of the Ministry of Munitions* Vol XI, Part VI, Appendix I p.102

Scott asserted inaccurately in *Leeds in the Great War* that Greenwood & Batley made more .303 cartridges than any other supplier. The table opposite shows that Greenwood & Batley were by no means the largest producers of .303 cartridges. As a Ministry 'listed' firm, contracts were awarded promptly to Greenwood & Batley in August and September 1914 and were quickly followed up with requests to speed up delivery as much as possible, often before contracts had actually been signed. In the early months, delivery was consistently missed by all suppliers due to shortages in raw material, machinery and labour. As can be seen from the table in Appendix 4, Greenwood & Batley became ever more accurate and efficient producers as time went on despite near constant expansion of the works. In 1912, the peacetime capacity of the cartridge works was set at 450,000 per week.

By 1917, capacity had risen to more than 8million per week and plans were in hand to create a new works with cartridge rolling facilities to produce 12million per week. Archival sources show that Greenwoods were also major suppliers of machine tools to the main UK munitions producers, delivering 496 different machine tools to ROFs, The Royal Navy, NSFFs and other listed .303 cartridge suppliers before the end of May 1915. [217] By October 1915, a further 452 machines were delivered. [218] Greenwood & Batley also supplied their new line in electric dynamos (commenced manufacture in 1899). One such order was for the Coghlan Steel Co in Thwaite Gate. In March 1915, they wanted to switch to electric power for their rolling mill and, in April 1915, their factory cranes needed dynamos 'urgently'. Marginalia

[217] WYL 298/11/67 *Greenwood & Batley Main Order Books.*

[218] *Greenwood & Batley Main Order Books Vol.R2 1914-15* WYL1207/1/1/R2.

in the Greenwood & Batley Order Book records, "Very urgent order required to speed up delivery of shell bars for the War Department".[219] The war was a considerable stimulus for electrification across the country. In Leeds the plant capacity in June 1914 was 22,940 Kw. compared to 56,600 Kw. in 1918. [220]

Also, as their letter to the Ministry of War in March 1914 indicates,Greenwood& Batley werealways looking to ensure their costings were 'profitable'. [221] Appendix 5 shows the pre-war net profits of Greenwood & Batley. Like many other suppliers to the Ministry during wartime, Greenwood & Batley clearly understood they had the upper hand in cost negotiations, as will be discussed in Chapter 8.

Scott refers to several other munitions operations in Leeds in passing but misses out on the contributions of many other firms. While Scott mentions the expansions of Kitsons, Fowlers and Fairbairn Lawson, his analysis does not go into further detail. [222] One firm is said to have abandoned its printing machinery activities to swap to shell manufacture (possibly Manns in Elland Road or R.W. Crabtree of Holbeck) as a feeder to the big ordinance factories, another from lamp manufacture (Kayes?) to submarine mines, and one from motor cars to ambulances. The production of steel casings for mines was a significant volume output as were fuse components by George Bray, copper tubing and shell driving bands. The copper 'driving bands' for shells wereusually added to rebates in the lower part of the shell exterior and patched in with the rifling in the gun barrel to provide the spin for the shell when fired. T.F. Braime, from their new works in Hunslet Road opposite the Steam Plough Works, developed a means of pressing the copper driving bands rather than the previous method using copper tubing. This proved to be both process and cost efficient and was taken up on a national basis.

It was Braimes who made, as suggested by Scott, the pressed steel sea mine casings for the Admiralty. [223] Butlers of Stanningley machined, hardened and tested steel plates for Kitsons to turn into tanks. Crabtrees also made shell components including 8 million gaines and fuses at a rate of thousands per

[219]*Greenwood & Batley Order Books 1896-1917.* WYL298/Adnl/Box1.
[220]*History of the Ministry of Munitions* Vol 8 PART III, p.171.
[221]*Greenwood & Batley, Tenders for Cartridges 1913-19,* WYL298/11/63.
[222]Scott, W.H. L*eeds in the Great War.*p.188-90.
[223]The handbook for the 1926 Leeds Industrial Exhibition describes Braimes Sea mine casings as WW1 exhibits.

week, as well as gears for Kitsons tanks. [224] Kirkstall Forge was busy making, amongst other items, the axles for 9" Howitzers. The secondary source by Edwin Kitson-Clark, *Kitsons of Leeds 1837-1937 – a firm and its folk by one of them* (1937) is not a book of record but of reminiscence, usually of people and interactions in a long working life. The book lists a wide variety of munitions outputs from Kitson's works, chief amongst them were both 'male' and 'female' tanks but no marks, dates or volumes are given for any output.

