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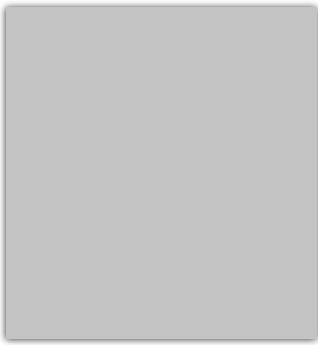
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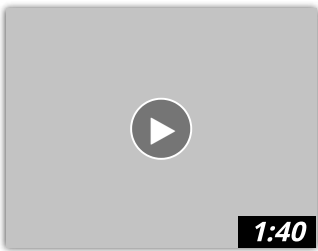
Textile handiworkers who destroyed machines for fear of losing their jobs were called Luddites.

INTRODUCTION

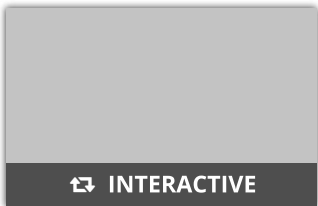




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Most products that people in industrialized countries use today are turned out swiftly by the process of mass production. This process involves people (and sometimes robots) working on assembly lines using power-driven machines. People of ancient and medieval times had no such products. They had to spend long, tedious hours of hand labor even on simple objects. The energy, or power, they employed in work came almost wholly from their own and animals' muscles. The Industrial Revolution is the name of the movement in which machines changed people's way of life as well as their methods of manufacture.

About the time of the American Revolution in the late 1700s, the people of England began to use machines to make cloth and steam engines to run the machines. A little later they invented locomotives. Productivity began a spectacular climb. By 1850 most English workers were laboring in industrial towns and Great Britain had become the workshop of the world. From Britain the Industrial Revolution spread gradually throughout Europe and to the United States.

SETTING THE STAGE

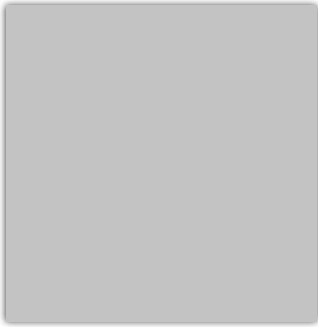


CHANGES THAT LED TO THE REVOLUTION

A number of changes brought about the Industrial Revolution. The most important of these were:

- The invention of machines to do the work of hand tools
- The use of steam, and later of other kinds of power, in place of the muscles of human beings and of animals
- The adoption of the factory system

It is almost impossible to imagine what the world would be like if the effects of the Industrial Revolution were swept away. Electric lights would go out. Cars and airplanes would vanish. Phones, computers, radios, and television would disappear. Most of the abundant stock on the shelves of big-box retail stores would be gone. The children of the poor would have little or no schooling and would work from dawn to dark on the farm or in the home. Before machines were invented, work by children as well as by adults was needed in order to provide enough food, clothing, and shelter for all.



© Photos.com/Getty Images

The Industrial Revolution came gradually. It happened in a short span of time, however, when measured against the centuries people had worked entirely by hand. Making yarn and weaving cloth had been done in much the same way for thousands of years. Then, [John Kay](#) invented the flying shuttle for looms in 1733, and [James Hargreaves](#) developed the spinning jenny 31 years later. By 1800 a host of new and faster processes were in use in both manufacture and transportation.

EXPANDING COMMERCE AFFECTS INDUSTRY

Commerce and industry have always been closely related. Sometimes one is ahead and sometimes the other, but the one behind is always trying to catch up. Beginning about 1400, world commerce grew and changed so greatly that writers sometimes use the term *commercial revolution* to describe the economic progress of the next three and a half centuries.

Many factors helped bring about this revolution in trade. The Crusades opened up the riches of the East to western Europe. (The Crusades were a series of wars fought by European Christians who wanted to take control of Jerusalem and other holy places from Muslims.) Europeans established their first permanent settlements in the Americas, and European countries began to develop rich colonies there and elsewhere. New trade routes were opened. Trading firms, such as the British East India Company, were established by governments. Larger ships were built, and flourishing cities grew up.

