Europe's Industrial Revolution

1769–1900

BRITAIN HAD LONG BEEN famous for its textiles when Richard Arkwright, a wigmaker by trade, patented a new machine for spinning cotton into strong thread. The year was 1769.

At the time, textiles were a cottage industry. Skilled spinners and weavers, working at home, made cloth from wool. Women turned wool into thread or yarn with a spinning wheel, one strand at a time. From such threads, men wove cloth.

Weaving efficiency had improved with John Kay's invention of the flying shuttle, which he patented in 1733. It so speeded passing the yarn through the loom that weavers fearful of technological unemployment later ransacked Kay's house, a foretaste of things to come. The spinning jenny, patented in 1769, allowed one person to spin more than a dozen threads at once.

Arkwright's spinning frame made stronger, finer thread than its predecessors, but it was too large to be worked by hand. Arkwright settled on waterpower. His invention, which became known as the water frame, needed a power source, so a factory had to be built. The work of spinning thread began to move out of the home.

Thus began the industrial revolution, a gradual transformation of work, workers, and workplace. For about 150 years, it would progress from the modernization of traditional industries to the invention of new technologies such as the telegraph and radio. And no one could have predicted the social upheaval that would ensue not only in Britain, but also across Europe a generation later. Changing work would change everything.

Cradle of Transformation

Britain was poised for revolution more than other European countries. The cottage textile industry was ripe for change. Coal and iron ore, raw materials for industrialization, were abundant. Advances in agricultural technology helped feed a booming population. And Britain's scientific revolution had paved the way for new inventions.

Innovations in textile manufacturing were matched by advances in other fields. Thomas Newcomen had invented a steam engine first used in 1712 to pump seeping water from mines, but his engine was not efficient enough to power other machinery. James Watt solved that problem in 1769 with an improved engine eventually adopted by Arkwright to power his water frames. A nearby river was no longer mandatory; he could build a factory wherever he wished.

Britain enjoys a coastline of many inlets and a large number of waterways that simplified transportation of raw materials to—and finished products from—many of its cities. By the early 1800s, improvements in land transportation opened up more of the country to factories. Watt's steam engines began to replace horses for pulling hoppers of coal at mines and later all manner of goods. In 1804, the first steam-powered railway locomotive pulled 10 tons of iron and 70 people from an iron works in Wales to a town nine miles distant in a couple of hours.

As these elements of industrialization matured, a factory model of work gained ground over the cottage-industry model in which work came to the workers. With big machines grouped to share a power source—water or steam—such change was inevitable. From now on, workers would go to the work.

Hard Labor in the Factory

The new workplace, often as not, was a house of horrors, economically, physically, and mentally. Paltry wages meant that the entire family—children included—had to work to survive. Working hours were unregulated. In 1833 Parliament declined to prohibit factory owners from working people under age 18 more than ten hours a day. At the time, children worked 12 hours. Factory owners punished children for tardiness and docked

A patient anesthetized with ether, a surgical technique introduced in the mid-1840s, undergoes an operation. Before ether, surgeons could dull pain only with narcotics.

their pay even though most families could afford no clock. Children pushing coal carts grew up misshapen. Many died young.

Dust of cotton, flax, and wool polluted the air inside textile factories. Initial exposure caused "mill fever," a general malaise. Years of breathing the dust caused a high incidence of tuberculosis and other respiratory diseases among workers. Without safety shields, whirring machinery regularly claimed arms and legs. A German visitor to Manchester, England, in 1842 commented that the city's many amputees reminded him of "living in the midst of the army just returned from a campaign."

The Rich Get Richer

Money not paid to workers lined the pockets of factory owners. Many owners, including Richard Arkwright, who had developed the water frame, became wealthy. In time Arkwright built factories as far away as Scotland. When he died in 1792, he was worth £500,000, an immense sum at the time.

Such wealth propelled the Arkwrights of the era to the top of a new middle class. They lived much like the landed aristocracy that had occupied the summit of the social pyramid for centuries. Below them emerged a layer of well-to-do industrial experts and well-educated doctors and lawyers, followed by a lower middle class of office workers, teachers, and governesses. At the top of the lower classes were factory supervisors, highly skilled workers, and even head butlers of the wealthy. Next came semiskilled factory workers, who struggled to support a family. At the bottom toiled the unskilled workers.