6.7. Conclusion

This chapter has disclosed for the first time the influence of Leeds engineering management on national munitions policy and has analysed Leeds's munitions outputs, comparing them to those of the larger metal working area of Birmingham. The Leeds response to the problems of shell manufacture via 'The Leeds Plan' was prompt, although it took three months to set up and start despatches of shell. By May 1915, 30 million artillery rounds had been ordered but only 1.4 million delivered and, by the end of May, the B.E.F. was down to one weeks' supply of artillery ammunition. [225] It was clear by the spring of 1915 that peacetime arrangements could no longer deliver the volume of munitions required. In anticipation of these requirements and the looming 'shell crisis' which became a public scandal on May 14th with Col. Repington's article in *The Times* the Leeds Committee had already defined the necessary shape of local industry to meet the needs of the war.[226]

The Leeds engineers' plan for National Factories and, shortly afterwards, for National Filling Factories was quickly adopted as national policy for all others to follow. The Leeds Committee, with its wealth of engineering experience and a large and varied engineering capacity under its control, took early action and influenced critical national policy. Using Archbald as a source and as someone who knew and worked with the Leeds Board, it's evident that much of the credit for this must go to Bernal Bagshawe. His brief

[224]Crabtrees – manufacturers of printing machinery.

[225]Mead, G. T*he Good Soldier. The Biography of Douglas Haigh.*p.212. B.E.F – British Expeditionary Force.

[226]*The Times* headline of 14.05.15. was 'Need for Shells. British Attack Checked. Limited Supplies the Cause. A Lesson from France'. No correspondents were allowed in France so (former Colonel) Repington's visits to Field Marshal French were undertaken on a personal basis Also, Adams, R.J.Q. Arms and the Wizard. p.39.

in the Leeds Board of Control was Finance and Organisation and, even before the Leeds Committee visited Woolwich, Bagshawe was making changes at Leeds Forge to accommodate munitions manufacture. Unlike the primary source from Archbald, the secondary source, Adams in *Arms and the Wizard* makes no mention of the names of the Leeds Committee or their roles. Scott lists their names but not their roles. Bagshawe was well known in Leeds in his day, but unknown now despite his significant, individual contribution to National Munitions policy. McLaren, the Chairman of the Leeds Committee, was knighted, and 'Soapy Joe' Watson, the Chairman of the Barnbow Filling Factory Committee, was ennobled. Bernal Bagshawe went back to running the Leeds Forge. During his visit to Leeds on October 10, 1918, the Minister of Munitions, Mr. Winston Churchill said in his speech:

> Leeds has the credit of having begun almost before any other similar local organisation for the production of munitions had faced the problem in any part of the country and though you are now one of the branches of the organisation of the Ministry of Munitions, I can assure you we never forget how you came to our assistance before really we were born. [227]

Repeating the quotation from the head of the chapter, Archbald confirmed the above Churchill quotation by writing:

> When the Shell crisis broke certain gentlemen in this country had already done the work, and that an organisation to produce not only munitions for ourselves but eventually for nearly all our allies had been started. [228]

Here Archbald with the deference of the age and a measure of wartime reticence refers only to the 'certain gentlemen' of the Leeds Board but given their roles, this must point to Bernal Bagshawe in particular as having the greatest influence on policy and given his experiences in the USA, as the man most able to 'make things happen'.[229]

[227] *Yorkshire Evening News* 10.10.1918.

[228] Archbald, R.H. *Record of the National Ordnance Factories, Leeds 1915-1918*.p.28.

[229] Leeds Forge is referenced as the source for the policy in *A History of the Ministry of Munitions* Vol I. Part III Chap IV, p.71 – so who else but Bernal Bagshawe, Chairman of Leeds Forge? Also, Maclaren, during the visit to Leeds of W. Churchill as Minister of Munitions emphasised in his speech the early response of Leeds Engineers regarding the organisation of shell manufacture (*Leeds Mercury* 11.10.1918).

