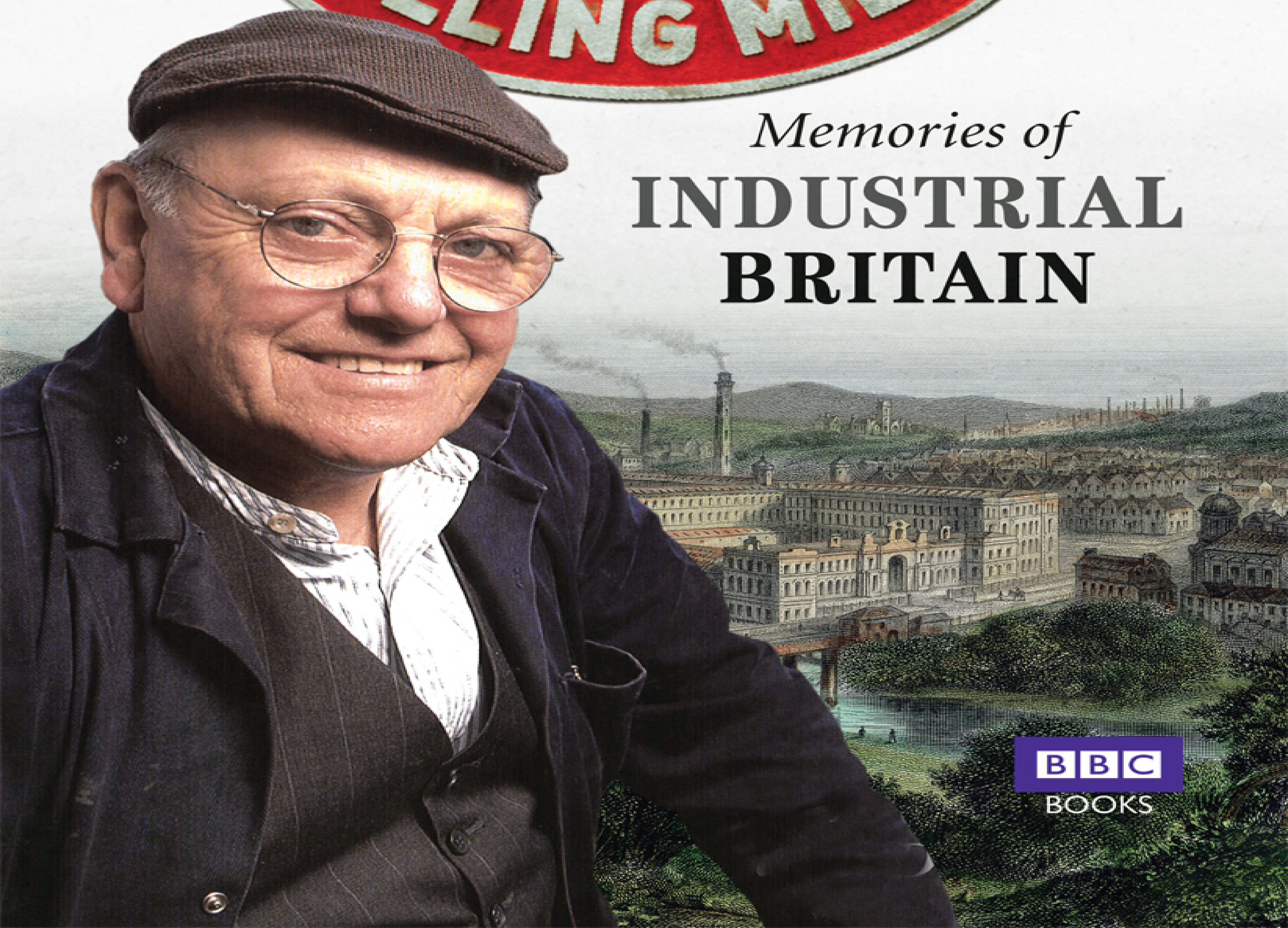
FRED DIBNAH

& DAVID HALL

FOUNDRIES AND ROLLING MILLS

Memories of

INDUSTRIAL BRITAIN



BBC BOOKS

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INTRODUCTION

Britain was the birthplace of the Industrial Revolution. Throughout the eighteenth and nineteenth centuries we led the world in harnessing the power of coal, water and steam to drive the heavy machinery that made mass production possible. Perhaps the most significant breakthrough was the one that took place in 1709 at Coalbrookdale in Shropshire when Abraham Darby patented his coke-smelting process for making iron. Soon his coke-fired iron-works were producing more iron than anywhere else in the world, and the iron made there was cheaper and better than any seen previously.

