Dalton's Manchester
The First Industrial City

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John Dalton; born at Eaglesfield in the Lake District about 5 September, 1766, died in Manchester on 27 July 1844. His life spans an era of extraordinary scientific and technological development that has been characterised as the Industrial Revolution. When he was born, the fastest way a person could travel was by galloping horse. When he died, the network of railways with their express trains was spreading across the length and breadth of Britain. When he was born, industries such as textiles were handcrafts in peoples' homes; the spinner at her wheel, the weaver at his loom. When Dalton died, there were cotton spinning mills of over 50,000 spindles and weaving sheds of over 1,000 looms. The unreliable sources of power such as wind and water had been replaced by steam engines of over 500 indicated horsepower. These advances were based on the development of technologies such as mechanical engineering, while scientific discoveries too were beginning to make themselves felt, such as chlorine for bleaching and the new art of photography.

What was it that made Manchester so pre-eminent in so many industries during this period? What was it that made Manchester so attractive to ambitious people with the result that famous people in science and engineering should seek their fortunes in Manchester? I instance members of the Literary and Philosophical Society such as Peter Ewart from Dumfries, James Watt junior from Birmingham, Richard Roberts from Llanymynech, Wales, James Nasmyth from Edinburgh, Joseph Whitworth from Stockport, Charles Beyer from Germany and even Dalton himself. Why was Manchester more attractive to them than other industrial towns like Birmingham, Leeds, Sheffield and even London?

Perhaps where we are meeting tonight gives one clue – Cross Street Chapel - Unitarianism and non-conformity. In 1791, Birmingham suffered four days of anarchy when the mob, crying 'No Philosophers – Church and King for Ever', ransacked the houses of dissenters, burning the laboratory and valuable library of Joseph Priestley, the non-conformist minister and scientist. Manchester avoided any such major riot. It was an unincorporated town so was free to expand without the restrictions of guilds and similar organisations. And expand it did. In 1758, shortly before Dalton was born there were around 17,000 citizens. In 1788, just before he moved to Manchester, there were 43,000. At the first census in 1801, the figure was 70,409. This had more than doubled by 1831 to 142,026 while ten years later Manchester and Salford had 235,507 people. The growth rate slowed down a little after that.

While there had been growth in population across the whole of Britain during this period, Manchester had been leading the way compared with most other areas. If we take the years 1775 and 1821, we find that in 1775 the size of population in towns such as Birmingham, Leeds, Sheffield and Manchester was small but roughly equal. London was way ahead. If now we turn to 1821, while Manchester lagged behind London, it had far outstripped both Leeds and Sheffield although maintaining parity with Birmingham. But the corridor between Manchester and Liverpool as well as the hinterland of Manchester had developed enormously compared with the Birmingham region, giving support to my claim for Manchester being the first true industrial city.

Other Comparable Cities

Let us look at Sheffield. For what products has Sheffield been best known? I suggest Sheffield plate and cutlery. While Sheffield plate has been a cheap alternative to genuine silver, neither it nor cutlery are items that you purchase frequently. They should both last a long time so there is no mass market for them. In Sheffield, cutlery was made in small workshops where specialisation was highly developed. For example, one craftsman might forge a knife blade from the high quality Sheffield steel. A lad would carry a bundle of these partly finished blades to the next craftsman in another shop where the tangs would be forged. Then the handles would be fitted in the shop of a third craftsman, and so on. While there were water-powered forges in the valleys

surrounding Sheffield, industry here never developed the scale of manufacturing compared with the Manchester cotton industry and its steam-powered mills. At Sheffield, there was only one steam engine installed by Boulton and Watt between 11775 and 1800 compared with over 30 to the cotton industry in Manchester and Salford.