NOTABLE DATES

1769
Richard Arkwright introduces the spinning frame. James Watt improves steam engine efficiency.

1785
Edmund Cartwright's power loom is the death knell for hand loom weavers.

1830
Rail service between Liverpool and London is started by George Stephenson.

1837
Samuel F. B. Morse exhibits the telegraph, revolutionizing communications.

1840
Samuel Cunard's *Britannia* inaugurates steamship service between Britain and North America.

1856
Henry Bessemer's converter makes steel economical to produce.

1866
The Siemens brothers' open-hearth furnace makes possible the refining of scrap metal into steel.

1866
On his third attempt, Cyrus Field lays the first successful transatlantic cable.

1876
Alexander Graham Bell invents the telephone and one year later establishes the Bell Telephone Company.

1879
Thomas Edison improves the incandescent lightbulb.

1895
Guglielmo Marconi sends his first radio signals one and a half miles.

1898
Rudolf Diesel receives a patent for the diesel engine.

The industrial revolution raised the standard of living of almost every layer of society, yet the financial gap between rich and poor remained a chasm. And some people grew worse off as the industrial revolution brought technological unemployment. The new machinery required fewer workers to make more thread or cloth than ever before, throwing many craftsmen and women out of work or into unrewarding jobs.

By the early 1820s, for example, the power loom automated every part of weaving but repairing broken threads in the loom. One operator could run two power looms that wove as much cloth in two days as a skilled hand loom weaver could produce in a week. By 1850 there were 250,000 power looms in Britain, each of them displacing at least one hand loom weaver.

Most victims of the novel textile technology reacted passively to their new miseries, but not all. In 1811 a knot of men gathered after darkness in a town near Nottingham to ransack a weaving shop. Inside were machines that wove stockings six times as fast as a traditional stocking loom. After destroying the machines, the men dispersed. The Luddite movement had begun.

Named for Gen. Ned Ludd—likely a fictitious person—these men and others like them sought redress for the calamity of industrialization

Urban Migration

A CENSUS OF ENGLAND AND WALES TAKEN IN 1851 recorded a remarkable development. For the first time, more people lived in British cities than in the country. By 1825 London had become the world's largest metropolis. In the next 75 years its population would increase to 648,000. Some of the growth resulted from high birth rates among city dwellers, but much was the product of migration of rural populations to cities, hoping to improve their lot with better jobs.

The urbanization of Britain improved the nation's economy in that it moved workers from regions of low productivity to high-productivity work in factories. For individuals, however, moving to the city was like a lottery: A few people found themselves better off, but most were poorer in every way.

Horses pull a tram along an avenue in Glasgow, Scotland, at the end of the 19th century. The city became famous for shipbuilding.

Living conditions were atrocious; disease could reach epidemic proportions. An outbreak of cholera in the summer of 1849 killed nearly 13,000 Londoners. In the 1860s a Dr. Letheby inspected more than 2,200 tenements in London. Nearly all these single rooms, he wrote, "are filthy or overcrowded or imperfectly drained, or badly ventilated, or out of repair." By overcrowded, he meant an average of three people per room; as many as ten lived in some. *The Seven Curses of London,* published in 1869, set the number of thieves in the city at 20,000. Infanticide was rife, as desperate mothers sought to rid themselves of illegitimate children they could not support. Even insects felt the effects; coal smoke so blackened buildings in some cities that the common moth evolved from white to gray.

These tragic conditions, highlighted by studies like Dr. Letheby's and chronicled by authors like Charles Dickens, sparked measures intended to clean up the cities and improve conditions for the working classes, who suffered disproportionately. Progress would be slow. Not until the end of the 19th century would the blight fade. ■

that had befallen them. The Luddites opposed not all machinery but machines "hurtful to the commonality," or those that threatened their livelihoods. Over a span of 14 months, Luddite raiders smashed machinery, torched factories, and injured or killed several factory owners. In response the government sent more than 14,000 troops to quell the violence and approved the death penalty for anyone convicted of wrecking machinery.

