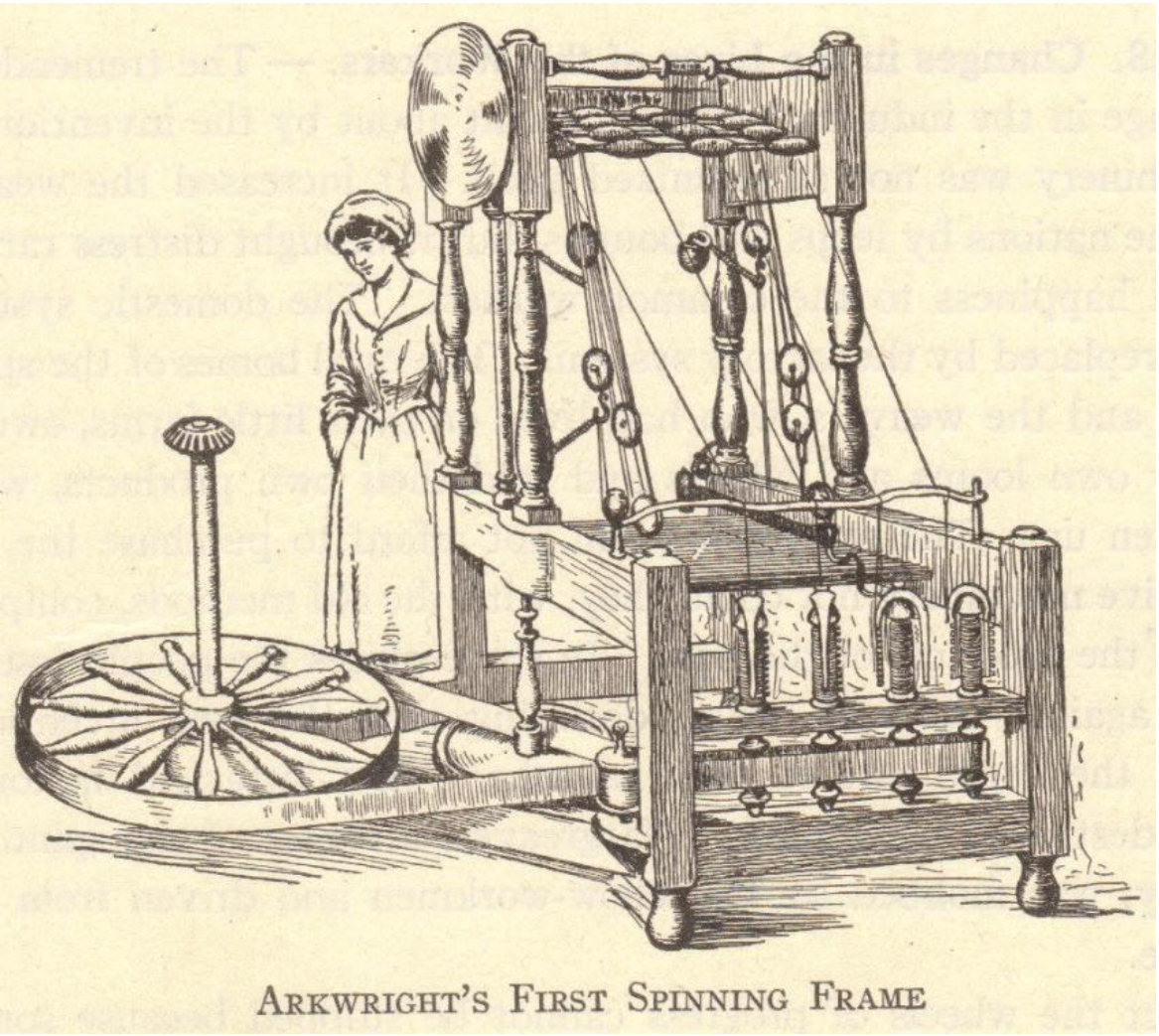


ARKWRIGHT'S FIRST SPINNING FRAME

The First Industrial Revolution

Historical Significance of the Industrial Revolution

- An ancient Greek or Roman would have been just as comfortable in Europe in 1700 because daily life was not much different – agriculture and technology were not much changed in 2000+ years
- The Industrial Revolution changed human life drastically
- More was created in the last 250+ years than in the previous 2500+ years of known human history

What was the Industrial Revolution?

