Zeitschrift: Ferrum : Nachrichten aus der Eisenbibliothek, Stiftung der Georg Fischer AG

Herausgeber: Eisenbibliothek

Band: 81 (2009)

Artikel: The British machine tool industry (1790-1825)

Autor: Russel, Ben

DOI: https://doi.org/10.5169/seals-378454

The British machine tool industry (1790–1825)

Ben Russell

Ben Russell trained as an economic historian specialising in Britain's industrial history, and worked on the conservation of technological artefacts. He joined the Science Museum in London in 1999, and has been the Curator of the Mechanical Engineering collections since 2004.

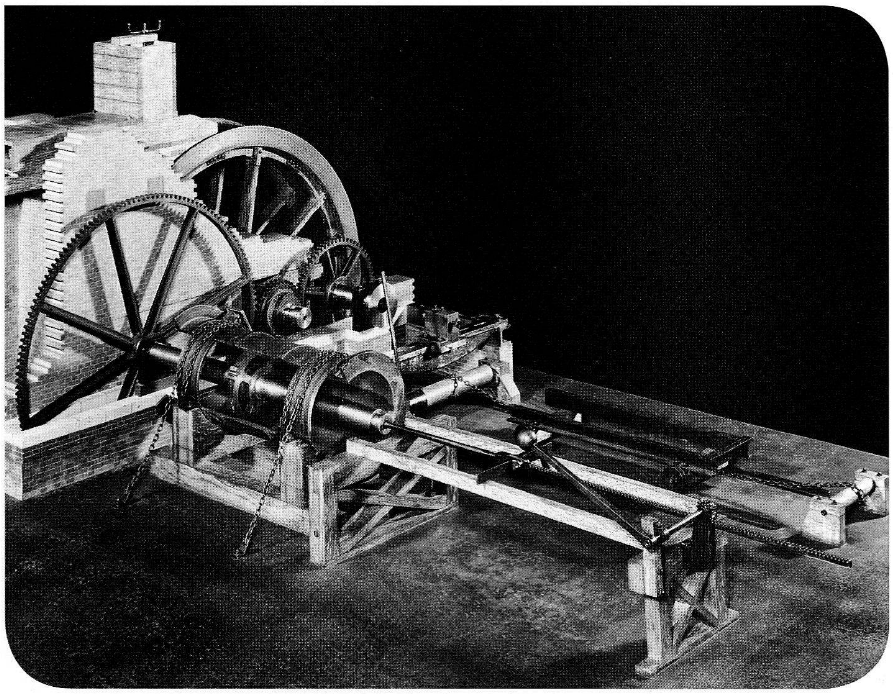

Plate 1: Model of John Wilkinson's boring mill at Bersham, 1775. Inside the left-hand cylinder can be seen the boring bar and rotary cutter vital to making the cylinder bore straight and true. (Photo: Science Museum/Science & Society Picture Library)

Britain's early success as an industrial nation depended in large part on machine tools. By 1825, British toolmakers had created a suite of new machine tools that had not existed in 1790. London was the centre of this transformation, thanks to a combination of three factors: the application of iron construction, the encouragement of creative engineering design, and the demands of young, expanding and potentially global markets.

Grossbritanniens früher Erfolg als führende Industrienation beruhte zum Grossteil auf den Werkzeugmaschinen. Bis 1825 erschufen britische Werkzeugmacher eine Serie von neuen Werkzeugmaschinen, welche 1790 noch nicht existiert hatten. London war dabei das Zentrum dieser Entwicklung. Die drei ausschlaggebenden Faktoren waren hierbei die Anwendung von Eisenkonstruktion, die Förderung kreativer Konstruktionstechniken und die Forderungen junger, expandierender und potentiell globaler Märkte.

Britain's success as an industrial nation relied not just on generating ideas for new innovations, but turning them into economically viable projects. To a large degree, this relied on machine tools – large, general-purpose tools capable of building other machines of an equal or larger size.[1] In Britain from 1790 until 1825 there was a revolution in how machine tools were made. At the start of the period they were largely of wooden construction with metal fittings, relatively crude and lacking robustness. At the end of the period, they were constructed of metal, durable, precisely made and capable of high-precision output. This transformation was the product of an interaction between three factors: new materials, engineering creativity, and economic imperative. These factors were most successfully combined in London during the first quarter of the nineteenth century. This paper will address how this was done, and with what result.