At Dalton's birth, the wool industry was spread broadly across most of England with centres in East Anglia, the West Country as well as Yorkshire. Even in 1757, Malachy Postlethwayte could write:

> The woollen manufacture being the great staple of England, it will remain her everlasting interest to support this branch as much as possible against all competitors as well as any such attempts to injure it either in Ireland or Scotland, and the British plantations, as well as the efforts of France or any other foreign rival to ruin it; for the loss of this capital branch will first ruin a great part of the landed interest, and banish our woollen manufacturers out of the kingdom, after that the rest of our other artists may soon go a wool-gathering too, according to our English proverb; for our woollen fabrics have provided a great support of most of our other, by promoting their sale in conjunction at the same time. [1]

The cotton industry was of only secondary importance at Dalton's birth. But this would change with the inventions of James Hargreaves, Rich-

ard Arkwright and Samuel Crompton for spinning cotton after the 1760s. These inventions did not spread to the wool industry until the 1790s. There were other factors in the later growth of the Yorkshire woollen industry such as the provision of the raw material for it was not until fine quality wool started to arrive from Australia in the 1820s that this industry could begin to expand quickly and centre itself on Leeds and that area. By this time, Manchester had taken the lead in textile manufacture from both silk and wool. We will examine the importance of the cotton industry later.

If Manchester was ahead of Leeds, what about another main rival, Birmingham? Once again for what was it famous? I suggest small arms, chains, horseshoes and what were called 'toys', consisting of small metal wares like buckles and broaches. How were the small arms or muskets and pistols made? While demanding higher standards of accuracy than cutlery, each gun was made and assembled individually, once again in small workshops. Eli Whitney is said to have introduced standardisation of musket production in 1798 in the United States, but this did not influence this trade in Birmingham until the explosive demand for guns in the Crimea War of the early 1850s.

Likewise the other main Birmingham trade of 'toys' was also carried on by craftsman in their small shops. The important exception was Matthew Boulton who established the famous Soho Manufactory in 1761. But even here his Manufactory was more a building where he could

house craftsmen in their own workshops specialising in their own trades than what we would consider a factory today with the whole workforce combining to make the product. In Boulton's Manufactory, there was produced some exquisite work such as his beautiful ormolu clocks and vases but here again we are dealing with a luxury product for which the demand was small and sometimes non-existant. His Manufactory was not copied again in Birmingham.

After the partnership of Boulton and Watt had been settled, they only supplied specialist parts for their steam engines from the Soho Manufactory, contracting out the large parts such as the cylinders and working beams. Probably only one rotative Boulton and Watt engine was supplied to a Birmingham manufactory between 1775 and 1800 other than those to the Soho Manufactory itself. Generally the Birmingham manufacturers confined themselves to small products which could be carried away in the panniers of horses because the state of the roads was so inadequate. Birmingham high up in the centre of England had to wait for the development of the canal system in the last quarter of the eighteenth century before its industry could really develop. Once again, Manchester was far ahead.

<u>The Main rival, London</u>

What about our capital city, London? In terms of population, London has always outstripped all other British town and cities. Demand for

food and drink was always paramount so we have, for example, the construction in 1786 of the Albion corn and flour mill at Blackfriars with its steam engines by Boulton and Watt. It should have been the show-piece for Watt's new type of rotative steam engine but it was not a commercial success and burnt down in 1791. The fire raged for three days. Arson was suspected but never proved. It did not lead to the industrialisation of the food industry. There was a textile industry in London, Spitalfields silk. The silk industry had shown the way for mechanisation with the Italian throwing machines installed originally by the London merchant Thomas Lombe and his half-brother John at Derby in 1722. These machines in their mill may have provided the basis for later textile spinning mills but there were none in London. Once again silk remained a high quality expensive fabric that could be afforded only by the rich.

There was an important engineering industry in London, exemplified by Joseph Bramah and his apprentice Henry Maudslay. Bramah designed complex locks which defied thieves, a flushable water closet as well as an hydraulic press. Maudslay, learning precision engineering from his skilled master, set up on his own and pioneered a series of machine tools. His fame soon spread and, after the end of the Napoleonic Wars, attracted pupils like our own Richard Roberts, James Nasmyth and Joseph Whitworth. Maudslay built some fine steam engines for ships but ship building would move to places of primary production such as Newcastle-upon-Tyne with its abundant resources of coal. Coal, and

hence fuel, was always expensive in London through the taxation of sea-born coal, another instance where Manchester had the advantage.