At about the same time, Newcomen's steam engine, developed for draining mines, allowed miners to dig deeper than had ever been possible before and to reach richer seams of coal and iron ore, the raw materials of the Industrial Revolution. As the eighteenth century progressed, one invention followed another: James Watt's rotary steam engine, which improved on Newcomen's design and adapted it to other uses, Hargreaves's spinning jenny and Arkwright's water-powered spinning frame were just some of the inventions that enabled British manufacturers to increase their output while cutting their costs, making Britain prosperous on a scale that no other country in the world could match.

By the nineteenth century steam power was being adapted to provide revolutionary new means of transport and, through the work of the great railway pioneers, such as Stephenson, Hedley and Hackworth, Britain saw the development of the first steam locomotives and the world's first railways. Portable steam engines were developed to provide the power to increase agricultural production, and Brunel built the world's first steam-powered iron ship.

It is only within our own lifetime in the second half of the twentieth century that the great industries of iron and steel, coal-mining, textile-manufacturing, and ship and railway engine-building, on which our industrial supremacy was built, have disappeared. In the 1960s the skylines of the Lancashire mill towns bristled with the chimneys of huge cotton-spinning mills. In the 1970s crossing Sheffield's Tinsley Viaduct on the M1 motorway at night gave a view of something like Dante's Inferno, with the fiery glow of the furnaces lighting the sky and glimpses of rivers of glowing, white-hot, molten steel flowing through the smoke. And the miners' strike and pit closures of the Thatcher years are still very recent history.

But as the mines, the mills, the factories, the steel-works and the engineering works closed, the demolition men moved in, and the machinery that had made Britain the workshop of the world came under the wrecker's hammer. The scrap merchants became wealthy as they stripped the brass and anything else that was worth having from the engines.

Then dedicated bands of enthusiasts began to appear – people who were aware that, if action were not taken quickly, nothing would be left to show for one of the most important parts of our history. Steam railway preservation societies sprang up; individuals started to rescue traction engines from breakers' yards, and groups such as the Greasy Gang, who restored the magnificent beam engine at the Levant tin-mine in Cornwall, began to appear.

When the Northern Mill Engine Society first started its collection of mill engines in the 1960s, its members were looked upon as being slightly unbalanced. Who in their right mind would want to spend all their time restoring old engines? But the society made a stand and rescued all it could from the scrap men, realizing that these engines would be lost for ever if it didn't. Fortunately, there were like-minded individuals and groups all around the country – preserving pumping stations, restoring old mills and rebuilding coal-mining engines. Thanks largely to the dedication of these people, a small part of our great industrial heritage has been preserved for future generations.

This book tells the story of our industrial past and provides a comprehensive guide to sites throughout Britain where this industrial heritage has been preserved and brought to life again. It's as important a part of our history as our great houses, abbeys and castles, and in many cases these sites provide opportunities for real hands-on involvement in history. Restoration and preservation work is an ongoing process, so with few funds available, volunteer help is often welcome at many of the sites listed in the Gazetteer. (Sites in bold in the main text appear in the Gazetteer.)

I've always been interested in our industrial past and over the years I've built up my own collection of steam engines and steam-driven machinery, so I think it's vitally important work. But that's not the only thing. It's fun as well. And if you get even half the enjoyment and satisfaction out of it as I've had, you're in for a good time.

CHAPTER ONE

THE POWER TO DRIVE MACHINES
Wind, Water and Steam

My father had a bicycle, and when I was big enough and capable of riding with two wheels he used to take me along the Bridgewater Canal and show me what he called one of the seven wonders of the world – Barton Bridge. It's where the Bridgewater Canal passes over the Manchester Ship Canal in a big iron tank, and was one of the sights of my early youth that has always stayed with me. The canals are part of a whole network around Manchester and Bolton that had been built in the eighteenth and nineteenth centuries to transport coal and cotton. Some places were completely waterbound and you couldn't get to them by road. Along the banks of the Bolton-Bury-Manchester Canal, where we went on another of our bike rides, there were wonderful examples of Victorian mining engineering, all made of wood, with inclined railways down the side of the banking, pit winding headgear, a huge boilerhouse at the bottom of a great big chimney and, near the access to the pithead, a little basin for the canal boats. Even the old pit winding engine was still *in situ* with gas lamps all around it. It was like going into a time warp.