It is first useful to survey the state of machine construction at the beginning of our period. Machines of many sorts were largely constructed from wood, including moving parts like shafts and wheels, and making use of wrought iron or possibly brass only where absolutely necessary. The man responsible for these machines was the millwright. At the other end of the spectrum, both in terms of scale and the extent to which metal was used, was the clock and watch-maker. Many

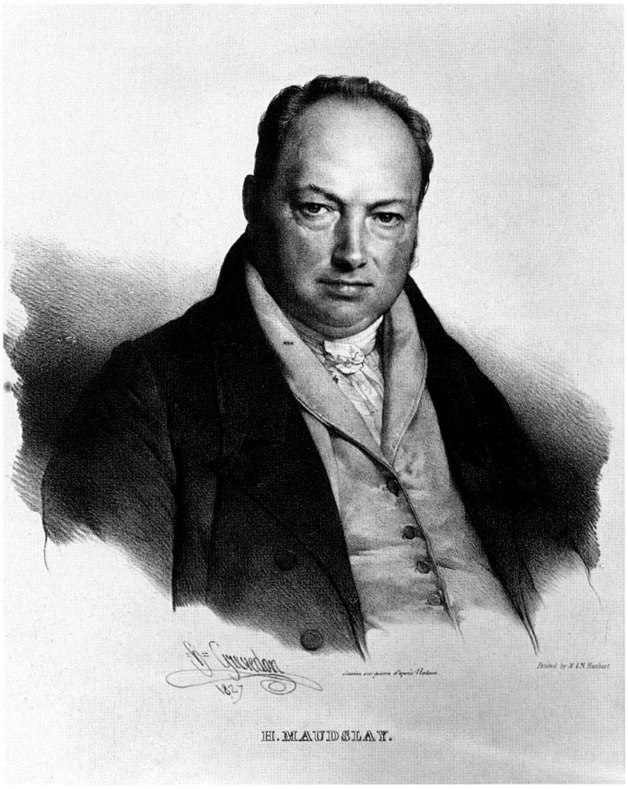

Plate 2: Portrait of Henry Maudslay, by Henri Grevedon, 1827. The portrait reflects James Nasmyth's description of Maudslay as '...an honest, upright, straight-forward, hard-working, intelligent Englishman'. (Photo: Science Museum/Science & Society Picture Library)

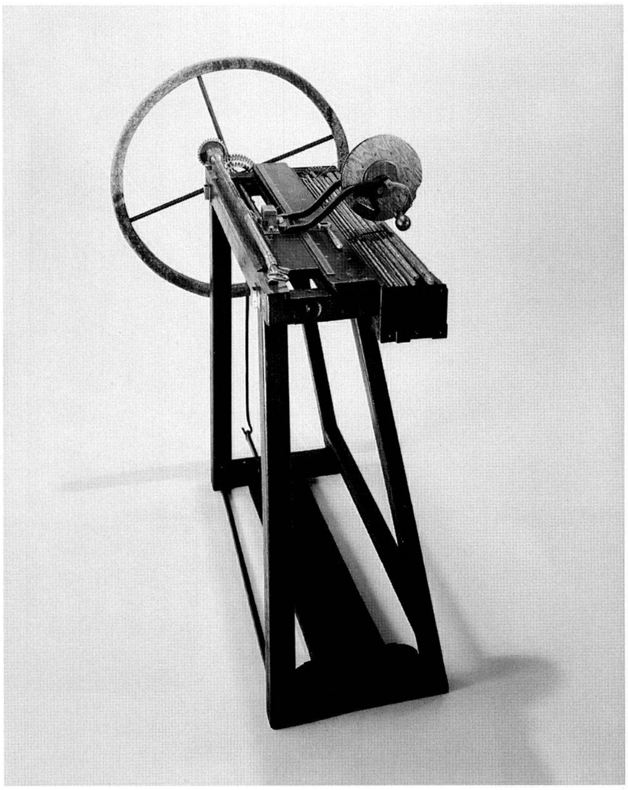

Plate 3: Spring-winding machine built by Henry Maudslay for Joseph Bramah, 1790–1797. (Photo: Science Museum/Science & Society Picture Library)

early clocks had wrought iron frames, with very sparing use of steel for some small parts. Clocks and watches were prestigious articles, status symbols for their owners, and this may account for such widespread use of metal construction.

Cast iron was the material that brought a convergence of the techniques used by the millwright on one hand, and the clockmaker on the other. But this was a lengthy process: it took four decades for the coke smelting techniques pioneered by Abram Darby at Coalbrookdale to be more widely adopted throughout the UK economy.[2] Even then, as machine builders began to appreciate the advantages of cast iron construction, so they had to confront the difficulties involved in working it. Once cast, it could only be worked by hand, by drilling, chiselling, turning or filing. Forced to economise to reduce labour costs, pattern-making to reduce the amount of hand finishing required became important. Machines with cast iron frames are often characterised by the use of chipping strips, narrow raised strips set above the main body of a casting to reduce the amount of hand fitting required when it was joined to other components.