With the expansion of trade, more money was needed. Much of the earlier trade had been carried out by barter—the process of exchanging goods and services directly, without money. That wouldn't work for large-scale commerce. Gold and silver from the New World helped meet the need for more money. Banks and credit systems developed. By the end of the 17th century Europe had a large supply of capital, or money. Money had to be available before machinery and steam engines could come into wide use for they were costly to manufacture and install.

By 1750 large quantities of goods were being exchanged among the European countries. There was a demand for more goods than were being produced. England was the leading commercial country, and the manufacture of cloth was its leading industry.

ORGANIZING PRODUCTION

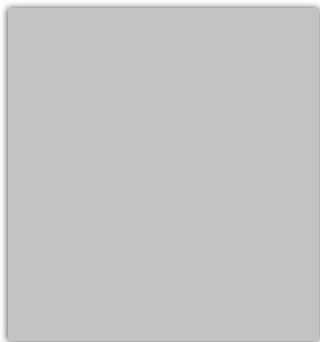
Several systems of making goods had grown up by the time of the Industrial Revolution. In country districts families produced most of the food, clothing, and other articles they used, as they had done for centuries. In the cities merchandise was made in shops, and manufacturing was strictly regulated by guilds and by the government. (A guild is a group of people who do the same job or share similar interests.) The goods made in these shops, though of high quality, were limited and costly.

The merchants needed cheaper items, as well as larger quantities, for their growing trade. As early as the 15th century they already had begun to go outside the cities, beyond the reach of the tight regulations, and to establish another system of producing goods.

FROM COTTAGE INDUSTRY TO FACTORY

Cloth merchants, for instance, would buy raw wool from the sheep owners and have farmers' wives spin it into yarn. The merchants would then take the yarn to country weavers to be made into textiles. These country weavers could manufacture the cloth more cheaply than city craftsmen could because they got part of their living from their gardens or small farms.

The merchants would then collect the cloth and give it out again to finishers and dyers. Thus, the merchants controlled cloth making from start to finish. Similar methods of organizing and controlling the process of manufacture came to prevail in other industries, such as those that produced nails, cutlery (knives and other cutting tools), and leather goods.



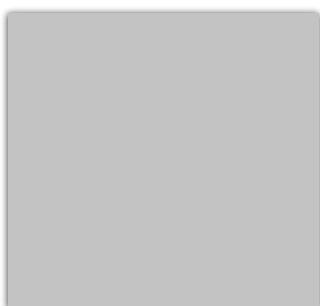
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Some writers call this the domestic system because the work was done in the home (*domestic* comes from the Latin word for home). Another term is cottage industry, for most of the workers belonged to the class of farm laborers known as cotters and carried on the work in their cottages.

This system of industry had several advantages over older systems. It gave the merchant a large supply of manufactured articles at a low price. It also enabled him to order the particular kinds of items that he needed for his markets. It provided employment for every member of a craft worker's family and gave jobs to skilled workers who had no capital to start businesses for themselves.

A few merchants who had enough capital had gone a step further. They brought workers together under one roof and supplied them with spinning wheels and looms or with the tools of other trades. These establishments were factories, though they bear slight resemblance to the factories of today.

WHY THE REVOLUTION BEGAN IN ENGLAND



There are a number of reasons why the Industrial Revolution began in England. One reason is that England had abundant natural resources, particularly coal and iron ore. These were essential for powering and building machinery. Another reason is England's geography, with its many natural ports and inland waterways. The network of ports and waterways supported efficient transportation and trade.

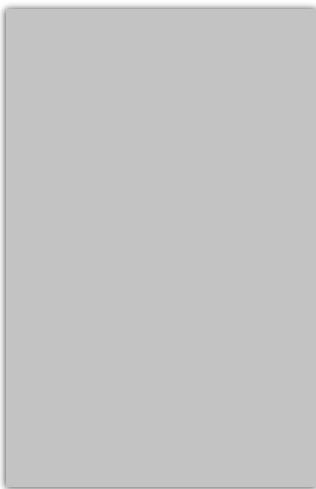
Economically, England also benefited from its overseas colonies.