I was fascinated by this industrial landscape, and I have been ever since. I wanted to know more about the people who built it and about those who worked there. But more than anything I was fascinated by the machines and the engines that drove them, and I wanted to know how they worked. Ever since then I've been finding out.

Those first bike rides along the canal with my dad were what got me started, but things were changing even then. It was sad, really – I saw these pitheads, winding gear and machinery only about three times, and every time I got there the feeling of anticipation was magic. Each time I went I was full of excitement at the prospect of seeing these strange things and at the thought of being able to stand at the top of the mineshaft and see the cage hanging on the rope and hear all this water swishing about with strange noises coming up from the bottom. Then, after about three visits, we turned up one day and were bitterly disappointed to find the wires had gone, the wheels had gone, the chimney had been felled at the bottom of the hill and all the railway lines had been taken up. The railway wagons were all in the lagoon at the bottom of the hill, and you can see them under water even to this day. Soon after this, they pulled down the last aqueduct and, of course, dammed up the canal when they were doing it.

But I started to go round looking for more of these sorts of places because they were like magic lands to me. I remember one day as a kid when I really thought I'd found something. I climbed over a fence made from railway sleepers and found an old water wheel. It was about 25 feet (7.6 m) in diameter and 5 feet (1.5 m) wide with a tree growing through the spokes and coming out the other side. I don't know how old it was, but you could still see the millrace where it went under what was left of the mill and the yard. This was a great discovery for me – seeing how water had been used to power the mills and factories round where I lived. In fact, I realized that some of them were still being driven by water power. Marsden's bleach-works, where my mum worked, must have been powered by some sort of water turbine because you could see clearly where the water was taken in from a stone weir round the back of the works. But all the mills and factories used steam as well. That’s the way a number of them operated, with water and steam power running side by side. I know that when I was little, there were two Lancashire boilers at my mum’s works just like the one in my back garden that drives all the machinery I’ve got there.

The boiler I have in the garden makes steam for turning a steam engine round, and that engine powers no fewer than fifteen machines. The boiler comes in handy for lots of occasions, and particularly for repairs to the traction engine. I’ve been repairing the engine now for fourteen years and it’s almost a kit of parts that’s ready for assembly – just a little bit more finance and time and I could complete the work.

It will be an unbelievable sense of achievement when I get the engine finished because by then I would have built the whole thing myself from scratch with a complete new boiler and all the parts hand-made. I’ve made new piston rods myself and new covers and valve rods for the valve chest covers and taken off all the corroded parts to get them looking like new – even better than new, some of them.

The vertical boiler I’ve got out in the back is very primitive. It’s the simplest form of boiler next to a kettle. Basically, it’s just a cylinder full of water with a very shallow firebox at the bottom and a tube straight up through it for the gas and the smoke to escape and to create a bit more heat. The crudest boilers like this have just two tubes going from one side of the firebox to the other; all the water is in those two tubes and the flames have to circumnavigate them. When they were being used commercially coal was cheap, you know, and these vertical boilers would burn any old rubbish – wet coal dust, they would fire them on, stuff they would normally throw away. It’s amazing how late they survived on British Rail. All the breakdown trains were steam-driven and all had vertical cross-tubed boilers.

Another boiler I have, the horizontal one, is quite modern, and the design is good because the circulation of the water in it is very good, and that's the most important thing with a steam boiler.

People say I'm eccentric, running all this old machinery in my back garden, but it's more efficient than some of the modern things I've come across that people have working for them in their gardens. I know one man in Shropshire who's built a windmill in his – that's really going back to an old-fashioned way of generating power. The wind was one of the very earliest forms of power used to drive machinery, and there are basically two different types of windmill. There is the post mill, which pivots on a vertical shaft so that the whole mill can be turned automatically to face the sails square into the eye of the wind. Then there's the conventional windmill, which is called a tower mill. In this the whole top is on a bit of a railway track to allow the top to turn automatically so that it faces into the wind. As you can imagine, there's not a lot of room, so it was quite a precarious occupation being a miller; you could end up mangled in your own machinery.

If you want to see a good example of a post mill, Suffolk is the place to go. East Suffolk post mills were reputed to be the finest of their type in the world, and **Saxtead Green** near Framlingham has one of the best. There has been a mill there since 1287, but from the records we know that the present mill dates from at least the end of the eighteenth century. A close look at it reveals quite a sophisticated level of technology. All the vanes in the sails could be opened or shut simultaneously, an action that's a bit like opening and shutting an umbrella. This made it possible to 'put the power off' with all the vanes open or 'put the power on' with all the vanes closed, without stopping the mill. The speed of the mill could also be regulated. A mass of weights was hung on a separate chain within the mill, which would open the vanes to decrease their speed should the wind rise sharply. This was known as ‘spilling the wind’.