The growing demand for cast iron was reflected in the rise of a number of larger foundries: Boulton & Watt's Soho Foundry at Birmingham or Matthew Murray's Round Foundry at Leeds are well-known examples, and their work in constructing steam engines is the subject of a considerable bibliography. Boulton and Watt started out as consulting engineers, providing engine erectors, drawings and some special parts but otherwise out-sourcing much to sub-contractors like John Wilkinson of Bersham, whose cylinder-boring mill was vital to the success of Watt's engine.[3] The Soho Foundry was only built later, when the expiry of Watt's patents in 1800 was in prospect, and the concurrent need to 'systematise' the engine-making business provided a catalyst.[4] Murray was capable of high-quality work and was perceived as a major competitor by Boulton and Watt, to the extent that they undertook industrial espionage against him and even attempted to block the expansion of his works.

This is not to disparage the enormous contribution Boulton & Watt and their steam engine made to engineering: The Soho Foundry was the world's first factory specifically dedi-

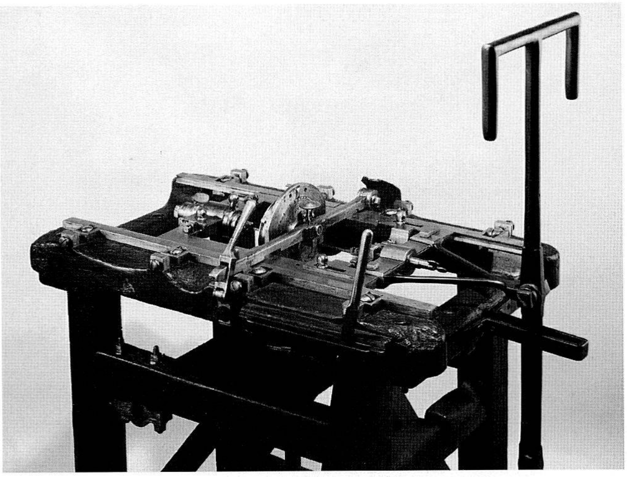

Plate 4: Lock barrel-sawing machine, made by Henry Maudslay for Joseph Bramah, 1790–1797. (Photo: Science Museum/Science & Society Picture Library)

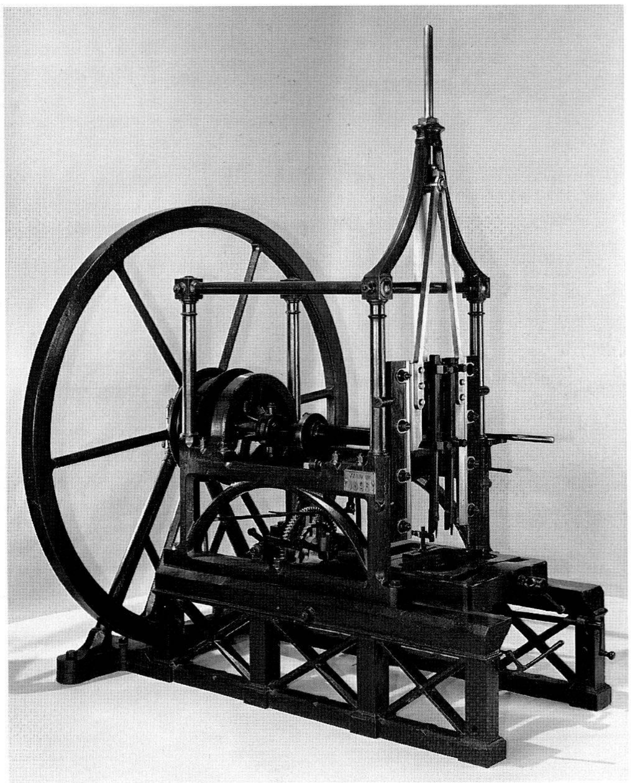

Plate 5: A mortising machine from the Portsmouth block-mills, built by Maudslay, 1803. The two vertical mortising chisels are on the right. (Photo: Science Museum/Science & Society Picture Library)

cated to the manufacture of machines.[5] However, it may be more fruitful to consider a rather neglected facet of Britain's early machine tool industry: the engineers of London. This is partly a response to the belief held by many in the UK today that industry and engineering were something that only happened 'Up North', in Lancashire, the Black Country or on Tyneside. But it also reflects that, although to some extent predated by engineering concerns elsewhere, the London engineers comprised a critical mass, a community of enterprises whose mutual interaction gave them an advantage over their earlier rivals. Assessing what they achieved will form the basis of the remainder of this paper.