There was one famous engineer who settled in London, John Rennie, born at Haddington near Edinburgh in 1761. He was trained as a mill-wright before moving south to Birmingham to work for Boulton and Watt. His ability was quickly recognised and he was sent to erect the steam engines at the Albion Mill. He established his own mill-wright-ing business and engineering works at Blackfriars but Boulton was very disappointed when Rennie turned his attention to civil engineering in which he became the leading exponent in Britain before his death in 1820. London was more the centre for civil than mechanical engineer-ing. Rennie's sons carried on his firm which built waterwheels, steam engines and later railway locomotives but it never achieved the fame of similar concerns in the north. Of course there were in London other engineering concerns such as John Hall of Dartford, millwrights, where Bryan Donkin so dramatically changed the Frenchman Nicholas Robert's papermaking machine into a viable proposition soon after 1800 but here again, the papermaking industry never expanded to the same extent as did the cotton industry and always remained dispersed throughout the country.

<u>The Cotton Industry</u>

Before Dalton's birth, the cotton industry had for a long while been the bete noir of the British government. It did not fit in with the mercantilist economic policies of around 1700 and it was seen as a threat to the long-established wool trade. During the second half of the seventeenth century, the East India Company organised a profitable business bringing back colourful calico and fine muslin cloth from India which became popular forms of dress. So popular and fashionable did these become that it was feared that they would threaten the wool trade so that in 1700 Parliament imposed heavy duties on the colourful Indian calicos. The result was to stimulate the small English calico-printing industry which expanded rapidly by printing white or grey cloth. This further angered the wool interests resulting in an Act of 1721 prohibiting any printed material made of cotton or mixed with cotton with the exception of fustian. This had become the mainstay of Manchester's trade and it was surprising the variety of cloth which could be termed 'fustian'. Manchester flourished, only for the wool interests to attack again, resulting in a further Act of 1736. This permitted the use of printed fustians, provided the warp was entirely linen. Those who wore pure cottons might be fined £5 while those who sold them could be fined £20, a fortune in those days.

This was still the legal situation in about 1764 when James Hargreaves invented his spinning jenny as well as in 1769 when Richard Arkwright patented his waterframe. Both these machines could spin more than a single thread at a time. Prior to this all cotton and wool was spun on

either one of two types of spinning wheels. My own experience spinning on these wheels bears out the assertion that 'one person could with difficulty produce a pound of [cotton] thread by close and diligent application the whole day'. [2] It was certainly a monotonous occupation. My attempts at spinning also pointed to the fact that, while it is easier to spin wool on such wheels, it is easier to mechanise the spinning of cotton. This is due to the staple length of the individual fibres. The staple length of cotton fibres is shorter than those of wool so that it is easier to draw them out on machines into the roving needed for spinning. So mechanisation in the woollen industry followed that of the cotton industry. This was also true of the worsted branch where mechanisation of combing wool occurred around the time of Dalton's death. This partly explains how Manchester took the lead in textiles from silk and wool.

Another factor was the ready supply of cotton. Well before the 1780s, fine cotton was being grown in the West Indies. Cotton is an annual crop and virgin land was plentiful both there and in the southern United States of America so that provision of raw cotton could be quickly matched to demand. There was greater demand for cotton cloth compared with wool. As we have seen, cottons could be printed with bright colours. They could be washed more easily than wool. Cotton calico and muslins could be worn in hot climates. Through the new spinning machinery reducing the price, Lancashire cotton cloth quickly captured foreign markets. The export of cotton cloth created a demand far greater than was needed for domestic consumption in Britain so that the

cotton textile industry expanded to a size far greater than could have been sustained solely by the market in this country.

But before this great expansion of the cotton industry could take place, the restrictive laws imposing penalties on the wearing of all-cotton cloth had to be repealed. This Arkwright and his partner Jedediah Strutt achieved in 1774 so that production of cotton cloth expanded enormously. The spinning jenny of Hargreaves always remained operated manually, first probably with eight spindles, increasing to over one hundred. In contrast, Arkwright's waterframe, as its name implies, could be driven by something much more powerful than a human being. From his home town of Preston, Arkwright moved to Nottingham where he used a horse and then in 1771 to a site at Cromford. This mill, which still exists, was a great advance since it was powered by a much more powerful waterwheel. In 1775, Arkwright patented machines to process the whole of the spinning process from the cotton bale to the finished yarn. Soon he was selling licences to other manufacturers for mills of over 1,000 spindles each. Waterpowered mills sprang up all over the country wherever a suitable fall in a river could be found. A survey was carried out in 1788 which listed nineteen cotton mills in Scotland and 124 in England, most of them driven by waterwheels.