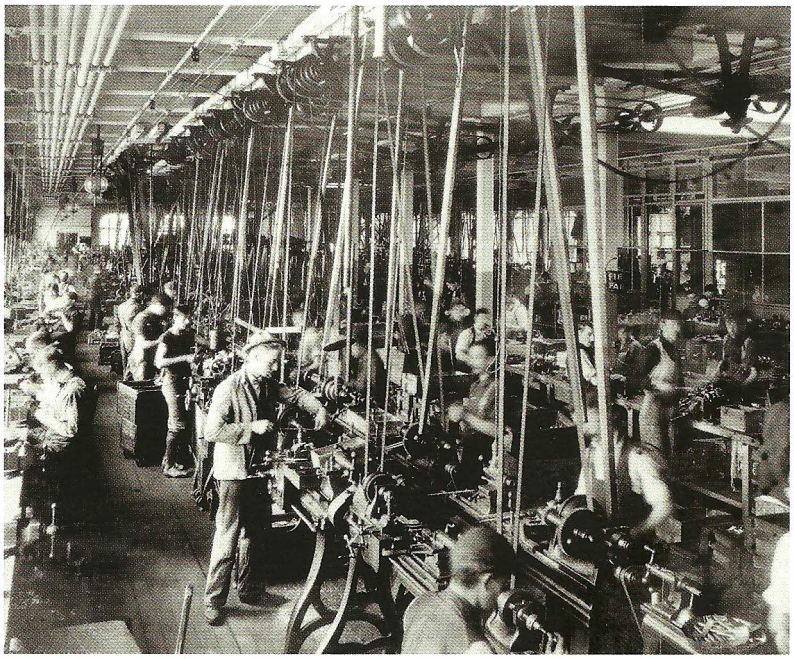
During the rampage the courts exiled to Australia or executed dozens of Luddites. The uprising cost the British government and industry some 1.5 million pounds. The working classes gained little, if anything.

Hands Off

The crown's response to the Luddite uprising is compelling evidence of the British government's laissez-faire policy toward industry—let business do as it pleases, regardless of consequences. Yet some who had benefited so grandly from this policy began to recognize the abuses it had created.

Despite Parliament's failure to regulate child labor in 1832, the next year it passed the first Factory Act. This legislation established a minimum working age of nine years, limited working hours for children, and prohibited children under 18 from night shifts.

The new laws proved difficult to enforce, so the Factory Act of 1844 provided more inspectors as it reduced a child's workday and regulated the adult workweek for the first time. A final Factory Act, passed in 1853, established for men and women a 12-hour workday with a half-hour break. Twenty years to establish a 72-hour workweek seems slow progress indeed, but the Factory Acts represented early steps toward better treatment of the workforce.



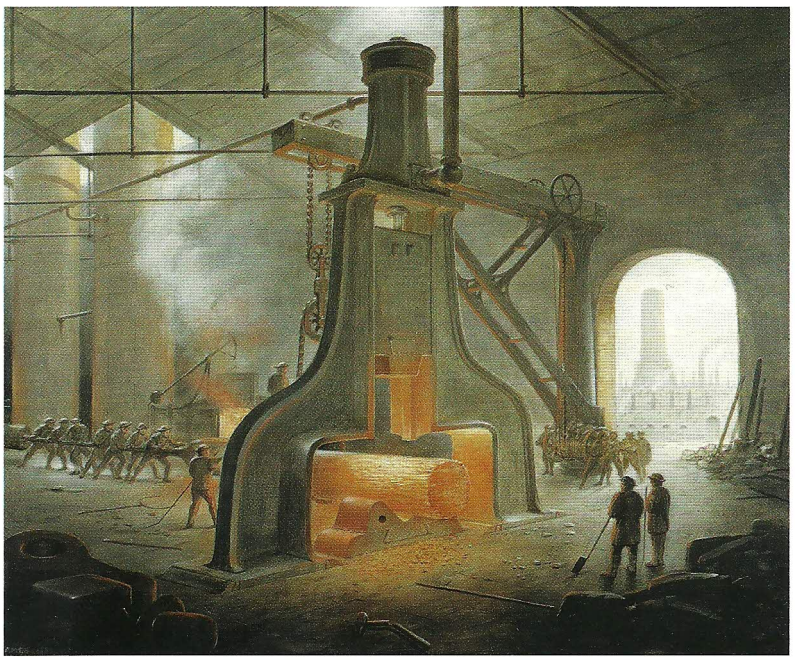
Drive belts connect machinery on a factory floor to an overhead shaft from a central power source in 1888. Such unshielded drive trains imperiled workers and led to accidents.