The UK's transformation of machine-making in the first quarter of the nineteenth century can be encapsulated in a small selection of machines built by Henry Maudslay. Maudslay started his career at the Royal Arsenal at Woolwich, where he worked as a carpenter. Later he retrained as a blacksmith as his talent for mechanical problem-solving became apparent.[6] One of his first big projects was to construct a suite of machines for Joseph Bramah, to manufacture Bramah's security lock. The lock was effectively unpickable; Bramah patented it in 1784 but one was only opened without a key by an American locksmith in 1851, after sixteen days' work. The lock was not an economic proposition if made by hand due to the high labour costs incurred, suggesting the significance of Maudslay's contribution. Two of his machines survive. One wound the springs used in the locks, having a saddle that traversed the length of the machine and which wound the wire onto an arbor as it did so. The second machine cut slots in the lock barrels at precise angles, the barrel being mounted on an index plate and the saw being guided by V-shaped slides. Both machines are very much in the old tradition, with wooden construction and metal fittings as appropriate.[7]

These machines can be compared with those Maudslay built shortly afterwards for the block-mills at Portsmouth dockyard.[8] The Portsmouth machines were the world's first suite of single-purpose mass production machines. Although not 'flow production' in a modern sense[9], they ably satisfied the Royal Navy's demand for 130,000 pulley blocks per year to equip its ships. As Richard Beamish later wrote: '...ten men, by the aid of this machinery, can accomplish with uniformity, celerity and ease, what formerly required the uncertain labour of one hundred and ten.[10]

The success of the machines lay in their construction, which was profoundly different from that used in the Bramah lock machinery. The Portsmouth machinery was almost entirely metal, making it rigid, not liable to deflection under load, and capable of withstanding the application of steam power. The machines were durable, working into the 1950s.[11] Their components parts were well proportioned, with careful use of bracing to reduce the amount of material needed in their con-

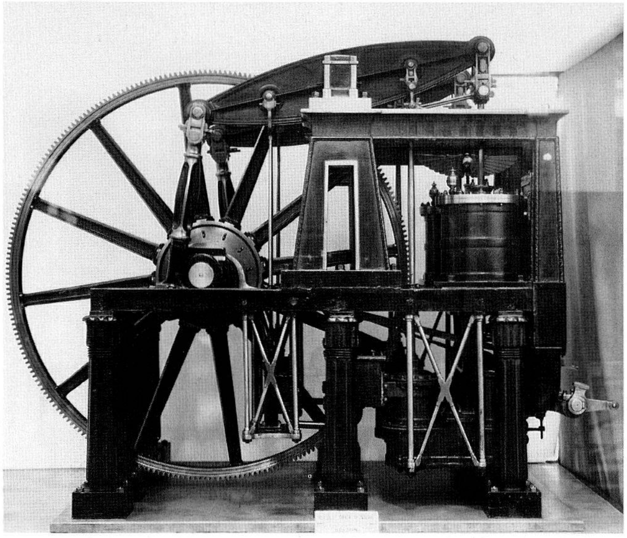

Plate 6: Model of a double beam engine built in the Egyptian style by Benjamin Hick, 1840. On the right, the engine governor is shaped like a scarab beetle. (Photo: Science Museum/Science & Society Picture Library)

