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SCIENCE AND TECHNOLOGY

Links, heros, and stories from science and technology

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Richard Arkwright, Cotton King

Right in the middle of England, in deepest Derbyshire, there nestles between the steep hills of the eastern Pennines a little town called Cromford, where the first cotton-spinning mill was built in 1771. This mill was more important than just a place for spinning cotton, however, for it heralded the start of the industrial revolution.

The father of the factory system was Richard Arkwright.

Arkwright was born at Preston in Lancashire on 23 December 1732. He was the youngest of 13 children, and was sent off as a teenager to be apprenticed to a hairdresser. He became a hairdresser himself, and a maker of wigs, or perukes.

(Also born Dec 23: Akihito, Japanese Emperor, 1933; Neils Jerne, British-Danish immunologist (Nobel prize 1984), 1911.)

About 1767, with some friends, he began to build a machine to spin cotton. They rented a room in a secluded teacher's house behind some gooseberry bushes, but they were so secretive that the neighbours were suspicious and accused them of sorcery, and two old women complained that the humming noises they heard at night must be the devil tuning his bagpipes.

So Richard Arkwright moved over the hills to Nottingham, and designed a big machine to be driven by five or six horses, but before he even got it working he took a momentous step. He borrowed money and built a huge ``manufactory,'' to house dozens of machines and hundreds of people.

He probably borrowed the idea from Matthew Boulton, the great industrialist in Birmingham, a titan who loomed through the mists of the eighteenth century. In 1762 Boulton had gathered together a whole collection of

small businesses and put them together in one complex in Soho in Birmingham; he called it the Soho Manufactory.

Arkwright went one stage further. He planned the whole thing from the ground up, and employed unskilled workers to operate the machines that he had designed and built. He leased the land in August 1771---it cost him GBP14 pounds per annum---and the mill was finished before the end of the year. The building was five floors high, and three of them still stand, although it all looks rather sorry for itself today.

What took him to the savage outback of Derbyshire? The roads were so bad that it was probably a day's journey from Nottingham, even though the distance is less than 30 miles. What he wanted was a strong and regular flow of water to power his factory. He chose Cromford because of Bonsall Brook, a good swift stream that flows out into the River Derwent half a mile downstream. And flowing into Bonsall Brook is Cromford Sough, which is essentially a drain from the lead mines in that hill.

The point is that the water comes out of the ground positively warm---there are hot springs just up the road---and so the sough never froze in winter. And that is what Arkwright wanted---a fast and reliable stream of water.

So he rented a little piece of land, took the brook under the factory, and put a water wheel on the end of the building. Then he brought the sough down the other side of the factory, with another waterwheel. The waterwheels have gone, but you can still see the massive stones where the bearings were, and a mark where the stones have been scraped by the wheel going round.

To begin with he used undershot wheels, with the stream flowing underneath and the wheels just hanging in it, but then he heard about John Smeaton's pioneering experiments, which proved that overshot wheels are much more efficient. So Arkwright raised the levels both of the sough and of the brook so that his wheels could be overshot. That gave him enough power to run the entire mill. Five floors of water power.

He had tremendous confidence in his idea, considering that the experimental mill in Nottingham did not work until a year later. He must have seen the potential of a full-sized mill, and persuaded his backers that they would make a fortune.

Why did he have such confidence? What was his great invention?

The conventional way to spin cotton was to start with raw imported cotton, straight from Egypt or somewhere. First, card it; this gets rid of some of the seeds and other grot, and straightens out the fibres a bit.

The cotton is then teased out into a long thin sliver, and then further into ``roving.'' This has just a suspicion of a twist in it, but it is extremely weak. The critical process comes next, the actual spinning, which converts the thick weak roving to strong thin thread.

The problem in 1770 was that one person can spin only one thread at a time. You need half a dozen spinners to keep one weaver busy, and the demand for cloth was going up. That's why a spinning machine seemed like a good idea. The spinning jenny had already been invented, but that was essentially a mechanical version of the hand-spinning technique, and it needed not only hand power but also a highly skilled operator.

Arkwright analysed the spinner's action, and realised that two things are going on. First you have to stretch out the roving, and second you have to twist the thread.

Several spinning machines were designed at about this time, but most of them tried to do the stretching and the spinning together. The problem is that the moment you start twisting the roving you lock the fibres together.