The milling process is divided into three stages on three floors. The top one is called the bin floor and the most prominent features of this are the heavy wooden windshaft that carries the sails and the grain bins. The second floor is called the stone floor. Here, two pairs of millstones are located on either side of the upright, wallower shaft in the front or breast of the mill. The wallower shaft is vertically positioned and holds the wallower, which is an iron gear wheel that’s turned by the sails. Above the stone cases, which house the millstones, are wooden stools supporting the hoppers, which hold the grain and feed it to the millstones.

The two sets of stones are typical of most mills. The right-hand pair are made of Derbyshire millstone grit and are usually referred to as Peak stones. These are used for grist work – that is, relatively coarse meal used for feeding livestock. The left-hand stones are those used mainly for milling wheat for flour and are constructed from a very hard stone quarried from freshwater quartz from the Paris (Seine) Basin. Its common name is ‘French Burr’, owing to the nature of the stone, which looks a bit like Gruyère cheese. It cannot be quarried in large pieces, so each millstone has to be built up from a number of smaller sections. This stone was so valuable that even at the height of the Napoleonic War dealers, with government permission, paid handsome prices to the enemy for it. The lower stone or bed stone of each pair of millstones is stationary; only the upper stone, called the runner stone, revolves and so grinds the corn.

The meal floor lies at the base of the windmill on the ground floor, and it’s here that you can see the actual drive to the millstones. The iron great spur wheel is mounted on the lower end of the wallower shaft. Its wooden cogs drive two iron stone nuts that, each in their turn, drive a runner stone on the floor above.

The grain was ground between the two sets of runner stones and bed stones. These are fed from above by grain hoppers leading from the bins on the bin floor. Grain trickles into the ‘eye’ in the centre of the millstones and slowly passes out towards the edge of the stones. All the time the grain is being crushed and ground into finer and finer particles.

A centrifugal governor controls the gap between the millstones which determines the fineness of the flour that is produced. The governors regulate the gap automatically according to the speed of the sails. So if the wind is light, the stones are kept further apart and grinding is slow; if the wind increases in force and the sails begin to revolve faster, the action of the governors is to lower the runner stone and create more friction. This prevents the sails from ‘running away’, while at the same time maintaining the fineness of the flour that is being ground.

Windmills are usually associated with corn milling, but not all mills were built for the grinding and processing of corn. The Norfolk and Suffolk marshes at one time depended entirely on wind power to keep them drained. With seven floors, the **Berney Arms Windmill** is by far the tallest marsh mill in the Broadland area. For the latter part of its life it has been used solely for draining the marshes, but at one time it ground cement clinker and was probably built for that purpose. The cement was made on the site from the chalky mud drained from the river. The mill is just near Great Yarmouth, and it’s worth going to see because it’s as good an example of a working tower mill as you’ll find.

Tower mills were usually built of stone or brick – unlike post mills, which were usually constructed of wood. At the top of the tower’s brickwork is a trough-shaped iron track or ‘curb’. In this track runs an independent ring of rollers. A similar track is attached to the bottom of the cap, which sits on top of the ring of rollers. The whole arrangement forms a roller bearing, and it’s on this that the cap turns.

The problem with any type of windmill is the unpredictability of the weather, so water has been used to power machines for more than 2000 years. It was the Greeks who were first credited with using it for milling cereals in the first century BC. The Romans also used grain watermills and introduced them to Britain. But it was from the twelfth century onwards that the number of watermills in Britain increased significantly. Most of them belonged to either the local manor or to a monastery.

The dissolution of the monasteries, an increasing population and the development of better transportation all contributed to the establishment in the eighteenth century of the independent miller, who milled for a living. It’s with the appearance of the independent miller that we reach the heyday of water-driven stone mills. This lasted for more than 100 years from the mid-eighteenth century to the end of the nineteenth.

The basic principles of grinding corn are common to both windmills and watermills but, unlike wind, water can be harnessed far more easily and much more dependably. When a water wheel is in operation, water passes through the mill ‘leat’ and falls into ‘buckets’ that are attached to the wheel. The weight of the water in the buckets causes the wheel to turn. As the wheel turns, it operates a gearing system that eventually causes the millstones to rotate. The flow of water on to the wheel from the leat is regulated by a penstock, a sluicegate that is operated from inside the mill.