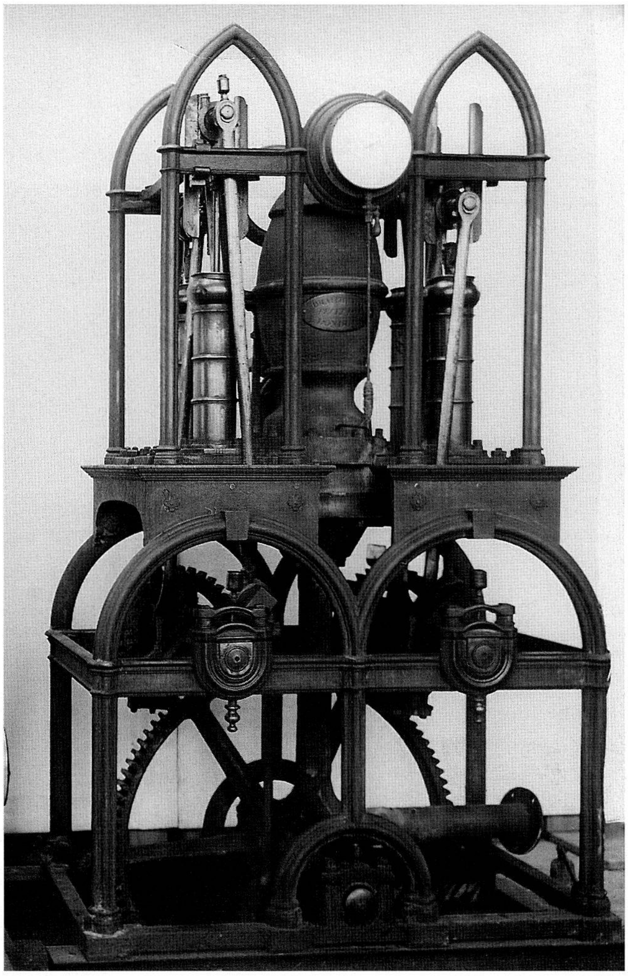

Plate 7: Pumping set by Braithwaite, 1817. The pumps were supplied to a prestigious customer, and this may have influenced their design. (Photo: Science Museum/Science & Society Picture Library)

struction. And they are also elegant, having design details like columns and diagonal bracing that Maudslay used in many other machines. It is important to remember that what appeals to us for aesthetic reasons now originally reflected the new challenges of working in cast iron: sharp corners were weak points, and the relatively smooth, rounded nature of the castings reflected the need to make the machines as strong as possible.

Two main points about Maudslay's Portsmouth machines should be emphasised. First, Maudslay had laid the basics for how machine tools should be built in future. Maudslay later reduced these basics to a series of pithy sayings: 'Keep a sharp look-out on your materials; get rid of every pound of material you can do without...'; 'avoid complexities, and make everything as simple as possible'.[12] Second, cast iron construction enabled the adoption of a new aesthetic that complemented machines' basic functions: more than simply working, they had to look good too. More widely, the Science Museum's engineering collections contain striking examples of highly creative machine design, from a model of a double-beam engine built in 1840 by Benjamin Hick of Bolton in the Egyptian style, to a pumping set by Braithwaite of London dated 1817 and incorporating strong gothic influences.[13]

Maudslay's works at Lambeth, South London, became the UK's foremost engineering academy, and many notable engineers trained there. Among them were Joseph Whitworth, tool-maker and proponent of standardisation, and James Nasmyth, who built his reputation around the steam hammer. They were accompanied by Richard Roberts, who constructed one of the earliest large industrial lathes and a very early metal-planing machine[14], and Joseph Clement, who built Charles Babbage's Difference Engine, the first mechanical computer and the finest piece of precision engineering of its time. Nasmyth, Whitworth and Roberts later relocated to Manchester, the centre of England's industrial north-west. They took with them the best-practice techniques they had learned in London, and diffused them further into the expanding industrial economy.

Maudslay's works were important in themselves, but were also one part of a wider London engineering industry. Alongside Maudslay, other companies made major contributions to machine-tool design. The firm established by John Jacob Holtzapffel around 1794 was the major manufacturer of

Plate 8: Henry Maudslay's works on Westminster Bridge Road, London, 1835. (Photo: Science Museum/Science & Society Picture Library)

ornamental lathes for turners. Their high precision and fine quality were reflected in high prices, making them popular among wealthy amateur turners.[15] Reflecting concerns about banknote forgery, Bryan Donkin of Bermondsey built a fine geometric lathe to engrave the elaborate printing plates needed for banknotes.[16] Elsewhere, Joseph Clement pioneered the construction of a planing machine – it proved so invaluable for the manufacture of other machine tool components like lathe beds that it was often kept running day and night.[17] And other companies like John Penn of Greenwich established themselves with machinery on an unprecedented scale to build marine engines and ships for the booming maritime industry based in London. By 1825, there were approximately 10,000 men working in the London machine trade. Together, they created a complete suite of new machine tools that had not been available 20 years before.[18]

The one unifying feature of all these new machines was the degree of accuracy embodied in their construction, and which they were capable of reproducing. Henry Maudslay and the Royal Mint's John Barton genially competed to see who could better perfect the means of precision measurement. Maudslay devised his 'Lord Chancellor' micrometer, so-called because it was the ultimate arbiter on questions of accuracy in Maudslay's works, while Barton built his 'Atomometer', whose name suggests the degree of precision it aimed to achieve.[19] Rather than being content with accuracy defined for James Watt's engine cylinders as being within the 'thickness of a thin sixpence', Maudslay and his associates aspired to work to $^{1}/_{10,000}$ of an inch or less – and this was later surpassed by Joseph Whitworth's 'Millionth measuring machine'.[20] The use of slide rests, surface plates, micrometers, and highly accurate screw threads were all popularised by the London engineers.[21] Coupled with self-acting machines that could replace hand-work, these new levels of precision brought large-scale standardised and interchangeable manufacture into prospect. Although this is widely credited in the UK to Whitworth in the late 1840s, he was building on foundations that had been laid in London some time previously.