<u>Growth of Industry in Manchester</u>

So where was the town of Manchester in all of this great flurry of mill building? I am afraid to say, left far behind at this stage because Manchester itself lacked suitable waterpower sites. But this position rapidly changed for three reasons – one, a new type of spinning machine, two, the introduction of the steam engine, and three, adequate supplies of coal through a new transport system. First, by 1779 in his home at Hall-i-th-Wood near Bolton, Samuel Crompton was spinning cotton on his mule finer than could be done by any hand spinner. The new spinning machines produced a better quality product. The mule could spin a finer yarn than Arkwright's waterframe. At last it became possible to spin and weave in this country fine quality muslin that outclassed the Indian. The demand was immense so much so that in 1787 it was estimated that there were 550 mules and 20,700 jennies which, together with waterframes, contained nearly two million spindles. The mule would become the most popular spinning machine in Manchester.

In 1780, Arkwright built a large spinning mill on Shudehill. It has been suggested that he was challenging the well-established Manchester cotton magnates by being the first to build such a mill at the centre of the cotton industry. However, only a small stream ran down Shudehill, totally inadequate to power any textile mill, let alone one the size Arkwright planned. So he turned to the steam engine. This was probably the first time that steam power was used in a textile mill. We do not know the actual type but he probably intended it to drive the machinery

directly. It was a failure so he adapted it to pump water over a water-wheel.

Meanwhile in Birmingham, James Watt was busy improving his more economical type of steam engine. In 1781, Matthew Boulton pointed out to him how 'the people in London, Manchester and Birmingham are Steam Mill mad'. [3] In 1784, Watt perfected his rotative steam engine with his parallel motion to drive machinery directly. He sent Rennie to install the first in a textile mill at Papplewick to the north of Nottingham in 1785. Some of its parts ended up by mistake in Manchester. The first Boulton and Watt engine in Manchester was purchased by Peter Drinkwater (Member of the Lit. & Phil. 1786) to drive the preparatory machinery for his mules. He consulted Watt not only about the opposition he faced through pollution from steam engines but also about the toilet facilities in his mill. Peter Ewart (member 1798, vice president 1812) was trained by Boulton and Watt and helped to erect this engine. He remained in Manchester, giving a paper to the Lit. and Phil. on 'The Measure of Moving Force', eventually owning his own mill. Drinkwater's mill was working soon after 1789 and a little later he employed Robert Owen (member 1793), the famous philanthropist of New Lanark. By this time Manchester was well on the way to becoming the first industrial city with true factories. We do not know the total number of steam-powered mills in Manchester because a list in the archives of the Lit. and Phil. was destroyed in the blitz along with our George Street house. We know that there were 32 Boutlon and Watt

engines in Manchester in 1800 totalling 430 horse power but this does not include any built by rivals such as Joshua Wrigley or Bateman and Sherratt. Incidentally John Sherratt was elected a member in 1823. Steam power moved the textile industry from its country mills into the centre of Manchester and other towns.

At this point, we must turn to the third factor that enabled Manchester to develop its industries; improved transport. In contrast to Birmingham and Sheffield, Manchester was linked by water transport to a major port, Liverpool, by 1735 through the Manchester and Irwell Navigation. Manchester would set the trend for the first main transport system across the heart of England, incidentally reaching Birmingham. The Duke of Bridgewater, having been unsuccessful in marriage, decided to improve his estates at Worsley. He employed James Brindley to link the coal mines there with a canal into Manchester. Wonder of wonders; his barges floated high over the River Irwell in a magnificent stone aqueduct. His canal was completed in 1766, examined by Watt in 1767, and extended in 1776 to form a rival route to Liverpool through Runcorn and the Mersey.

For Manchester, the real importance of the Bridgewater Canal lay in bringing cheap coal to the city for heating and the steam engines – incidentally, the coal was carried in containers which could be quickly loaded into the barges and off-loaded in Manchester and carried on carts around the city, perhaps another first. In the next few years, other

canals followed quickly, the Manchester, Bolton and Bury; the Rochdale; the Ashton; the Huddersfield; the Peak Forest and their branches. Manchester became the centre of a spider's web of canals and was nicknamed Little Venice. At Preston Brook, the Bridgwater Canal met the Trent and Mersey Canal coming up from the south through the Potteries. These canals linked other towns with Liverpool so that shipping increased dramatically through that port. In 1800, 4,746 ships docked with a tonnage of 450,060 which had risen in 1825 to 110,837 ships and a tonnage of 1,223, 820. The importance of the cotton industry in this whole development is shown by figures for the import of raw cotton.