Before starting the mill, the miller would open the penstock to start the water wheel. He began the milling process by lowering the runner stone that would have been resting just clear of the bed stone. As in windmills, the stones were usually Peak stones and French Burrs. The speed of the runner stone, the amount of grain fed into the eye and the adjustment of the gap between the stones all combined to determine the quality and quantity of the meal.

There are plenty of working water wheels to see all over the country. **Otterton Mill** is in South Devon and can be traced back to 1785. The sluicegates divert water from the River Otter into the mill's own millstream, or leat; from this the water wheel harnesses the water's energy to drive the mill. The process is cyclical – when the water leaves the mill it flows for about a quarter of a mile (0.4 km) and then rejoins the river again.

Tide mills are a variation of watermills and use trapped tidal water to turn the machinery. When the tide comes in, it flows into a millpond through a one-way gate. When the tide goes out again, the water is released to flow under the water wheel and turn the machinery. In practice, this gives about four or five hours' work twice a day. Tide mills were usually located along shallow creeks some miles away from the open sea; a large pond would be dug out to hold the water from the incoming tide. The pressure of the incoming tide opened sluicegates in the bank and filled the pond. As the tide fell, the first out-flowing water closed the gates, which were held firmly in that position by the pressure of the trapped water. When the tide had fallen sufficiently, the miller opened the sluicegates and the escaping water rushed out and turned the wheel. **Woodbridge Tide Mill** is a rare example of this type of watermill. Situated on the

Suffolk coast not far from Ipswich, it was built in the eighteenth century.

Water power has been used for a wide variety of industrial purposes. **Gunton Park Sawmill** near Cromer in Norfolk was constructed in the 1820s and is probably the oldest surviving mechanical saw in Britain. It uses two iron water wheels to harness the water power – the right wheel drives the circular saw bench, while the left wheel drives the frame saw. The wheels themselves turn an intricate system of pulleys and belts, which in turn provide the motion for the mechanical saws.

Muncaster Watermill in Cumbria is next to the **Ravenglass & Eskdale Railway**, which I've visited many times. It is a working corn mill and is very old and quite interesting. It's one of two water wheels that you'll see if you take a trip along this line. The other is **Eskdale Mill** at Boot, which is at the top end of the line right up in the high Lakeland fells near Scafell Pike. There was quite a lot of mining activity here in olden days, which was what the Ravenglass & Eskdale Railway was built for. I've been to this mill on my travels, or at least I bobbed in to have a look at the water wheels for the sake of interest when I was there to see the railway. It's amazing how some of these places have survived, hidden away as they are up little valleys like this one. Thinking about it, though, I suppose they've got more chance of surviving in these places than they would in somewhere like Bolton. But when you compare them with the sort of big industrial water wheels that you used to get around Bolton they are quite small things of small power.

Before the development of the steam engine, water power was used for just about everything – forging, spinning, weaving, nearly everything that requires machinery that will turn round. A number of rural areas had water wheels for making things like scythes and ploughshares and lots of other agricultural tools and implements; anywhere, in fact, that needed a bit of something that took the pain out of doing the work by hand. Round Bolton I think more than half of the bleaching industry and the spinning industry used water power. On nearly every river, if you follow its course coming into Bolton, you'll find five or six bleach-works that all used water wheels initially. And you can see in the buildings, if you look carefully, when steam replaced water, because the architecture of the engine houses is more modern than the original set-up of the place.

You can't see any of Bolton's wheels now, which is a pity because some of them were huge and must have been quite a sight. There was one at a bleach-works just down the road from where I live at Edgerton that was 16 feet (4.8 m) wide and a massive 64 feet (19.5 m) in diameter. That's a big wheel! It was made by William Fairburn in Manchester. Fairburn was the pioneering water wheel construction company in Lancashire – well, in the whole of England, really. The biggest water wheels that were ever made were at a place in Glasgow, and they were something like 80 feet (24 m) in diameter, an unbelievable size, and they were reputed to be Fairburn's.

In the industrial development of Britain water continued to serve man, but it also frustrated him. At the start of the Industrial Revolution in the eighteenth century, it was water that was used to power all the early mills and factories. So a number of those first factories were built in the countryside in scenic areas. Places such as Richard Arkwright's **Cromford Mill** at Matlock in Derbyshire and Robert Owen's **New Lanark Mill** were built in rural settings by the side of fast-flowing rivers that provided the power required to keep the millwheels turning. As with wind power, though, water power wasn't the most reliable source of energy. Something was needed that would be certain to keep the machines running day and night. Relying on water meant that a drought would bring a factory to its knees as everything would have to stop.