Appendix 1

Output of Filled Shell from NFF's

Leeds (Barnbow)

	1915	1916	1917	1918	Total
18-pdr H.E.	-	949,400	3,096,500	5,012,100	**9,058,000**
18-pdr H.E. (completing foreign shell)	-	4,800	-	-	**4,800**
18-pdr S	-	321,700	-	-	**321,700**
18-pdr S (completing foreign shell)	-	10,600	-	-	**10,600**
60-pdr H.E.	-	6,600	-	-	**6,600**
60-pdr S	-	2,000	142,900	39,500	**184,400**
4.5-in H.E.	-	2,939,000	6,040,900	4,328,700	**13,308,600**
6-in How H.E	-	277,200	362,700	1,035,100	**1,675,000**
	-	**4,511,300**	**9,643,000**	**10,415,400**	**24,569,700**

Source: - *History of the Ministry of Munitions* Vol VIII Part II Chap V Appendix 3 p.241-244

Appendix 2

Output of Filled Shell from NSFF's

1	Leeds (Barnbow)	24,569,700	19%	
2	Chilwell (Nottingham)	19,342,700	15%	
3	Georgetown (Glasgow)	19,293,200	15%	
4	Liverpool	17,340,100	14%	
5	Hayes	12,381,000	10%	Top 5 = 73%
6	Gloucester	10,299,600	8%	
7	Horley	4,737,100	4%	
8	Hereford	4,170,400	3%	
9	Watford (1&2 & Greenford)	4,046,600	3%	
10	Banbury	3,865,600	3%	
11	Devonport	3,057,000	2%	
12	Morecambe	2,893,100	2%	
13	Chittening	86,400	0%	
		126,082,500		

Source: - History of the Ministry of Munitions Vol VIII Part II Chap V Appendix 3 p.241-244

Output of Filled Shell from all Sources

NOF	National Ordinance Factories	43,322,300	20%
NSFF	National Filling Factories	126,081,900	58%
	UK Trade	26,610,500	12%
	Total Home	**196,014,700**	90%
	Imported Shell	21,026,600	10%
	Grand Total	**217,041,300**	
	Leeds NSFF as % of total Home	24,569,700	13%

Source: - *History of the Ministry of Munitions* Vol VIII Part II Chap V Appendix 3 p.241-244

Appendix 3

National Factories Controlled by Ministry of Munitions via the Leeds Board of Management

Leeds

	Place	Type	Date of Initiation	Date of First Output	Output	Form of Administration	CapEx
1	Leeds Armley Road	NSF, NPF, NOF	May-15	Sep-15	4.5-in, 6-in Shells. Repair & inspection of Guns 1917-18	Board of Management	£248,400
2	Leeds, Newlay	NSF, NPF, NOF	Aug-15	Apr-16	9.2-in & 15-in Shell	Board of Management	£230,600
3	Leeds, Barnbow	NFF	Sep-15	Jan-16	Filling Shell (18-pdr to 6-in) cartridges, components	Board of Management	£813,500
4	Leeds, Goodman St., Hunslet	NSF, NPF, NOF	Early 1916	Aug-16	9.2-in & 15-in Shell. Making & repairing Guns	Board of Management	£274,400
5	Leeds, Armley Rd, Wellington St, Sweet St	National Fuse Factory (NPF 1916-17, NOF 1917-18)	Early 1916	Aug-16	Shell Components	Board of Management	£26,400
6	Leeds, Wellington St	National Box Factory	Sep-17	Oct-17	Making & repairing Ammunition Boxes	J.H.Abrahams Ltd.	£2,300

Source: - *History of the Ministry of Munitions* Vol. VIII Part II Chap V Appendix 4 p.245-2455