The colonies provided raw materials and served as markets for manufactured goods. This created a cycle of supply and demand that fueled industrial growth. In addition, England's expanding population contributed to a growing domestic market, which helped drive industrialization.

There also were new ideas in England that aided the movement. One of these was the growing interest in scientific investigation and invention. Another was the doctrine of *laissez-faire*, or letting business alone. This doctrine had been growing in favor throughout the 18th century. It was especially popular after the British economist [Adam Smith](#) argued powerfully for it in his great work *The Wealth of Nations* (1776).

For centuries the craft guilds and the government had controlled commerce and industry down to the smallest detail. Now many people in England had come to believe that it was better to let business be regulated by the free play of supply and demand rather than by laws. Thus, the English government for the most part kept its hands off. It left business free to adopt the new inventions and the methods of production that were best suited to them.

BREAKTHROUGH INVENTIONS



Culver Pictures

The most important of the machines that ushered in the Industrial Revolution were invented in the last third of the 18th century. Earlier in the century, however, three inventions had been made that opened the way for the later machines. One was the crude, slow-moving steam engine built by Thomas Newcomen (1712), which was used to pump water out of mines. The second was [John Kay](#)'s flying shuttle (1733). It enabled one person to handle a wide loom more rapidly than two persons could operate it before. The third was a frame for spinning cotton thread with rollers, first set up by Lewis Paul and John Wyatt (1741). Their invention was not commercially practical, but it was the first step toward solving the problem of machine spinning.

INVENTIONS IN TEXTILE INDUSTRY

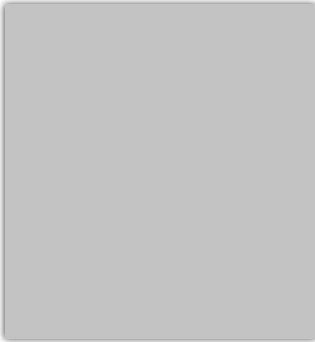
As the flying shuttle sped up weaving, the demand for cotton yarn increased. Many inventors set to work to improve the spinning wheel. [James Hargreaves](#), a weaver who was also a carpenter, patented his spinning jenny in 1770. It enabled one worker to run eight spindles instead of one.



About the same time, [Richard Arkwright](#) developed his water frame, a machine for spinning with rollers operated by water power. In 1779 [Samuel Crompton](#), a spinner, combined Hargreaves' jenny and Arkwright's roller frame into a spinning machine, called a [mule](#). It produced thread of greater fineness and strength than the jenny or the roller frame. Since the roller



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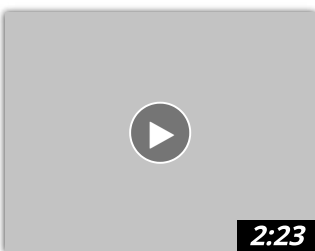
frame and the mule were large and heavy, it became the practice to install them in mills, where they could be run by water power. They were tended by women and children.

These improvements in spinning machinery called for further improvements in weaving. In 1785 [Edmund Cartwright](#) patented a power loom. In spite of the need for it, weaving machinery came into use very slowly. First, many improvements had to be made before the loom was satisfactory. Second, the hand weavers violently opposed its adoption because it threw many of them out of work. Those who got jobs in the factories were obliged to take the same pay as unskilled workers. Thus, some people rioted, smashed the machines, and tried to prevent their use.

The power loom was only coming into wide operation in the cotton industry by 1813. It did not completely replace the hand loom in weaving cotton until 1850. It was not well adapted to the making of some woolsens. As late as 1880 many hand looms were still in use for weaving woolen cloth.