In 1700, roughly 1,000,000 lbs were imported.
In the 1760s when Dalton was born, 3,681,904 lbs.
In 1781, 5,000,000 lbs.
In 1790, 31,447,650 lbs.
In 1800, 58,878,163 lbs.

Surely the world had never seen a phenomenon like this before. The price of fine cotton yarn fell from 38/- in 1786 to 9/5 in 1800 and in 1829 to only 3/2.

The ramifications of the textile industry stretched far beyond spinning and weaving. The mills to house the machinery had to be built so there was a demand for suitable materials. Wooden floors and wooden beams soaked with oil from the machines were a fire hazard. The

Strutts at had been experimenting with cast iron pillars and beams at Derby, Milford and Belper during the 1790s which became the pattern for others. In 1800, George Lee consulted Watt about a new mill he was going to build in Salford with his partner Philips. The Salford Twist Mill was the first of many iron-framed ones in the area. A Boulton and Watt engine was installed which Lee tested to determine its power and the power needed to drive various types of machines. This shows the scientific interest of many Manchester mill owners.

However the Salford Twist Mill is more important for its place in the history of gas lighting. The story starts in 1792 with William Murdock, Watt's representative in Cornwall, experimenting with a gas flame to light his house at Redruth. Ten years later, he celebrated the Peace of Amiens by including in the illuminations of the Soho Manufactory a couple of gas lights. Then in 1805, Lee had Murdock light his house by gas. This proved so successful that in 1806 – 7 the Salford Twist Mill was lit by 271 Argand burners and 633 cockspur burners. This was the first major gas lighting installation in the world. At the same time, Samuel Clegg, a Mancunian and early gas engineer, provided a gas light outside the Police Office in King Street. Clegg later used lime to remove the obnoxious hydrogen sulphide from the gas. Another important step was taken in 1817 – 18 when the Police Commissioners established a gas works in Water Street. This was not only for lighting the streets but in addition for the first time the public

could ask for a supply for their own homes. This was another important step in the development of the city.

The mills had to be equipped with all the machinery. This took seven years in the Shudehill mill because the machines were built by the technical staff of the mills such as clockmakers. The larger mills proved to be excellent schools of engineering. Some parts such as spindles may always have been purchased ready-made in bulk from those who supplied the earlier cottage industry. Gradually such suppliers began to build complete textile machines. John Kennedy (member 1803) from Kirkcudbrightshire was one such who started by building mules in the 1790s but, having one left on his hands, turned to spinning and finished as a fine spinner with mills in Ancoats in the firm of M'Connel and Kennedy. James M'Connel was elected member in 1812.

Another person who was attracted by the prospects of Manchester as the first industrial city was Richard Roberts. Having been drawn for the Militia during the Napoleonic Wars, he fled from Tipton, first to Liverpool but finding no work walked on to Manchester. Arriving penniless he was given some wood turning before having to flee again, this time to London where he was employed by Maudslay. Having gained skills in metalworking, he returned to Manchester in around 1816 to set up his own business of machine tool building and supplying parts for textile machines. He developed better lathes, planning machines, gear cutting machines, machines for making reeds for looms, an improved power

loom, as well as his famous self-acting spinning mule in 1825 and 1830. He must have returned to Manchester with virtually no capital but he was elected member of the Lit. and Phil. in 1823. To me, this shows the openness of the Society at that time. Among other famous engineers who came to Manchester virtually penniless was William Fairbairn from Kelso, builder of mills, waterwheels and steam engines, elected member in 1824. Later he wrote important books on mill structures and engineering.

We have not yet finished with the importance of the textile industry because, as I have stressed, cotton cloth could be dyed and printed with bright colours. This needed chemicals from bleaching through to the final colours. Bleaching with lactic acid and washing the cloth with an alkali was a long slow process and was holding up the expansion of the cotton industry. In 1785, the Frenchman Claude-Louis Berthollet published his discovery of the whitening effects of chlorine. In Manchester Thomas Henry (member 1781, President 1807) was quick to start experiments with this highly dangerous gas. He originated in Wrexham and become one of the founding members of our Society and Secretary for the first five years. His apprenticeship as an apothecary and then his medical practice in Manchester had long involved him in chemical researches. He was deeply interested in the application of scientific principles to dyeing so he turned his attention to chlorine in 1787. Having learned something from Watt who did not give much away, Henry experimented until he made the bleaching process work and went into

partnership with John Wilson which failed after a year or two. Others quickly established bleaching with chlorine.