Appendix 4

Greenwood & Batley

.303 Cartridge Production Records

	1915			1916			1917			1918		
	Total	Faulty	% Faulty	Total	Faulty	% Faulty	Total	Faulty	% Faulty	Total	Faulty	% Faulty
Jan	3,450,000	8	0.0002%	17,000,000	354	0.0021%	31,200,000	243	0.0008%	-	-	-
Feb	3,450,000	18	0.0005%	15,000,000	404	0.0027%	31,800,000	336	0.0011%	-	-	-
Mar	4,650,000	27	0.0006%	17,000,000	466	0.0027%	25,200,000	283	0.0011%	250,000	6	0.0024%
Apr	5,662,000	46	0.0008%	20,400,000	338	0.0011%	9,000,000	86	0.0010%	14,077,000	165	0.0012%
May	10,300,000	111	0.0011%	31,200,000	234	0.0008%	1,000,000	15	0.0015%	19,294,391	121	0.0006%
Jun	11,950,000	153	0.0013%	28,800,000	325	0.0011%	781,000	12	0.0015%	24,805,000	140	0.0006%
Jul	15,550,000	334	0.0021%	31,800,000	264	0.0008%	-	-	-	29,400,000	125	0.0004%
Aug	13,400,000	102	0.0008%	26,400,000	197	0.0007%	-	-	-	18,807,000	66	0.0004%
Sep	21,320,000	161	0.0008%	18,000,000	166	0.0009%	-	-	-	20,300,000	88	0.0004%
Oct	14,700,000	305	0.0021%	30,600,000	227	0.0007%	-	-	-	17,000,000	166	0.0010%
Nov	16,800,000	310	0.0018%	33,000,000	231	0.0007%	-	-	-	16,000,000	87	0.0005%
Dec	15,600,000	223	0.0014%	28,800,000	255	0.0009%	-	-	-	6,400,000	40	0.0006%
	136,832,000	1,798	0.0013%	**298,000,000**	3,461	0.0012%	**98,981,000**	975	0.0010%	**166,333,391**	1,004	0.0006%

Total 1915 - 18	**700,146,391**
Faulty	7,238
%Faulty	0.0010%

Source: - West Yorkshire Archive - WYL298/Adnl/Box 3/ 1

Greenwood & Batley Cartridges Dept 1915 - 1936 Daily Record Books

Appendix 5

Greenwood & Batley Annual Net Profits[230]

	Profit			Turn Over				Profit			Turn Over		
	£	s	d	£	s	d		£	s	d	£	s	d
1874	14,419	19	7				1895	2,659	14	6			
1875	22117	18	8				1896	16,576	3	1			
1876	6,954	2	8				1897	28,233	10	11			
1877	5,743	9	0				1898	12,365	15	4			
1878	21,272	14	6				1899	29,355	14	2			
1879	3,440	8	11				1900	11,683	16	4			
1880	7,022	11	10				1901	44,259	17	0			
1881	20,149	5	3				1902	32,779	19	5			
1882	31,159	11	3				1903	19,764	10	0			
1883	21,026	16	6				1904	28,812	16	11			
1884	11,985	4	1				1905	36,556	1	8			
1885	23,178	17	1				1906	22,070	5	7			
1886	41,380	11	2	161,745	0	0	1907	12,907	5	11			
1887	38,558	2	2				1908	26,490	8	3			
1888	34,556	15	7				1909	9,948	5	6			
1889	38,165	3	0				1910	10,100	13	4	128,174	16	8
1890	41,296	5	5	228,239	0	0	1911	18,875	0	6			
1891	28,720	10	5				1912	25,174	19	11			
1892	16,367	17	11	185,516	0	0	1913	7,597	11	0			
1893	22,170	22	2				1914	24,166	2	3			
1894	8,160	10	2										

Also, 1910, Plant valued at £98,780

Source: - West Yorkshire Archive - WYL298/Box 48/5
Greenwood & Batley P&L Account Ledger
1874 - 1914

[230]Turnover is difficult to establish from the Balance Book. Net Profit appears to be calculated elsewhere and shows in the Balance Book as part of thecalculation of the equivalent of the modern Corporation Tax expressed each year as a % of average net profit over a rolling three year period.

Appendix 6

Comparative Shell Production between Leeds & Birmingham

Boards Of Management Output of Shell

Leeds and Birmingham 1915 - 1918

	Birmingham			Leeds		
	Area Group	N.S.F	Total	Area Group	N.S.F	Total
18-pdr H.E	300,000	57,000	357,000	-	-	0
18-pdr Shrapnel	223,000	-	223,000	-	-	0
4.5" H.E.	495,500	1,736,300	2,231,800	-	144,000	144,000
6" H.E.	25,000	-	25,000	-	922,200	922,200
9.2" H.E.	-	49,200	49,200	-	431,300	431,300
8" H.E.	-	-	0	-	13,800	13,800
12"H.E.	-	-	0	-	6,600	6,600
15" H.E.	-	-	0	-	7,300	7,300
	1,043,500	**1,842,500**	**2,886,000**	**0**	**1,525,200**	**1,525,200**

Source: *History of Ministry of Munitions* Vol. II, Part II Appendix V.