Many other machines contributed to the progress of the textile industry. In 1793 the available supply of cotton was increased by American [Eli Whitney](#)'s invention of the [cotton gin](#). The machine was designed to separate seeds from raw cotton. This procedure had proved inefficient and slow when done by hand. In 1804 [Joseph-Marie Jacquard](#), a Frenchman, perfected a loom on which patterns might be woven in fabrics by mechanical means. This loom was later adapted to the making of [lace](#), which became

JAMES WATT'S STEAM ENGINE



Contunico © ZDF Studios
GmbH, Mainz; Thumbnail
*James Watt. Etching by J. Scott,
1869, after J. E. Lauder.*
Wellcome Collection, London
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While textile machinery was developing, progress was being made in other directions. In 1763 [James Watt](#), a Scottish mechanic, was asked to repair a model of a Newcomen steam engine. He saw how crude and inefficient it was. By a series of improvements he made it a practical device for running machinery.

Wheels turned by running water had been the chief source of power for the early factories. These were necessarily situated on swift-running streams. When the steam engine became efficient, it was possible to locate factories in more convenient places.



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RISE OF THE COAL AND IRON INDUSTRIES

The first users of steam engines were the **coal** and **iron** industries. They were destined to be basic industries in the new age of machinery. As early as 1720 many steam engines were in operation. In coal mines they pumped out the water that usually flooded the deep shafts. In the iron industry they pumped water to create the draft in blast furnaces.

The iron industry benefited also from other early inventions of the 18th century. Iron was scarce and costly. Production was falling off because England's forests could not supply enough charcoal for smelting the ore. (Smelting is the process of heating iron ore to extract the metal.) Ironmasters had long been experimenting with coal as a fuel for smelting. Finally Abraham Darby, in 1709, succeeded with coal that had been converted into a material known as coke. (Coke is made by partly burning coal to remove the impurities.) This created a new demand for coal and laid the foundation for the British coal industry.

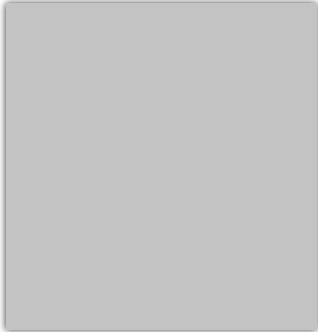
The next great steps were taken in the 1780s, when Henry Cort developed the process of puddling. Puddling produced wrought iron, a commercial form of iron that is relatively easy to work into different shapes. Puddling was the first method that allowed wrought iron to be produced on a large scale. Hand in hand with the adoption of the new inventions went

the rapid development of the factory system of manufacture.

ECONOMIC EFFECTS



CHANGING CONDITIONS IN ENGLAND



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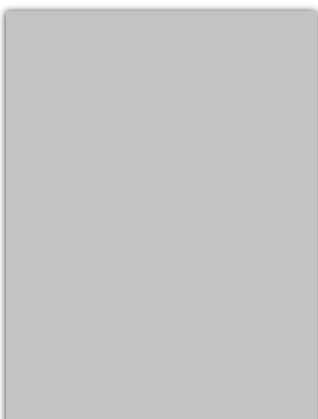
The new methods increased the amount of goods produced and decreased the cost. The worker at a machine with 100 spindles on it could spin 100 threads of cotton more rapidly than 100 workers could on the old spinning wheels. Southern planters in the United States were able to meet the increased demand for raw cotton because they were using the cotton gin. This machine could do the job of 50 people in cleaning cotton.

Similar improvements were being made in other lines of industry. British merchants no longer found it a problem to obtain enough goods to supply their markets. On the contrary, at times the markets were flooded with more goods than could be sold. Then mills were closed and workers were thrown out of employment.

With English factories calling for supplies, such as American cotton, and sending goods to all parts of the world, better transportation was needed. The roads of England were wretchedly poor and often impassable. Packhorses and wagons crawled along them, carrying small loads. Such slow and inadequate transportation kept the cost of goods high. Here again the need produced the invention. Thomas Telford and John MacAdam each developed a method of road construction better than any that had been known since the ancient Romans built their famous roads.

BUILDING CANALS AND RAILWAYS

Many canals were dug. They connected the main rivers and so furnished a network of waterways for transporting coal and other heavy goods. A canalboat held much more than a wagon. It moved smoothly if slowly over the water, with a single horse hitched to the towline. In some places, where it was impossible to dig canals and where heavy loads of coal had to be hauled, mine owners laid down wooden or iron rails. On these early railroads one horse could haul as much coal as 20 horses could on ordinary roads.



