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Coal – Parent of the Industrial Revolution in Great Britain: The early patent history

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ABSTRACT

From approximately 1770 to 1850 Great Britain successfully completed the world's first Industrial Revolution. One of the main reasons for this was the country being endowed with extensive cheap coal supplies which not only provided cheap energy and a lucrative export trade but also acted as a stimulus to innovation in a wide range of industries well before 1770. The author explores these developments through early GB patents.

1. Introduction: pre-1700

Nature has endowed Great Britain with large coal deposits but little use of it was made until around AD 1200 when shortage of wood in some areas caused it to be used for industrial purposes, e.g. lime burning. In some parts, e.g. round Newcastle in NE England and Fife in Scotland, the coal seams were exposed on the sea shore where it could be easy collected. For the next 400–500 years it was known as sea coal, as opposed to pit coal excavated in mines (the term "coal" was sometimes used to cover charcoal and peat while terms such as stone coal and earth coal were sometimes used). Use of coal for domestic and industrial purposes gradually increased until the late 16th century when the shortage of wood made the use of coal for fuel the norm. It was estimated that Great Britain produced five times as much coal as the rest of the world by 1650 with annual production of around 3 million tons in 1700, with 500,000 tons of it used in London alone.

2. National wealth and power

In the 16th century the Spanish Empire became the dominant power in Europe with its armies paid for by the wealth of its South American colonies, especially the silver mines of Peru. By the mid 17th century the treasure flow was ebbing and with it the power of Spain. The more perceptive noted that the rising powers were powered by trade and industry, especially coal. England's most popular poet John Cleveland (1613–1658) wrote *News from Newcastle*, first printed 1651, which included the famous stanza:

"England's a perfect world, has Indies too: Correct your maps, Newcastle is Peru"

3. Patents

The procedure for obtaining a patent in Great Britain before 1852 was both complex and extremely expensive. There was no technical search/examination, no real requirement for a technical disclosure in the early days, and (before 1624) some patents were granted as monopolies on known commodities as a way of raising money. Despite this the number of patents granted gradually rose with the increasing interest in technical innovation and its commercial application (see Annex).

4. Mine drainage

There was only a limited amount of surface coal and coal pits were easily flooded, so by the mid 16th century there were fears that accessible coal stocks would soon run out. There were attempts in England to ban coal exports and an actual ban in Scotland in 1563. Not surprisingly a high proportion of early GB Patents were concerned with draining mines, especially coal mines – see the Annex. This eventually led to the development of coal powered pumping engines of which Savery's patent 358 of 1698 was crucial. Although his ideas were not practicable his patent appeared to cover any use of steam to raise water. The first really practical machine was the Newcomen engine first operational in 1714 (not covered by a patent but he arranged matters with Savery). Though having low efficiency it was very effective in coal mines with cheap fuel. Throughout the 18th century inventors tried to improve on

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this for use in, e.g. tin mines where fuel was expensive, and the eventual result was the compact, cost effective Watt engine first patented as 913 of 1769 but perfected in the 1780's which could also be used to drive machinery in factories, e.g. textile mills. The extensive patent actions over the Watt engine fully established the commercial importance of patents [1]. By 1800 Great Britain was the world leader in steam engine technology and in an ideal position to lead the world in railways and steam driven ships which became economically viable from the 1820's.

5. Pollution

Coal smoke was rightly considered detrimental to health; as early as 1567 Eleanor the Queen of King Henry III left Nottingham on account of the smoke of sea coal. London had much industrial use of coal and the population raised so many objections to the air pollution that a Royal Proclamation was issued in 1306 prohibiting artificers (e.g. smiths, dyers, brewers) from using sea coal in their furnaces – to little effect. Later coke was used to reduce this problem (see below). As coal use increased so did the complaints. In the words of John Evelyn (1620–1706) English writer and diarist (who published *Fumifugium* in 1661 one of the earliest known works on air pollution):

> "It is this horrid Smoake which obscures our Churches and makes our Palaces look old, which fouls our Clothes and corrupts the Waters … the very Rain … and kills our Bees and Flowers"

6. Chimneys

In the era of wood/peat for domestic fires chimneys were a comparative rarity, the smoke escaping through a hole in the roof. However, this was insufferable with coal and in the mid 16th century there was a huge increase in the number of fixed chimneys or mobile iron fire grates. This, according to some older people, simply proved the decadence of the age. In the words of Harrison in 1577:

> "Now we have many chimneys, and yet our tenderlings complaine of rewmes, catarres, and poses; then we had none but rewdoses, and our heads did never ake."