Chapter 7. Conclusions

The questions posed in my introduction were fourfold, namely: -

1. to provide an analysis of the breadth and variety of Leeds engineering activity.
2. to explain the rapid growth of Leeds engineering in the period.
3. Leeds engineering's consequent ability to make a major contribution to the war effort 1914-18.
4. To suggest some Leeds-specific characteristics to explain its lack of presence in much of the literature and consequently why the history of Leeds engineering has become so obscured.

To provide a description of Leeds engineering the chapters have built from1850 towards the period 1902 –1914, which represented the highest level of engineering activity in the city and within that its most varied outputs.Chapter 2 argued that the Great Exhibition, in contrast to Cookson's argument, represented a pivot point in Leeds's engineering activities. Firstly, the Exhibition presented an opportunity to stave off perceived decline in woollen cloth manufacture. Secondly, it provided a chance for engineering to present its wares to the world and, thirdly, it created a realisation of the need for civic structures to be created to support the large manufacturing centre Leeds was becoming. Leeds engineers made deliberate choices about how to present Leeds engineering outputs to the world; the very materials that fuelled Leeds engineering expansion in the following decades.

Rapid growth in Leeds engineering during the second half of the nineteenth-century, as evidenced by Baker (BAAS speech in Leeds, 1858) is shown in Chapter 3 both graphically and in the text. This growth was based on the production of locomotive steam engines for empire and international use. The supporting commercial infrastructure it created is described in the text as the 'Hunslet Engineering Hub'. This growth was, as explained in Chapter 4, encouraged by the domestic market for locomotives being much reduced by the railway operators integrating 'vertically' and making their own locomotives. Chapter 4 included an analysis of the unusual diversity of engineering in Leeds whicharose out of the 'virtuous circle' of growing population and the concentration of engineering south of the river causing the development of an engineering 'ecosystem' with a variety of co-dependent firms trading with and supplying each other.

The development of imperial markets and, most importantly for Leeds locomotive builders, the development of the Indian railways after the 1857 Mutiny provided an important export market. Also,

the change from wooden ships to metal stimulated the heavy machine tool manufacturers in Leeds to a point where they were internationally important and to a lesser extent the Crimean War as a stimulus to steam engine manufactureas well as small arms and ammunition production and its associated machine tooling. [231]

Chapter 5 analysed the further rapid growth of engineering in Leeds. The quantity of firms engaged in engineering trades nearly doubled in the period. This indicated abuoyant demand for metalwork of all kinds and an ability to make profit that lessened the risk of market entry. The 62 different engineering trades listed by the Leeds Chamber of Commerce was shown to be unusually large when compared with Bradford and Newcastle upon Tyne. However, it is clearly shown in the employment data that employment in clothing trades has overtaken engineering during the period. Also discussed is the response of Leeds elites to the celebration of the achievement of their city and is compared with Birmingham and Manchester.

Chapter 6 analysed the very rapid response of senior engineering management in Leeds to the impending crisis at the outbreak of war. Through their mutual familiarity via the Chamber of Commerce, the City Council and the Leeds Club, engineering management was sufficiently cohesive as to be able to propose practical, local munitions plans to central Government. They had local knowledge of processes and capabilities and what they needed to know could be quickly discovered from among their wider number. This led to the early wartime organisation in Leeds of munitions work and the harnessing of the 'ecosystem' in all its diversity to the war effort. This 'ecosystem' also made possible the ready supply of skilled and experienced engineering workers and women able to replace men as they were 'combed out' for the front.

The 'Hub' also enabled several different responses. Firms like Fowlers shut down for a short period to reorder workshops for military production, sites were found for new shell production or filling factories

[231]Leeds steam engines ran on the Balaclava narrow gauge railway from the port to the allied front lines. Also, Greenwood & Batley making ammunition and supplying national arsenals with the machine tools to make ammunition and small arms.

like Newlay and Barnbow and other buildings in Hunslet were repurposed for munitions work. Much detail of the breadth and volume of war material production has been lost. Using figures from the Ministry of Munitions and detail from secondary sources and some primary ones I have enumerated many more of the wide-ranging engineering contributions made by the city to the war effort.