Workers in Revolt

British authorities had feared the overthrow of the government had they not suppressed the Luddites. And that is what happened on the Continent as France experienced its own industrial revolution. In 1848 French workers, angry at their steadily declining financial situation and a widening income gap, drove King Louis-Philippe into exile.

The social and economic inequities of the industrial revolution attracted the attention of social philosophers. Among the more influential was Karl Marx, a German citizen. Marx argued that "the interests of capitalists and wage-laborers are diametrically opposed to each other." Factory owners (capitalists) will always seek to pay labor as little as possible in order to maximize profits, reasoned Marx, and the only way for workers to receive fair treatment was to take over the factories. Because capitalists were unlikely to cede their assets voluntarily, their factories might have to be taken by force, as would happen in the Russian Revolution of 1905.

No such thing occurred in England, where the working classes continued to yearn for days past, when the home was the center of work, and to reject the notion, born of the industrial revolution, that work was the center of life. Few tried to change their lot or rise above it. They continued to be poor,



In an 1871 painting by James Nasmyth, a steam hammer forges machine parts; first demonstrated in 1845, it permitted the forging of objects larger than a blacksmith could make.

rudely sheltered, often unemployed, and victims of disease.

The Second Industrial Revolution

In the late 18th and early 19th centuries, following the introduction of Arkwright's water frame, a surge in technological discoveries fueled a second industrial revolution, this one powered by electricity, chemicals, and oils. Together the discoveries would make industry cleaner and more efficient than the coal-based, steam-powered industry of the first industrial revolution. And the new technologies would aid commerce beyond imagination.

In the 1790s William Murdock, a British inventor, discovered that he could produce a flammable gas by heating coal in a closed vessel akin to a teakettle. He built such a device in his garden and piped the resulting coal gas to burners inside his house, thus inventing the gaslight. By 1860 gaslighting, brighter than candlelight and about one-fourth the cost, had spread throughout Britain, allowing workers to work and students to study all night. A by-product of gas generation was coal tar, an essential ingredient of macadam pavement that made transporting goods by road cheap, quick, and reliable.

Michael Faraday, son of a blacksmith, discovered in 1831 that moving a magnet through a coiled wire produces an electric current in the wire. The next year an electric generator based on the Faraday effect debuted in Paris. Within 50 years power plants had become widespread, producing electricity for the recently invented lightbulb and for industry, especially in Germany and the U.S. Britain was less interested in electrifying its factories because of its relative abundance of coal.

Advances in electric motors helped address the fact that large cities had become overcrowded with horse-drawn traffic, overwhelmed by malodorous horse dung, and overbuilt with stables to shelter the livestock. A solution in part was the tramway, tracks laid in city streets and plied by passenger-carrying cars. Powered by electric motors, trams were affordable for the working class and slowed growth of the horse population.

Electricity also made possible the communications revolution of the telegraph, telephone, and radio. For the first time messages could be sent over distances that might have required days or weeks to cross on horseback.

The telegraph, developed in the early 1830s, sent messages coded in short pulses (dots) and long pulses (dashes). This code, devised by

Dead on His Feet

I have heard him crying out when getting within a few yards of the door, 'Mother, is my supper ready?' and I have seen him, when he was taken from my back, fall asleep before he could get it."