London provided fertile ground for innovation in machine-tool design. It was the largest city in the world, with a popula-

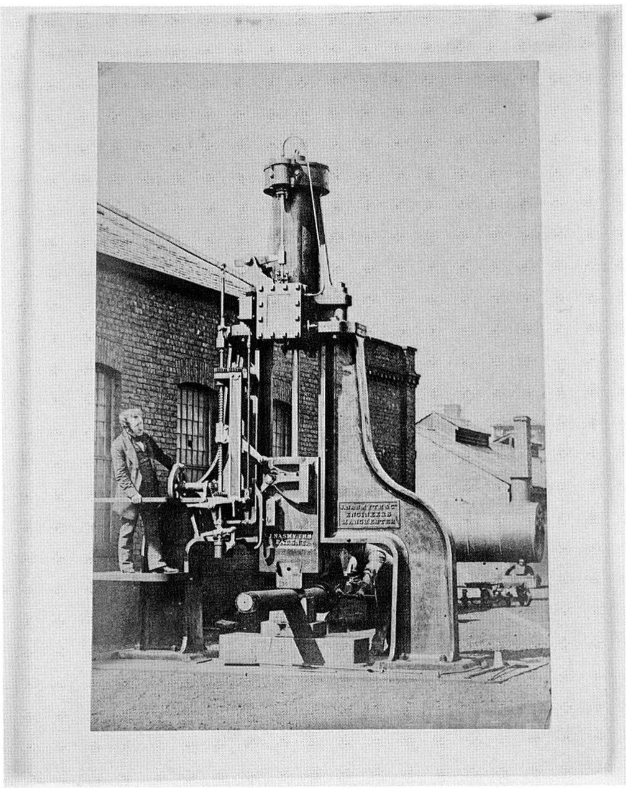

Plate 9: James Nasmyth and his steam hammer, 1845. Between 1843 and 1856, Nasmyth's company built almost 500 steam hammers. (Photo: Science Museum/Science & Society Picture Library)

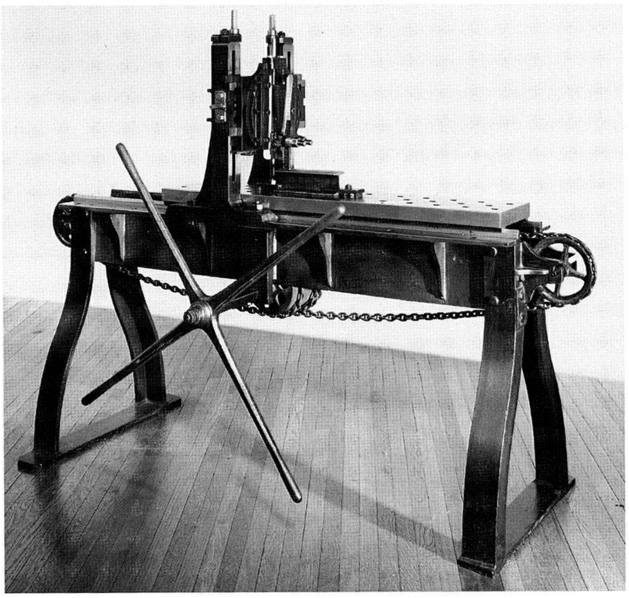

Plate 10: Metal-planing machine by Richard Roberts, 1817. Roberts' company diversified into power-looms, self-acting mules, and locomotives. (Photo: Science Museum/Science & Society Picture Library)

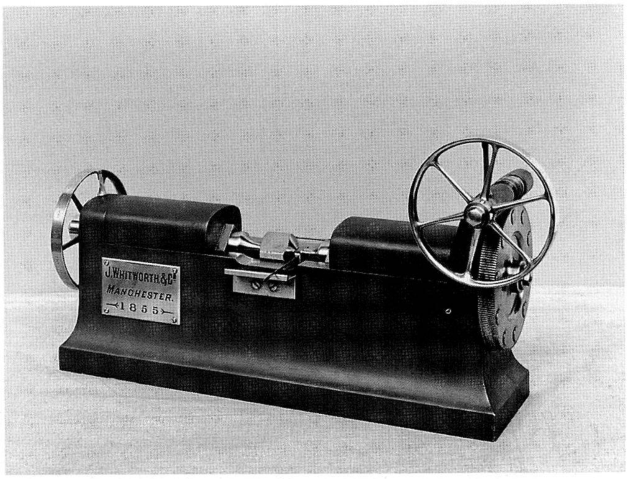

Plate 11: 'Millionth' measuring machine by Whitworth, 1855. One of these machines was displayed at the Great Exhibition of 1851. (Photo: Science Museum/Science & Society Picture Library)

tion that had doubled to 1.5 million over the period 1750–1825.[22] It was also the centre of a global maritime network, helping the value of Britain's sea trade rise by 140% between 1794 and 1846.[23] London was also the centre of a network of roads, canals and railways stretching across the UK, and it also provided an enormous pool of skilled labour for new engineering companies to draw upon, from millwrights and founders to copper and tin smiths, woodworkers, instrument- and clock-makers.[24]