In addressing failure of historians to feature Leeds very much in the literature of nineteenth-century industrial development I have looked at reasons why Leeds was different in character from many other industrial towns. Though its nineteenth-century growth was rapid and, from an early date, quickly outstripped its local rivals, Leeds was never big enough to be counted by historians such as A.J.P. Taylor, amongst the first rank of 'Empire' cities like Glasgow, Manchester, Liverpool or London and so, from an industrial viewpoint Leeds hasn't attracted as much academic interest. Still less recognised was its industrial and engineering history. Nor was Leeds much in the national press, a locus then as now for controversy and scandal. Leeds engineering featured often in the local press in the first half of the nineteenth-century and hardly at all in the latter half.So, arguably, engineering was regarded by the news media as uncontroversial and broadly 'successful' since reporting of a positive nature tended to appear less than negative reporting as evidenced by reporting in the first half of the nineteenth-century in Leeds.

In response to Ministry enquiries in 1914-15 about labour relations, the Leeds industrialists on the local munitions committee described relations as "good" and "traditional". This subject may repay some further investigation. The relatively calm situation in Leeds can be explained by the variety of work available in engineering in Leeds and the large pool of skilled, experienced and available labour which took some of the stress out of industrial relations. On the one hand there were always workers to hire and on the other, there were always other places for workers to go.

An answer to question posed in the introduction, "why has the history of Leeds engineering never been prominent in the literature, why has it been passed by so frequently and so completely"? - might rest with Leeds diversity in general and engineering trades in particular. Of note is the beautifully presented

volume for the 150th Anniversary of the Institution of Mechanical Engineers. In its 'Stephenson rich' text any mention of Leeds is entirely absent, nor does Leeds appear in the index. [232]

Leeds has never been a 'one activity' town and so never dubbed, "the home of…" a specific characteristic industry like a Newcastle or a Bradford as the home of shipbuilding or Worsted manufacture. These towns contrasted with Leeds in the text have much written history and, in these literatures, industrial development is more fully described. It might be suggested that because their industrial activity was less varied and its singularity somehow more appealing than Leeds it was actually much easier to write about and conversely in the case of Leeds the growing diversity of engineering in the nineteenth-century was more difficult for writers to assess and weave into a historical narrative.

Towns with only one main industry may have become more militant, newsworthy and prominent due to the lack of alternatives for both employees and employers. This general lack of exposure in turn made it difficult for Leeds to easily advertise itself, unlike for instance, Manchester. In this period Leeds elites had a different view of themselves as evidenced by a comparison of statuary in Leeds with Manchester and Birmingham whose statuary projected a different outward presentation of their cities when compared to Leeds as shown in chapter 5.

The rapid growth of Leeds engineering from 1850 and its unusual diversity was compared with Bradford and Newcastle. The driving factors behind this growth and variety have been presented and explained. Also, the hitherto undocumented contribution of Leeds engineering management to national munitions policy at a critical point in the nation's history has been revealed and Leeds'smajor munitions outputs during the Great War analysed, those being second only to those of Birmingham.

Leeds engineering in 1914 was at its zenith in terms of its size, breadth and organisation. In the post-war world, the time when Leeds was renowned throughout the Empire as a source of machine tools and

[232]The book does show a picture of the invitation the Leeds Meeting of 1858 but without any context.

'one of the most important industrial cities of the Empire' had passed many years ago, whereas Birmingham and Glasgow remained better known for their respective specialisms in metalworking and shipbuilding. [233] Now, there is little physical evidence left of its huge industrial concentration and there is little adequate explanation of it in the various histories which touch on Leeds. One key piece of evidence of Leeds's engineering past lies in the Chamber of Commerce emblem shown below.

(Figure 27)

This emblem appeared on the cover of the 1951 History of the Leeds Chamber ofCommerce.[234] Here the city coat of arms has been adapted to include as emblems of the city, along with the 'golden fleece', the classic origin symbol of the city's wealth, a press to symbolise the huge Leeds printing industry of the twentieth century, scissors to symbolise the tailoring trade and a gear wheel to symbolise as the last vestige of a great industry the many engineering trades of Leeds. By the time this design was created the centre piece were the scissors of the tailoring trade with printing and engineering at the margins. Since the end of the Great War, Leeds has continued to reinvent itself and its commercial purpose, leaving a fine engineering history as a theme largely unrecorded, unwritten and with the passage of time, ever more distant and difficult to appreciate.

[233] *Journal of the Society of Arts* Oct 8th, 1858, p.670. Joshua Buckton's speech – Leeds Exhibition of Local Industry. Also,Leeds Chamber of Commerce *Yearbook for 1910* – Foreword, p.24.

[234] Beresford, M.W. *The Leeds Chambers of Commerce.1951* (coat of arms on the front Cover).

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