—John Allett, a textile worker, of his son, exhausted by more than 12 hours' work in a mill

Allett was one of many factory workers interviewed by Michael Sadler in 1832. A member of the House of Commons, Sadler chaired a parliamentary committee assembled to study the sad condition of child laborers in England. His report, published in 1833, shocked the British public and pressured the government to address the plight of child factory workers.

Samuel F. B. Morse, represented the letters of the alphabet. Telegraph pulses traveled along wires strung across the countryside and even underwater. The first successful transatlantic telegraph cable was laid in 1866. News from across the ocean was weeks fresher than it had been when transported by ship.

In 1876 Alexander Graham Bell, a British expatriate living in America, invented the telephone. Soon people would be able to hold a conversation over long distances. Although Bell strung his first long-distance telephone line in 1884, a transatlantic phone cable would not be in use until 1956.

As the 19th century came to a close, Italian Guglielmo Marconi pioneered the technique of sending a "wireless" message using radio signals. In early experiments of 1895, he sent a signal a mile and a half; by 1901 he had succeeded in transmitting a telegraph message 2,100 miles across the Atlantic. Shipping companies eagerly embraced the new technology. For the first time they could receive news of their steamships as they plied the world's oceans.

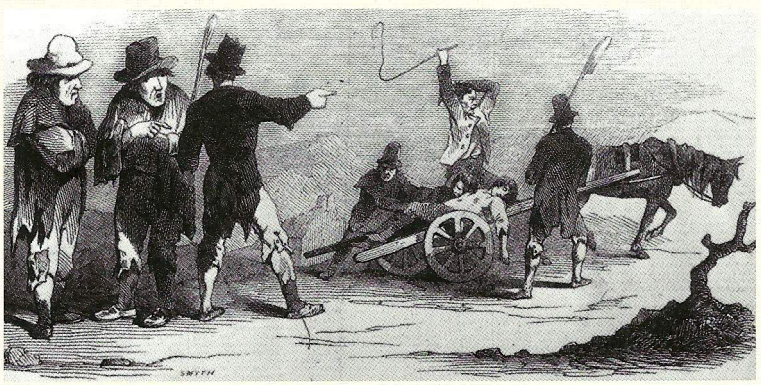
Steamships, telegraphs, electric motors—none of these could Richard Arkwright have foreseen when he unveiled his spinning frame in 1769. In the preceding century and a half, the world had completely and irreversibly remade itself, commercially, socially, politically. For better or worse, the industrial revolution introduced an emphasis on productivity and efficiency, of so-called "creative destruction," that vexes and rewards us to this day. ■

Ireland's Potato Famine

From about 1600 Ireland had become increasingly dependent on potatoes for food. By the 19th century the many poor among Irish farmers grew little else, potatoes yielding a far larger harvest than other crops. A farmer could feed his family for a year on a single acre of potatoes. Surpluses of the tuber allowed the Irish population to soar, from three million in the early 16th century to eight million in 1840.The folly of relying on a single crop became clear in 1845, when potatoes dug from fields turned to rotting mush a few days later—the result, unappreciated at the time, of infection by a fungus. The same thing happened in 1846 and 1848. Disaster followed.

Without potatoes to eat, many starved. Without potatoes to sell, farmers could neither buy food nor pay rents to their absentee English landlords, who evicted them. Many Irish were reduced to eating leaves and grass. Those who consumed the rotting potatoes sickened. Typhus and cholera depopulated entire villages. More than two million farmers and their families overwhelmed Ireland's workhouses, institutions established to provide room and board to the destitute in return for work. English efforts at relief fell far short, hampered by the belief that market forces would correct the problem and by a banking crisis that robbed aid programs of crucial funds.

Some one million Irish died of starvation and disease. Those with enough money bought passage to America or Canada in "coffin ships"; as many as one-third died during the voyage. During the famine Ireland's population fell by about three million. Many Irish blamed the English for the catastrophe, arguing that their modest response to the famine was yet another example of Protestant Britain's colonialist arrogance toward Catholic Ireland. True or not, that assessment stoked fires of resentment that would not be banked for another century and more. ■



Undertakers cart away a casualty of the Irish potato famine, one of some one million victims.