Early in the 19th century came [George Stephenson](#)'s locomotive and [Robert Fulton](#)'s steamboat, an American invention. These inventions marked the beginning of modern transportation on land and sea. Railroads called for the production of more goods, for they put factory-made products within reach of many more people at prices they could afford to pay.



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SOCIAL UPHEAVAL

GROWTH OF CITIES AND CHANGES IN RURAL LIFE

As conditions in industry changed, social and political conditions changed with them. Farm laborers and artisans flocked to the manufacturing centers and became industrial workers. Cities grew rapidly. Factory centers such as Manchester, England, grew from villages into cities of hundreds of thousands in a few short decades. The percentage of the total population located in cities expanded steadily.

Rapid city growth produced new hardships. The housing supply and sanitary facilities could not keep pace, though innovation slowly responded. Gas lighting improved street conditions in the better city neighborhoods from the 1830s onward. Sanitary reformers pressed for underground sewage systems at about this time. For those who were better-off, rapid suburban growth allowed some escape from the worst urban miseries.

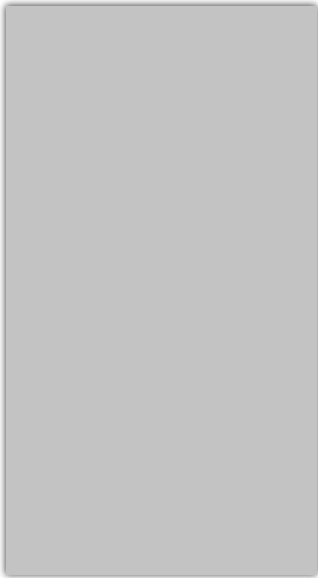


Rural life also changed. As cities grew, the percentage of farmers in the total population declined. Although a full-scale technological revolution in the countryside occurred only after the 1850s, factory-made tools spread widely even before this time. Scythes replaced the shorter-handled sickles for harvesting, allowing a substantial improvement in productivity. Larger estates began to introduce newer equipment, such as grain drills for planting.

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Washington, D.C. (Digital file
no. cph 3b03424)

THE CONDITION OF LABOR

Far-reaching changes were gradually brought about in the life of industrial workers. For one thing, machines took a great burden of physical work from the muscles of human beings. Some of the other changes, however, were not so welcome.



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Vectors/Getty Images

The change from domestic industry to the factory system meant a loss of independence to the worker. Home laborers could work whenever they pleased. Although the need for money often drove them to toil long hours at home, they could vary the monotony of the task by digging or planting a garden patch. When people became factory employees, however, they not only had to work long hours but had to leave the farm. Workers lived near the factory, often in a crowded slum district, and were forced to work continuously at the pace set by the machine. The long hours and the monotonous toil were an especially great hardship for women and children. The vast majority of factory jobs were held by them by 1816.

The change to industrialization was particularly hard on the weavers and the other skilled workers who sank to the position of factory workers. They had been independent masters and managers of their own businesses. They had pride in their skills. When they saw themselves being forced into factories to do the bidding of another person for the same pay as unskilled workers, it is no wonder that they rioted and broke up looms.

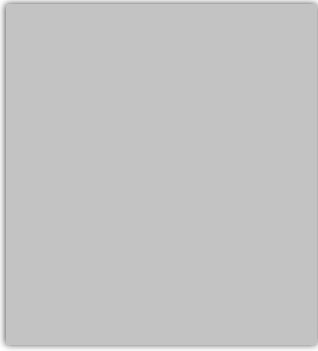
PROBLEMS OF CAPITAL AND LABOR

A person had to have a lot of capital to buy machines and open a factory. Those who were successful made huge profits with which to buy more machines, put up larger buildings, and purchase supplies in greater quantities at enormous savings. Thus, capital increased far more rapidly than it ever had before. Much of it was invested in building canals, railroads, and steamships and in developing foreign trade. The men who controlled these enterprises formed a powerful new class in England—the industrial capitalists.