Turkey red was a popular colour but a very difficult dye to produce. Watt was interested in the chemistry of this process and herein lies an extraordinary tale, showing once again the attraction of Manchester as an industrial city. James Watt junior was also passionately interested in chemistry because it seemed to unlock so many mysteries. He was being groomed to take over his father's role in the steam engine partnership of Boulton and Watt. Quite suddenly in the summer of 1788, he threw it all up. It is not known why; possibly there was a broken love affair for he never married. Also at the age of 19, he wanted to make his own career away from being his father's shadow. It was finally agreed that he should be apprenticed for three years to Taylor and Maxwell, fustian manufacturers, printers and dyers in Manchester who would instruct him 'respecting the Manufactory, Dying, Dressing, printing and finishing of the cotton goods we deal in, & also Bookeeping'. [4] The premium would be £400. Now Charles Taylor was an expert in dyeing turkey red and was concerned that Watt junior was being sent to Manchester as a spy and that Watt was planning to set up a rival concern. However Watt junior was accepted and soon found himself in an ambiguous position as a junior clerk in an office while being expected by others to act as his father's representative for the steam engine business. He made a regular visit every morning to the barbers and quickly ran up debts so he had to ask Matthew Boulton for a loan of £50 at

Christmas 1789. I hate to suggest that part of his extravagance may have aided his election both as member and Secretary of our Society in February 1789. His father pointed out that he knew 'for a certainty that people live in the [your] situation you should live upon much smaller sums'.

A much later spin-off from the dyeing and calico printing industry was photography. Chemists in for example Strines Print Works were investigating early photographic processes possibly as a means of printing on cloth. One of the exhibits the Society passed to the Museum of Science and Industry was a photo of Mercer printed on cloth. Before this, the scientific instrument maker, John Benjamin Dancer (member 1842) left Liverpool for Manchester around 1841. In 1842, he took the first photograph of a Manchester street scene on a Daguerreotype plate. He probably took the photograph of Dalton as well as supplying Dalton with a microscope. He also supplied other members such as James Joule with scientific apparatus in addition to pioneering microphotography. So here we have further industries supported by the textile industry.

Importance of the Manchester Literary and Philosophical Society

It has surprised me how many people who made contributions to the development of Manchester as the first industrial city were members of the Lit. and Phil. Our Society played a central role in the transforma-

tion of Manchester in a way that neither the Royal Society of London nor the Lunar Society in Birmingham did in their respective cities. Election to the Royal Society confirmed your standing in your scientific career. Publication of a paper in the *Philosophical Transactions* was a mark of honour – in modern parlance, 'you had arrived'. While based in London, it drew its elected members from all over the country but had little impact on the industries of its host city, other than perhaps being a select club.

The famous Lunar Society of Birmingham was a private dining group by invitation only. While its core members such as Matthew Boulton, James Watt and William Small lived in Birmingham, Erasmus Darwin came from Lichfield, Josiah Wedgwood from Stoke-on-Trent, Joseph Priestley from Leeds although latterly living in Birmingham. Individually each member had made important scientific or technical discoveries or inventions but these had little connection with businesses in Birmingham. After a brilliant beginning, it had petered out before 1800. Watt barely mentions the dates of meetings in his Journals, let alone the topics discussed. No records were kept of their discussions. Boulton's dining room at Soho House might hold ten people at a pinch. It certainly was not a society that aimed to enhance the industrialisation of Birmingham.

In contrast, we have seen how the Lit. and Phil. was closely involved with the social and industrial life of Manchester. Its members met and

discussed their mutual concerns which were based on a wide variety of scientific and industrial interests. I have no need to remind you that the Lit. and Phil. was founded in 1781 by members of the Manchester Infirmary. The establishment of an Infirmary in 1752 gave Manchester an edge over its rival Bolton. The Infirmary moved to Piccadilly Gardens in 1755 where it was joined ten years later by the Lunatic Hospital and Asylum. Such places were alas very necessary because Manchester paid the price for early industrialisation in the state of its inhabitants and city as described by John Aikin in 1795.