The water that provided the power for hundreds of mills threatened to destroy the very basis of prosperity for another growing industry. Until 1712 the ‘engines’ available for pumping water from flooded mines were quite inadequate to deal with the problems that faced the owners of coal-mines and of the Cornish tin-mines. The problems of pumping water and drainage had been met with varying degrees of success throughout history since the early empires of Babylon and Egypt. The ‘chain of pots’ system of drainage used then hadn’t changed much by the eighteenth century. Power to drive this sort of bucket elevator system could be provided by man, beast, wind or water, each of which was either inefficient or unreliable.

Certainly, this method couldn’t cope with the pressing drainage problems that faced the Cornish tin-mine owners at the start of the eighteenth century. The search for a more efficient and reliable source of power for draining mines was the most pressing technological problem of the time. And so the steam engine was born.

Basically, it started life as a rather crude creation for pumping water out of deep mines. By the middle of the seventeenth century, the quest for mineral wealth had driven miners deep enough to encounter flood water, their most impenetrable barrier. English miners were beginning to find the greatest difficulty in clearing their shafts of the vast quantities of water they were meeting at the great depths they were getting down to. Many mines had been drowned out and abandoned; existing pumps simply could not cope with the water.

By the eighteenth century every element of the modern type of steam engine had been separately invented and practically applied. Ideas about atmospheric pressure and the pressure of gases had become understood. The nature of a vacuum was known, and the method of obtaining it by the displacement of air by steam and by the condensation of the vapour was also understood. The importance of utilizing the power of steam was not only recognized but had been attempted successfully by pioneers such as Denis Papin and Thomas Savery.

It was Thomas Newcomen, however, who, between 1710 and 1712, invented the atmospheric engine, so named because its power was derived from the weight of the atmosphere pushing down the piston in an open-topped cylinder containing a partial vacuum. With its invention, the original template for the beam engine, which was to last 220 years, was created and, once created, it spread very quickly.

Newcomen has his predecessors to thank for his invention. It was their pioneering work that made it possible. Denis Papin, a French doctor, can be credited as the first to develop the idea of using steam, while Thomas Savery actually patented an engine that had been used to drain water from mines. This was used in the Cornish mines with some success. Indeed, Newcomen may well have even been employed by Savery. What is certain is that Savery's water-draining engine was known to Newcomen.

Savery recognized the engineering difficulties involved in keeping the deep pits of Cornwall free from water. But it was Newcomen who had the foresight to combine the ideas of both Papin and Savery in developing his atmospheric engine to achieve this task. In principle, the Newcomen engine is simply a combination of earlier ideas. All he did was to take the piston and cylinder concept that had been developed by Papin and combine it with Savery's principle of boiling and condensing steam. The resulting engine was so similar to Savery's patented engine that Savery was prevented from taking legal action against Newcomen only by being taken into partnership with him. The first successful model was completed in 1705, and the first engine was then set up at Dudley Castle in Tipton, Wolverhampton, in 1712.

Within a few years of its invention, Newcomen's engine had been introduced into nearly all the large mines in Great Britain. Many new mines, which could not have been worked at all previously, were opened when it was found that the new machine could be relied on to raise the large quantities of water to be handled. Newcomen's engine now meant that mines could be sunk to more than twice the depth of what had until then been possible.

Old as they are, it is still possible to see a working Newcomen engine today. When the Newcomen Society for the Study of the History of Engineering and Technology decided to create a suitable memorial to Thomas Newcomen on the occasion of the tercentenary of his birth, the British Transport Commission donated to the society a small engine very similar to the 1712 Dudley Castle one. It had stood idle for around fifty years, but was dismantled, removed and re-erected at Dartmouth in Devon, where what is now the **Newcomen Memorial Engine** is on show in a newly constructed engine house. Dating from 1725, it is a direct descendant of Newcomen's first machine, displaying many features of the earlier engine.

A similar engine can be seen at **Elsecar**, near Barnsley in South Yorkshire. Believed to date from 1795, the Newcomen-type pumping engine there is claimed to be one of Britain's finest surviving legacies of the Industrial Revolution. The engine operated continuously as an efficient system of mines drainage until 1923. Ironically, it was briefly brought out of retirement in 1928 when the electrically operated pumps that were introduced to replace it were put out of action by flood water! Although damaged in 1953 and no longer having a source of steam, it is still technically workable and now deservedly holds pride of place at Elsecar.