The capitalists had a struggle to obtain a voice in the government. They needed a better system of banking, currency, and credit. They had to find and hold markets for their products. They had many difficulties in organizing their factories to run efficiently. They also had to make a profit on their investments in the face of intense competition.

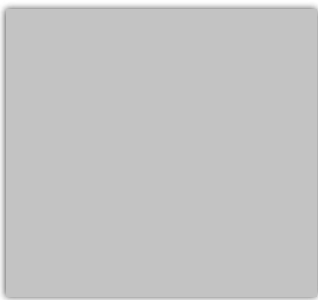
Laissez-faire was the rule in England. This meant that the government had accepted the doctrine that it should keep hands off business. Factory owners could therefore arrange working conditions in whatever way they pleased. Grave problems arose for the workers—problems of long working hours, low wages, unemployment, accidents, employment of children, and poor housing conditions.

IMPACT ON CHILDREN



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The rapid development of large-scale manufacturing, especially during the early years of the Industrial Revolution, made possible the exploitation of young children in many factories. (To exploit means to make use of unfairly for one's own advantage.) In England, as well as in other countries, there existed considerable demand for child labor. Children could tend many of the machines as well as older persons could, and they could be hired for less pay. Great numbers of children were worked from 12 to 14 hours a day under terrible conditions. Many were housed in miserable dormitories. Ill-fed and ill-clothed, they were sometimes driven under the lash of an overseer.



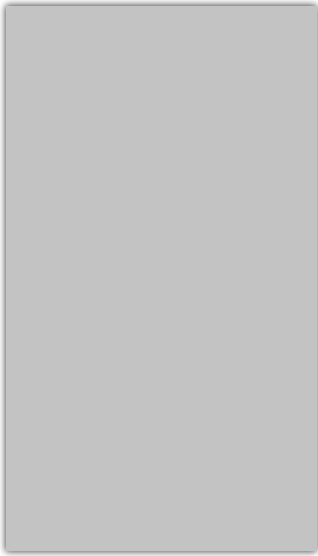
*National Child Labor
Committee collection, Library
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The high death rate of these enslaved children eventually roused efforts to pass laws limiting the daily toil for child workers. The first law, in 1802, was ineffective because it did not provide for enforcement. Several decades later, stronger reform laws began to emerge. Legislation in England, France, and Prussia during the 1830s, for instance, restricted the employment of young children in the factories and encouraged school attendance.

CLASS DIVISIONS AND PROTEST MOVEMENTS

Along with the dramatic economic changes of the period, new tensions emerged among the urban social classes of England and other European countries. The key division lay between the members of the middle class and those of the working class. Middle-class people owned businesses or acquired professional education. Working-class people depended on the sale of their labor for a wage. Neither group was uniform in their views. Many middle-class people criticized the profit-seeking behavior of the new factory owners. Some skilled workers, earning good wages, followed the example of middle-class people by seeking education and acquiring domestic trappings such as pianos.

Nevertheless, the social divide was considerable. It increasingly affected residential patterns, as wealthier classes moved away from the crowded slums of the poor. City governments often enacted strict measures against beggars, while new national laws attempted to make charity harder to obtain. The British Poor Law Reform of 1834, in particular, tightened the limits on public relief for the poor. The law was based on a harsh philosophy that regarded poverty among able-bodied workers as a moral failing.



Hulton Archive/Getty Images

Class divisions became evident in protest movements. Middle-class people joined political protests hoping to win new rights from the ruling class. Workers increasingly organized on their own. Some workers attacked the reliance on machinery in the name of older, more humane traditions of work. Others formed labor unions. These unions often started as “friendly societies” that collected dues from workers and extended aid during illness or unemployment. Soon, however, they became organizations for winning improvements by collective bargaining and strikes.