What you must do is first pull them gently out, so the thread gets longer, and then twist it to lock the fibres together and give it strength. If you twist it first and then try to lengthen it the fibres lock up and break.

Arkwright's idea was to stretch first and then twist. The roving passed from a bobbin between a pair of rollers, and then a couple of inches later between another pair that were rotating at twice the speed. The result was to

stretch the roving to twice its original length. A third pair of rollers repeated the process. Arkwright's original machine had four sets of rollers. Later ones had three. They increased the length of the cotton yarn by a factor of four.

He discovered that a critical feature was the distance between the rollers; it had to be between one and three inches. The best cotton fibres were about an inch long. The rollers had to be more than an inch apart, because if they were less then they would snap the fibres.

The machine was called a water frame because it was powered by a water wheel. There is still one Arkwright water frame, at the Helmshore Museum, and a quarter of it works, powered by electricity, since they don't yet have a working water wheel.

Two things are obvious the moment you see the wonderful beast in action. First, there are 32 bobbins along each side of each end of the water frame---128 on the whole machine. Second, it is so automatic that even I could operate it.

A conventional spinning wheel needs one skilled operator to spin one thread. The spinning jenny could spin say a dozen threads, but needed a highly skilled operator. Arkwright's water frame needed no skill, and spun 128 threads at a time. Arkwright was well on the way to mass-production.

There were really two separate parts of Arkwright's brilliance. First was the machine that turned what had been a slow and skilled operation into childsplay. Second was to get children to do it.

Not only did he build a huge mill, but he also built houses for his workers in the village. He transformed Cromford from a scattered community of lead-mining families into a tightly-knit village. He advertised for weavers with large families. Then he gave them houses with a weaving shed on the top floor, where his cotton could be woven, and he took the mothers and children to work in the mill.

The kids came in at the age of about ten. They worked from six in the morning until seven at night, with half an hour off for breakfast and 40 minutes for dinner. They got their education in the church on Sundays. The factory inspectors who came round said he treated the kids well, though in one report they said ``the privies were too offensive to be approached by us!"

The mills worked for 23 hours a day, and John Byng said ``when they are lighted up, on a dark night, look most luminously beautiful."

Arkwright's mill was essentially the first factory of this kind in the world. Never before had people been put to work in such a well-organized way. Never had people been told to come in at a fixed time in the morning, and work all day at a prescribed task. His factories became the model for factories all over the country and all over the world. This was the way to build a factory. And he himself usually followed the same pattern---stone buildings 30 feet wide, 100 feet long, or longer if there was room, and five, six, or seven floors high.

He built houses for the workers, and a chapel, and he built himself first a house and later a castle, about which John Byng wrote ``it is really, within, an effort of inconvenient ill-taste."

Arkwright himself, one-time hairdresser, one-time pub landlord, was, according to Carlyle, ``a plain, almost gross, bag-cheeked, pot-bellied Lancashire man ... of copious free digestion," which I think meant that he farted a lot. Yet he was knighted, and became High Sheriff of Derbyshire.

He was bright enough to invent a spinning machine. He had the vision to see that he could make lots of money by mass-production, even though no one had ever done that before. And he was a brilliant manager; he was exceptionally skilful at persuading people to work for long hours in difficult conditions.

He built his first mill when he was nearing 40, in 1771. In the next 20 years he built mills all over Derbyshire, Lancashire, and Scotland, and they were not only cotton spinners but money spinners too, for when he died on 3

August 1792 he left half a million, equivalent today to perhaps 200 million pounds.

Portrait image from University of Texas, USA (originally Helmolt, H.F., ed. History of the World. New York: Dodd, Mead and Company, 1902).

LINKS

Arkwright and the Industrial Revolution
Lycos search on Industrial Revolution, Unabomber's diatribe, Relevance to software patents today (see third quote).
Science on the Web
The London Science Museum, and their list of other museums on the Web, Scientific Web Resources.
Magazines
Yahoo's science-magazine section. Franklin Institute's bulletin (weekly).
Search tools
Yahoo's science section. Searches by word: WebCrawler, Yahoo, Lycos, InfoSeek. Other searches: INFOMINE (The University of California's "Physical Sciences, Engineering, Computer Science and Math search tool). Yahoo' history section.
Back Issues
1995 September 1 (Henry Bessemer, Man of Steel).
Other links
Portraits (University of Texas, USA), Adam's home page.

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