As London provided an ideal climate for engineering companies to thrive in, so those companies imparted a powerful multiplier effect to the wider industrial economy. In Francois Crouzet's words, 'As the progress of machine tools has a leverage effect on productivity throughout the economy, this sequence brought about the general mechanisation of industry after 1850'.[25] This effect was felt in everything from motive power to marine and production engineering. Whereas by 1800 James Watt had built steam engines with a total power output of under 10,000 hp[26], by 1851 Maudslay, Sons & Field alone had constructed marine engines with a total power output of over 35,000 hp.[27] In the late 1820s London's John Braithwaite worked with John Ericsson to build the locomotive Novelty that competed against Stephenson's Rocket in the Rainhill Trials, establishing for good the dominance of the steam locomotive over other forms of motive power for transport. Having built the Portsmouth block machinery, Maudslay later sold duplicate sets of similar machines to Turkey, Russia and Spain.[28] The principles they embodied were widely adopted in the USA, being later re-introduced to the UK as 'the American System' of manufacture.

To conclude, London's early machine tool makers contributed significantly to Britain's wider economy in three ways.

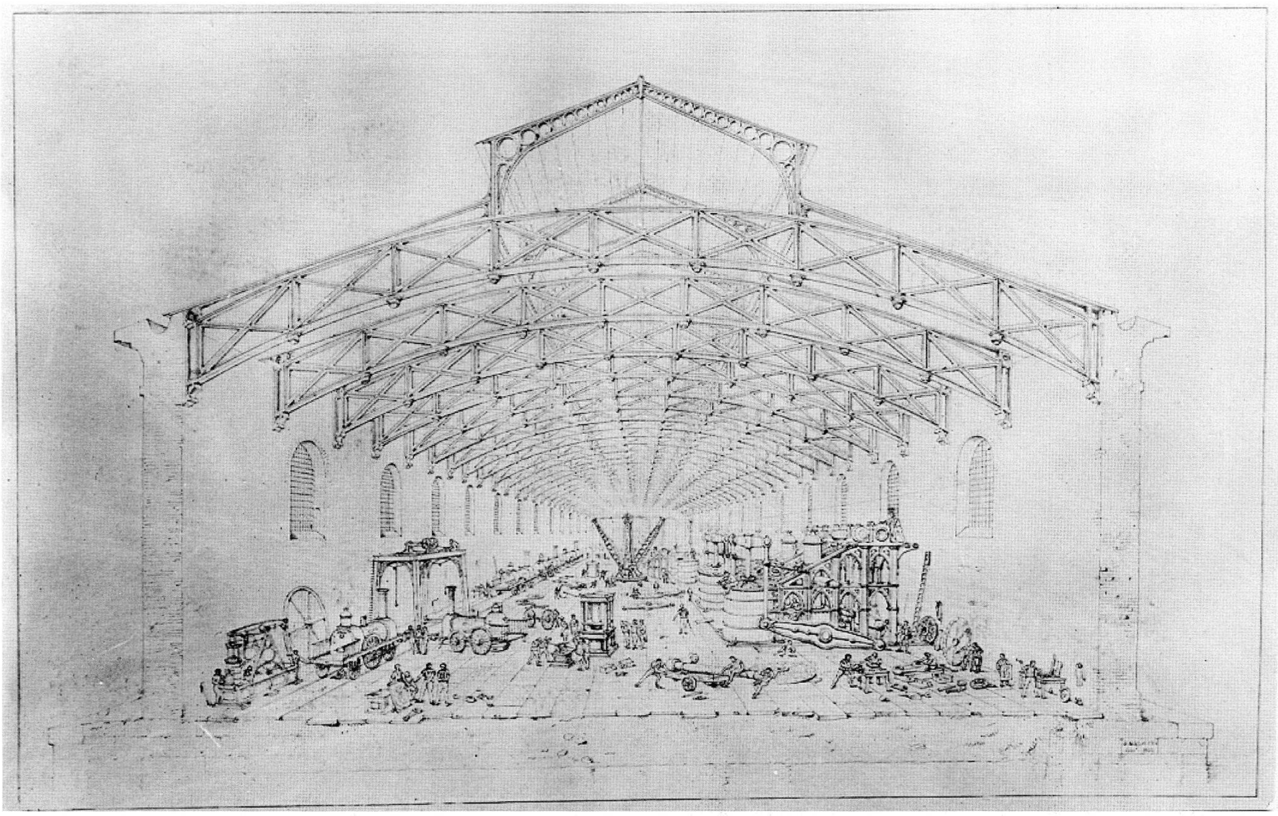

Plate 12: The erecting shop of an engineering works, sketched by James Nasmyth, 1866. All its contents would all have been made with machine tools. (Photo: Institution of Mechanical Engineers)