As recently as 1947 a Newcomen atmospheric pumping engine was still working on a colliery between Oldham and Ashton-under-Lyne. Henry Ford, in England on a fact-finding mission, found it, bought it lock, stock and barrel, and re-erected it in America. On the same visit he was in the middle of Manchester when he saw a steam wagon coming along the street. He flagged the driver down, enquired who his boss was, bought the wagon from him and took that back to America with him as well, where it was displayed for many years, along with the pumping engine, in the Henry Ford Motor Museum. Recently, though, a collector in the south of England heard that the museum was selling the wagon and he has now brought it back to this country.

But these engines of Newcomen's were only the beginning, and all these early developments paved the way for the man who is regarded as the father of steam. James Watt came from a humble background. He was born in Greenock, Scotland, in 1736. As a child he was sickly; his health was delicate and he was unable to attend school regularly or to apply himself to study. Yet he was a man born before his time, and is worthy of the credit he is given as the inventor of the modern steam engine. Watt himself had no money to spend on experiments, and he didn't have the capital to start manufacturing steam engines if his experiments proved to be successful. This meant he had to look elsewhere for his capital, and the two men who provided it, and made possible the successful development of his steam engine were, first of all, John Roebuck and then Matthew Boulton.

John Roebuck was born in Sheffield in 1718 and had become a wealthy man before deciding to establish a large-scale iron manufacturing business in Scotland. The site he chose was on the banks of the River Carron, in Stirlingshire, where there was plenty of water power, ready transport by sea, and good supplies of iron ore, limestone and coal. The first furnace was blown at Carron in 1760, and the first steam engine applied to working the blowing machinery of a blast furnace was erected at the Carron Iron Works in 1765.

The pits that Roebuck owned to provide the fuel for his iron-making were at Kinneil, near Falkirk, and he soon discovered to his cost that he had to ensure they were kept clear of water. In order to achieve this, he needed powerful pumping engines. In 1769 James Watt was engaged by Roebuck to construct a new engine for him from designs that he had already started to work on. Roebuck took on a £1000 debt that Watt had built up while developing his engine and put in further capital and funding in return for two-thirds of Watt's patent. Watt's engine, however, was not available for pumping the colliery, and Roebuck began to find himself in financial difficulties. It was in this year that he entered into an agreement with Matthew Boulton, in which Boulton would take a share of the business in return for paying half the expenses. But by 1773 Roebuck's affairs were showing no signs of improvement, so Boulton acquired two-thirds of the engine patent in exchange for the remission of a debt of £630 and a further payment of £1000. Ironically, Roebuck's financial difficulties were then further compounded by the fact that none of his creditors 'valued the engine at a farthing'!

With Roebuck off the scene, Boulton soon acquired the full patent on Watt's steam engine, and so the partnership of Boulton & Watt was born. Watt left Scotland for England, and the engine, which he designed for the Kinneil coal-mines, was erected at Boulton's Soho works in Handsworth, Birmingham, in a factory that produced buttons, buckles, clocks, vases and silverware. It was used to pump the water that provided the power for the works. In the early days of steam this was to become a very common arrangement, with steam and water used together to run mills, factories and engineering works.

Matthew Boulton was the son of a Birmingham silver stamper and piercer. He succeeded to his father's business and built up a great and very profitable establishment. He wasn't just a businessman, though; he was also a learned scholar and won the praise of Watt as a man of great ingenuity and foresight. When he acquired the patent on Watt's steam engine from Roebuck, he went on to forge a partnership with Watt that was to be one of the most important enterprises of the century: a pioneer engineering firm that for twenty-five years was the sole producer of steam engines in Great Britain. The partnership was in fact the union of one of the most inventive brains of the age with one of the first great commercial intelligences, for the purpose of selling one of the most valuable things in existence – power.

Boulton, like Roebuck before him, was also to face a financial crisis. Although the engine business was doing well, Boulton had speculated in other interests indirectly linked with engines. Overproduction at a time of depression in 1787 resulted in the insolvency of several firms. Boulton badly needed an extension of credit. He appealed to Watt, but Watt, with characteristic caution, had already safely invested his money, so the appeal was made in vain. When it is remembered that Boulton had, throughout the hard years of struggle, taken all the financial risks and worries on his own shoulders, that he had paid Watt a regular salary when the company was not making any money, and that he had, out of pure generosity, allowed Watt half the profits, instead of the agreed one-third, when profits did begin to come in, Watt's action at this crisis appears mean and ungrateful. And while Boulton weathered the storm and never again had his prosperity jeopardized, it appears that Watt's struggles with money, or rather lack of it, when setting out with his engine design had made him very miserly.