Industrial workers also sought to benefit themselves by political action. They fought such legislation as the English laws of 1799 and 1800 forbidding labor organizations. They campaigned to secure laws that would help them. Huge strikes in the silk industry around Lyon, France, in 1831 and 1834 sought a living minimum wage for all workers. The most ambitious worker movements tended to emphasize a desire to turn back the clock to older work systems where there was greater equality and a greater commitment to craft skill. Most of these movements failed, however. Smaller, local unions did achieve some success in preserving the conditions of traditional systems. The struggle by workers to extend their political power was one of the major factors in the spread of democracy during the 19th century.

REVOLUTION SPREADS TO THE UNITED STATES



BEGINNINGS OF AMERICAN INDUSTRIALIZATION

Until 1815 France was busy with the [Napoleonic Wars](#). It had little opportunity to introduce machinery. When peace came France began to follow England. Belgium was ahead of France in adopting the new methods. The other European countries made little progress until the second half of the 19th century.

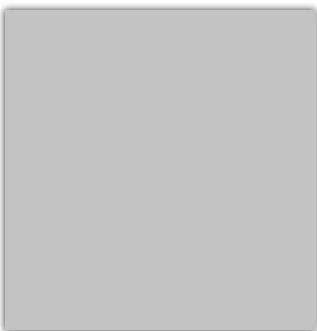
The United States too was slow in adopting machine methods of manufacture. Farming and trading were its chief interests until the [Civil War](#). The new country had little capital with which to buy the machinery and put up the buildings required. Such capital as existed was largely invested in shipping and commerce. Labor was scarce because people continued to push westward, clearing the forests and establishing themselves on the land.



*From Samuel Slater and the
Early Development of the
Cotton Manufacture in the
United States by William R.
Bagnall, 1890*

A start in manufacturing, however, was made in New England in 1790 by [Samuel Slater](#). An employee of Arkwright's spinning mills, Slater came to the United States in 1789. He was hired by Moses Brown of Providence, Rhode Island, to build a mill on the Pawtucket, or Seekonk, River. English laws forbade export of either the new machinery or plans for making it. Slater designed the machine from memory and built a mill which started operation in 1790. When the Napoleonic Wars and the [War of 1812](#) upset commerce and made English products difficult to obtain, more American investors began to build factories.

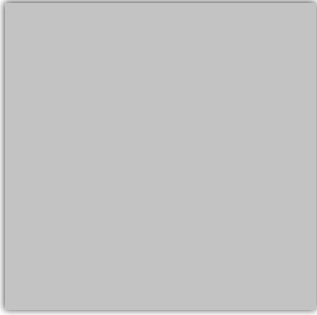
PIONEER INDUSTRIES AND INVENTIONS



*Library of Congress,
Washington, D.C. (cph
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New England soon developed an important textile industry. It had swift streams for power and a humid climate, which kept cotton and wool fibers in condition for spinning and weaving. In Pennsylvania iron for machines, tools, and guns was smelted in stone furnaces. Spinning machines driven by steam were operating in New York by 1810. The first practical power loom was installed at Waltham, Massachusetts, by Francis Cabot Lowell in 1814. Shoemaking was organized into a factory system of production in Massachusetts in the early 19th century. New England was the first area in the United States to industrialize.

American inventors produced many new machines that could be applied to industry as well as to agriculture. [Oliver Evans](#) designed a steam engine more powerful than that of James Watt. Engineers quickly adopted the new engine and used it to power locomotives and steamboats.



*Oxford Science—Print
Collector/Hulton Archive/Getty
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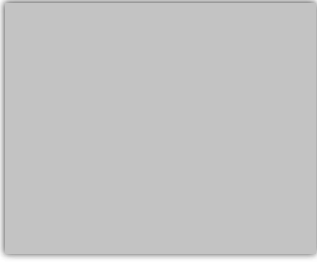
*Yale University Art Gallery, Gift
of George Hoadley, B.A. 1801,
1827.1*

[Cyrus McCormick](#) invented several machines used to mechanize farming. His mechanical reaper, patented in 1834, revolutionized harvesting, making it quicker and easier. [Elias Howe](#)'s sewing machine became a widely distributed home appliance and made the manufacture of clothing less expensive.