The tax gatherers had long targeted coal and eventually introduced the Hearth or Chimney Tax in 1662 which was wildly unpopular as it gave the collectors the right to enter every dwelling and count the number of hearths. Abolished in 1689 it was replaced by a tax on windows in 1696 (finally abolished in 1851) which was equally unpopular and led to many bricking up their windows to save money!

7. Glass making

This was one of the first industries to replace wood by coal as a fuel. Henry Wright was granted a patent in 1610 for using imported German/Hungarian furnaces to melt bell-metal with coal rather than wood. Next year a patent was requested for using these furnaces to make glass with coal and this was bought in 1614–5 by Sir Robert Mansell, a naval Vice Admiral with friends in high places who banned glass making with wood and glass imports from abroad. After many tribulations the glass works were successfully established in Newcastle where they flourished for the next two hundred years. His patent is 24 of 1623 – glass making with sea/pit coal not wood.

8. Smelting metal ores

Great Britain had large deposits of iron, copper, tin lead etc. and these were traditionally smelted using timber as fuel. However, increasing demand for metals, especially iron (e.g. for cannons), in the 16th century led to alarming shortages of timber as the forests were cleared. An Act of Parliament was passed in 1581 banning the use of wood for iron making in certain areas and limiting the number of smelters in others. Until some way of using coal for smelting could be found Great Britain's industrial development was severely constrained. As early as 1528 the Bishop of Durham had an unsuccessful scheme to smelt lead with coal. Robert Chantrell in 1607 was granted a patent "*to make and forge iron and steel with stone coal, sea coal, pit coal and peat coal*" and another was granted in 1612 to Simon Sturtevant for producing iron, steel, lead tin, copper, brass etc. by which he hoped to achieve savings of £330 000 p/a, a huge sum then. As he was outlawed, his patent was canceled and granted to John Rovenzon who also failed; a fresh patent was granted in 1620. The first to achieve some success was Dud Dudley (patent 18 of 1621) but, like many inventors since, his path was strewn with difficulties and it was not till the early 1700's that coal was being used successfully for smelting iron, tin, copper and lead and production could increase substantially. Coal was also used for a wide range of other applications (see Annex).

9. Coke

Cooking or charking coal to remove impurities, e.g. sulfur, was known at an early stage. A patent for "*making iron and steel and melting lead*" was granted to Thomas Proctor and William Peterson in 1589. It mentioned coking the coal first which was made a separate patent granted in 1590 to the Dean of York to "*purify pit-coal and free it from its offensive smell*". However, it was not a commercial success. In 1603 Hugh Plat had suggested that coal might be charked in a manner analogous to the way charcoal[1] is produced from wood. In 1620 a patent was granted to a company composed of William St. John and other knights, mentioning the use of coke in smelting ores and manufacturing metals. In 1627 a patent was granted to Sir John Hacket and Octavius de Strada for "*a method of rendering sea-coal and pit-coal as useful as charcoal for burning in houses, without offense by smell or smoke*".

This process was not put into practice until 1642, when coke was used for roasting malt; previously, brewers had preferred to use wood or straw, as uncorked coal used in brewing tended to impair the beer's taste with sulfurous fumes. Coking allowed lighter roasted malt, leading to the creation of what was eventually called pale ale.

In 1709 Abraham Darby (1678–1717, a great-grandnephew of Dud Dudley) established a coke-fired blast furnace to produce cast iron pots (patent 380 of 1707). Coke's superior crushing strength allowed blast furnaces to become taller and larger. In 1768 John Wilkinson built a more practical oven by building the coal heaps around a low central chimney built of loose bricks and with openings for the combustion gases to enter, resulting in a higher yield of better coke. Ironically early pollution legislation for railways insisted on low smoke emission so coke was used before the firebox arch was invented.

10. Coal handling and transportation

Given the high weight/value of coal, removing it from deep mines was a problem and economical transportation to the

[1] http://en.wikipedia.org/wiki/Charcoal.