First, they took new materials like cast iron, solving the problems its use presented, and exploiting opportunities where they arose. Second, they fostered a culture of creativity that was not only embodied in the aesthetic of the machine tools they made, but which was actively spread as widely as possible among the engineering community. Thirdly, the toolmakers were motivated by the demands and potential profits of young, rapidly expanding and potentially global markets. These three factors worked in unison most effectively in London, from the 1790s up until around 1825. The product of their interaction – the ability of machines to make machines – helped Britain achieve sustained industrial growth and consolidate her position as the world's major industrial power in the nineteenth century.

[1] Joel Mokyr: The Lever of Riches: Technological Creativity and Economic Progress, Oxford 1990, Page 103–104.

[2] Phyllis Deane: The First Industrial Revolution, Cambridge 1965, Page 108.

[3] What is stated to be the original Wilkinson boring bar is preserved by the Science Museum, Inv. No. 1913–172.

[4] Erich Roll: An Early Experiment in Industrial Organisation, Being a History of the Firm of Boulton & Watt, 1775–1805, London 1968, Page 156.

[5] Ibid Page 156.

[6] Samuel Smiles: Industrial Biography, Reprint, Newton Abbot 1967, Page 198–235.

[7] Science Museum Hand & Machine Tools collection, Inv. Nos. 1935–128 & 1935–129.

[8] Jonathan Coad: The Portsmouth Block Mills: Bentham: Brunel and the start of the Royal Navy's Industrial Revolution, Swindon 2005.

[9] Carolyn Cooper, 'The Portsmouth System of Manufacture', Technology and Culture, Vol.25 (1984) No.2, Page 212–213.

[10] Richard Beamish: Life of Sir Isambard Brunel, 1862.

[11] Keith Reginald Gilbert: The Portsmouth Blockmaking Machinery, London 1965, Page 1.

[12] Samuel Smiles (ed): James Nasmyth Engineer: an autobiography, London 1885, Page 127.

[13] Science Museum, Motive Power and Pumping Machinery collections, Inv. Nos. 1935–513 and 1933–30.

[14] Science Museum Hand & Machine Tools collection, Inv. Nos. 1909–65 & 1860–59.

[15] Warren G. Ogden: Notes on the History and Provenance of Holtzapffel Lathes, North Andover 1987.

[16] Maureen Greenland: 'Compound-plate printing and the nineteenth-century banknote'. In: V. Hewitt (ed.): The Banker's Art: Studies in Paper Money, London 1995.

[17] Samuel Smiles: Industrial Biography, Reprint Newton Abbot 1967, Page 251.

[18] Tony Woolrich: 'The London Engineering Industry at the time of Maudslay'. In: J. Cantrell & G. Cookson (ed.): Henry Maudslay & the Pioneers of the Machine Age, Stroud 2002, Page 39.

[19] Science Museum Industrial Metrology collection, Inv. Nos. 1900–75 & 1928–719.

[20] Science Museum, Industrial Metrology collection, Inv. No. 1919–265. More recent investigation has, however, found Whitworth's claims to be exaggerated.

[21] David S. Landes: The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present, Cambridge 1969, Page 107.

[22] David Barnett: London, Hub of the Industrial Revolution: A Revisionary History 1775–1825, London 1998, Page 1.

[23] Gordon Jackson: 'Sea Trade'. In: J. Langton & R.J. Morris (ed.): Atlas of Industrialising Britain 1780–1914, 1986, Page 94.

[24] Albert E. Musson: 'The Engineering Industry'. In: R. Church (ed): The Dynamics of Victorian Business: Problems and Perspectives to the 1870s, London 1980, Page 90.

[25] Albert E. Musson: 'The Engineering Industry'. In: R. Church (ed): The Dynamics of Victorian Business: Problems and Perspectives to the 1870s, London 1980, Page 90.

[26] Francois Crouzet: The Victorian Economy, London 1982, Page 248.

[27] Brian Bracegirdle: The Archaeology of the Industrial Revolution, London 1973, Page 112.

[28] Edgar C. Smith: A Short History of Marine Engineering, Cambridge 1937, Page 56.