> The Irwell at Manchester and for some distance below is destitute of fish, the water being poisoned by dye-works… New streets built within these few years have nearly doubled the size of the town. Most of them are wide and spacious, with excellent and large houses… but very few of the streets are yet flagged, which makes walking in them, to strangers, very disagreeable…Manchester may bear comparison with the metropolis itself in the rapidity with which whole new streets have been raised and its extension on every side towards the surrounding country… It unfortunately vies with or exceeds the metropolis in the closeness with which the poor are crowded in offensive dark, damp and incommodious habitations, a too fertile source of disease. [6]

Perhaps it is not surprising that Thomas Henry's milk of magnesia was so popular as a very useful indigestion powder, perhaps not one of Manchester's more memorable inventions.

This was the Manchester for which Dalton left the glorious countryside of the Lake District in 1793 to teach mathematics and natural philosophy at New College. He found himself in a flourishing scientific community in which he was soon at home. Thomas Henry, Thomas Percival (member 1781, President 1782) and Robert Owen sponsored him for membership of the Lit. and Phil. in 1794. He became Secretary in 1800, Vice President in 1808 and President in 1816. As well as being involved in Society affairs, he remained active in natural philosophy or science, bringing acclaim to both the Society and Manchester. His perceptive mind noted that he saw the colour of the geranium flower differently from other people in day or candle-light which led him to recognise his own colour blindness. His meticulous recordings of the weather, temperature and rainfall formed the basis of the atomic theory which he published in the Lit. and Phil. Memoirs in 1804. He presented upwards of an hundred papers, not all of which were published. These covered a wide variety of topics such as evaporation of water; respiration and animal heat; the rock strata in Manchester and its vicinity; properties of indigo and much more.

Through his range of interests and key positions in the Society, Dalton could give advice to others. He collaborated closely with William

Henry (member 1796) when William extended his father Thomas's Magnesia factory into soda water for medicinal use. They also attempted perhaps for the first time to develop the Leblanc process in Britain. Dalton had his laboratory in the Society's house in George Street where he taught science and mathematics to private pupils. One of his most famous pupils was James Joule (member). Joule probably learnt his meticulous experimental techniques from Dalton which enabled him to put the science of heat and thermodynamics on a correct foundation. Alas, the destruction of the archives of the Lit. and Phil. have deprived us of knowing more about Dalton's advisory role to industry.

Second Phase of the Industrial Revolution

The increasing scale of trade between Manchester and Liverpool demanded better transport facilities. Dalton lived long enough to see the start of a second phase of the Industrial Revolution with the opening of the Liverpool and Manchester Railway on 15 September 1830. In 1770, it had taken twelve hours to travel between Manchester and Liverpool. By the 1820s, this had been reduced to three hours at an average speed of 12 miles an hour. The new railway cut down the time by at least a third. People flocked to travel on it, exceeding the promoters' wildest expectations. During the first full year of operation in 1831, 445,047 passengers were carried. Whishaw wrote in 1842,

The Liverpool and Manchester Railway may truly be designated the Grand British Experimental Railway. The general extension of the railway-system not only throughout our own country, but also over the continents of Europe and America, is mainly owing to the success of this important work. [7]

James Nasmyth, then personal assistant to Maudslay in London, went to see the opening. Later he moved to Manchester where he started building steam engines, machine tools and his steam hammer. Nasmyth was born in Edinburgh and became a member in 1837. Likewise Joseph Whitworth (member 1839) from Stockport went for training at Maudslay's and other places in London before settling upon Manchester for building machine tools. Building textile machines and mill engines continued apace with for example the spinning mule by Roberts. Sharp Roberts, Fairbairn, and Galloway tried their hands at building railway locomotives with varying success. There is no doubt that the new railway industry gave a great boost to industrial enterprise. We can see one effect in the import of cotton stimulated by better transport communications for both passengers and goods. Imports increased dramatically.

1820	152,829,633 lbs.
1830	269,616,460 lbs.
1839-41	426,300,000 lbs.
1844-46	523,300,000 lbs.

In the export trade of Britain, cotton textiles achieved prime place, outclassing the combined value of all other exports. The cotton industry had become based primarily in Manchester. Dalton had lived through the formative years of the Industrial Revolution which turned Manchester into the first industrial city and changed the world for ever.

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