Techniques of factory production were refined in American workshops. [Eli Whitney](#) had invented the cotton gin, a machine for cleaning the seeds out of cotton. He also built a firearms factory. There he led the movement to standardize parts used in manufacture. They became interchangeable, enabling unskilled workers to assemble products from boxes of parts quickly. American factories used machine tools to make parts. These machines were arranged in lines for more efficient production. This was called the "American system of manufacturing." It was admired by all other industrial countries. After being first applied to the manufacture of firearms known as muskets, the system was later used in other industries such as clock and lock making.

SECOND INDUSTRIAL REVOLUTION





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The machines of the Industrial Revolution in the 18th and early 19th centuries were simple, mechanical devices compared with the industrial technology that followed. Many new products were devised. Important advances were made in the system of mass production. Changes in industry were so great that the period after 1860 has been called the Second Industrial Revolution.

New scientific knowledge was applied to industry as scientists and engineers unlocked the secrets of physics and chemistry.

Great new industries were founded on this scientific advance. The steel, chemicals, and petroleum industries benefited from new understandings of chemistry. Breakthroughs in the study of electricity provided the basis for a large electrical industry. These new industries were larger and more productive than any industries existing before. Germany and the United States became the leaders. By the end of the 19th century they were challenging Great Britain in the world market for industrial goods.

The age of electricity began in 1882 when [Thomas A. Edison](#) introduced a system of electric lighting in New York City. Electricity was later applied to driving all kinds of machinery as well as powering locomotives and streetcars. Electric lighting quickly spread across the United States and was soon adopted in Europe.

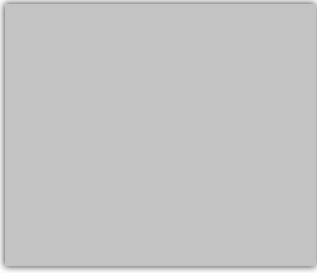
The electrical industry was dominated by large companies that developed new products and then manufactured and marketed them. These companies were based in Germany and the United States but sold their goods all over the world. They were the first multinational companies. Companies like Westinghouse and General Electric helped to electrify cities in Europe, Africa, and South America.

The steel and chemical industries used new technology that greatly increased production. The size of factories increased rapidly, employing more workers and using more machinery. Corporations such as U.S. Steel and Standard Oil bought out competitors and acquired sources of raw materials and retail outlets. They controlled all stages of manufacturing the product, from mining and drilling to delivering it to the customer. This gave them great economic power. The United States government took measures to limit their monopolies (or complete control) in steel and petroleum.



The larger size of business presented great challenges to managers of enormous organizations. Advances in communications and transportation helped decision makers to maintain control. The electric telegraph was invented by [Samuel Morse](#) in 1844. It was used to relay commercial information about prices and markets. It was used in the stock exchanges and on the railway systems. [Alexander Graham Bell](#) patented his telephone in 1876. Networks of telephone lines were built quickly across the United States. The telephone became a useful tool for managers to keep in contact with the widely scattered parts of their businesses.

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Ford Motor Company

The Second Industrial Revolution also marked great progress in the methods of mass production. More and more industries used interchangeable parts and machine tools. Electric power replaced steam power in factories. It was cheaper, faster, and more flexible. It allowed machine tools to be arranged more efficiently. Human power was replaced by machine power. In 1913 [Henry Ford](#) introduced the assembly line in the manufacture of his Model T Ford. Parts were assembled on a moving conveyor belt. The Model T took shape as it moved from one work station to the next. The assembly line greatly increased the speed of manufacture and soon was used in many industries.

By the outbreak of [World War I](#) in 1914, only a small number of industries in the most developed countries of the world had adopted advanced production methods and organization. Much of the world had not yet begun a first industrial revolution. Russia, Canada, Italy, and Japan were just beginning to industrialize. Only Great Britain, the United States, Germany, France, and some parts of the Scandinavian countries had successfully completed an industrial revolution. China, India, and Spain did not begin to industrialize until well into the 20th century.

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Andre Millard

Ed.

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