Although Watt is rightly regarded as the inventor of the steam engine, others helped to perfect it. Richard Trevithick was born in 1771 and was reported by his schoolmaster as being a 'disobedient, slow, obstinate, spoilt boy, frequently absent from school and very inattentive'. However, he was to bring about enormous improvements on the Watt engines through his principle of high-pressure steam, which he labelled 'strong steam'. Following his visits in the 1790s to the Darby Ironworks in **Coalbrookdale**, Shropshire, the cradle of the Industrial Revolution, he constructed his first high-pressure engine for winding ore in 1798. Trevithick is perhaps best known for his contribution to railway locomotives, but so successful was his boiler development for the Cornish beam engine that the annual output of tin mined in the county rose from 2500 tonnes in 1750 to 14,000 in the heyday of the industry around 1860. The period 1800 to 1870 was a time of unparalleled prosperity and change for Cornwall. Trevithick himself, however, died a pauper after going to South America to mine for silver and tin.

Today Cornwall means holiday beaches, picturesque fishing villages and clotted cream, but in the eighteenth and nineteenth centuries the county was a key industrial area due to the massive deposits of tin and copper ore. From mining followed a number of other industrial activities, at first associated with mining and the machinery required for deep, hard-rock mining. Important iron foundries were established to build steam engines for pumping mines, and this expertise led to the 'Cornish engine' being adapted for all manner of purposes, including pumping London's sewage and de-watering Holland's polders. The success of the Cornish engine meant that it was quickly put into use all over the world.

The steam engine became an integral part of Cornish mining for two and a half centuries. The first Cornish miners concentrated on washing tin ore out of deposits near the surface. But the coming of the steam engine enabled the miners to pump water from these increasingly deep mines, to raise the ore to the surface and then crush it. At the height of the mining industry in the 1860s there were over 650 beam engines working in Cornwall.

The **Levant Mine** is probably one of the best known of the Cornish mines. This great mine, on the cliffs near Land's End, was sunk in 1820 and at its peak extended for a mile (1.6 km) under the Atlantic. It was one of the most successful in the county, extracting both tin and copper ores. In 1919, though, there was a disaster. The man who was driving the winding engine said, 'There's something wrong: the engine keeps creaking, groaning and making funny noises'. But no one took any notice. He was so concerned about it that he handed in his notice and moved on to another mine. Three weeks later the beam broke on the engine and about thirty miners fell down the shaft with the wooden platforms that carried them. It must have been awful being speared with 4-foot (1.2-m) pieces of timber in your belly as you went hurtling down the shaft.

Mining at Levant stopped in 1930 and everything on the site was intended for scrap. But efforts were made to save the Levant engine as a memorial to a period when Cornish engineers were in the forefront of engine design. In 1985 a team of volunteers from the Trevithick Society – nicknamed the Greasy Gang – began to refurbish the historic engine, while the National Trust restored the building itself. Today you can see the engine working in its clifftop engine house. The only trouble is that, although an appeal was launched to help put it back in steam, it was powered by a concealed modern plant fired by oil.

Just half a mile (0.8 km) along the clifftop from the Levant engine site is the **Geevor Tin Mine**. There have been underground workings in this area since the seventeenth century, with many ruins of old mine buildings still seen along the cliffs. The Geevor Mine, although not active, is open to visitors, so if you want to go down a mine and see how tin was once mined, you can take an underground tour. A museum at the site covers the history of some of the famous old mines in the St Just district.

Beam engines were not only used for pumping water out of mines. **The Crofton Pumping Station** is on the Kennet and Avon Canal near Marlborough in Wiltshire. The canal, which links London with Bristol, reaches its highest point here, and as its summit level is higher than any natural source of water supply, it has to have water pumped up to it to fill the locks at the top every time a boat crosses the summit. The beam engines at Crofton were installed to ensure that there was always a supply of water to fill the locks. The two locks on the summit are 14 feet (4.2 m) wide and over 75 feet (23 m) long and require 70,000 gallons (318,215 litres) to fill them!

Today, Crofton is a wonderful working monument to the age of steam power. Its appeal lies in the fact that, when steaming, the engines perform the task for which they were originally installed – raising water vertically over 40 feet (12 m). The pumping house has the oldest working beam engine in the world still in its original building and still doing its original job. The Boulton & Watt engine dates from 1812 and its companion, a Harvey’s of Hayle, dates from 1845. Both are steam-driven from a coal-fired boiler.

The building that houses the engines is on three floors. At the top is the beam gallery, where you can see the engines themselves. They are supported on the beam wall,