- The Industrial Revolution was a fundamental change in the way goods were produced, from human labor to machines

- The more efficient means of production and subsequent higher levels of production triggered far-reaching changes to industrialized societies

The Industrial Revolution

- Machines were invented which replaced human labor
- New energy sources were developed to power the new machinery – water, steam, electricity, oil (gas, kerosene)
  - Some historians place advances in atomic, solar, and wind energy at the later stages of the Industrial Revolution
- Increased use of metals and minerals
  - Aluminum, coal, copper, iron, etc.

The Industrial Revolution

- Transportation improved
  - Ships
    - Wooden ships → Iron ships → Steel ships
    - Wind-powered sails → Steam-powered boilers
  - Trains
  - Automobiles
- Communication improved
  - Telegraph
  - Telephone
  - Radio

Developments

- Mass production of goods
  - Increased numbers of goods
  - Increased diversity of goods produced
- Development of factory system of production
- Rural-to-urban migration
  - People left farms to work in cities
- Development of capitalism
  - Financial capital for continued industrial growth
- Development and growth of new socio-economic classes
  - Working class, bourgeoisie, and wealthy industrial class
- Commitment to research and development
  - Investments in new technologies
  - Industrial and governmental interest in promoting invention, the sciences, and overall industrial growth

Background of the Industrial Revolution

- Commercial Revolution
  - 15th, 16th, and 17th centuries
  - Europeans expanded their power worldwide
  - Increased geographic knowledge
  - Colonies in the Americas and Asia
  - Increased trade and commerce
  - Guild system could not meet the demands of increasing numbers goods

Background of the Industrial Revolution

- Scientific Revolution
  - 17th and 18th centuries
  - Discoveries of Boyle, Lavoisier, Newton, etc.
- Intellectual Revolution
  - 17th and 18th centuries
  - Writings of Locke, Voltaire, etc.
- Atmosphere of discovery and free intellectual inquiry
  - Greater knowledge of the world
  - Weakened superstition and tradition
  - Encouraged learning and the search for better and newer ways of doing things

Development of the Domestic System of Production

- Domestic system developed in England
- Late 1600s-late 1800s
- Domestic system of production – "putting out" system
  - Businesspeople delivered raw materials to workers' homes
  - Workers manufactured goods from these raw materials in their homes (typically articles of clothing)
  - Businesspeople picked up finished goods and paid workers wages based on number of items
- Domestic system could not keep up with demand

Factory System

- Developed to replace the domestic system of production
- Faster method of production
- Workers concentrated in a set location
- Production anticipated demand
  - For example: Under the domestic system, a woman might select fabric and have a businessperson give it to a home-based worker to make into a dress. Under the factory system, the factory owner bought large lots of popular fabrics and had workers create multiple dresses in common sizes, anticipating that women would buy them.

	Domestic System	Factory System
Methods	•Hand tools	•Machines
Location	•Home	•Factory
Ownership and Kinds of Tools	•Small hand tools owned by worker	•Large power-driven machines owned by the capitalist
Production Output	•Small level of production •Sold only to local market •Manufactured on a per-order basis	•Large level of production •Sold to a worldwide market •Manufactured in anticipation of demand
Nature of Work Done by Worker	•Worker manufactured entire item	•Worker typically made one part of the larger whole •Henry Ford's assembly line (early 20th century) kept workers stationary
Hours of Work	•Worker worked as much as he/she would and could, according to demand	•Worker worked set daily hours
Worker Dependence on Employer	•Worker had multiple sources of sustenance–other employers, own garden or farm, and outside farm labor	•Worker relied entirely on capitalist for his/her income–urban living made personal farming and gardening impractical

England: Birthplace of the Industrial Revolution

- No concrete start date for the Industrial Revolution
- Marked by gradual, slow changes
- After 1750 – these changes were noticeable first in England

Why the Industrial Revolution Started in England

Capital for investing in the means of production	Colonies and Markets for manufactured goods	Raw materials for production
Workers	Merchant marine	Geography

England's Resources: Capital

- The Commercial Revolution made many English merchants very wealthy

- These merchants had the capital to invest in the factory system – money to buy buildings, machinery, and raw materials

England's Resources: Colonies and Markets

- Wealth from the Commercial Revolution spread beyond the merchant class
- England had more colonies than any other nation
- Its colonies gave England access to enormous markets and vast amounts of raw materials
- Colonies had rich textile industries for centuries
  - Many of the natural cloths popular today, such as calico and gingham, were originally created in India
  - China had a silk industry

England's Resources: Raw Materials

- England itself possessed the necessary raw materials to create the means of production
- Coal – vast coal reserves powered steam engines
- Iron – basic building block of large machines, railroad tracks, trains, and ships

England's Resources: Workers

- Serfdom and guilds ended earlier in England than other countries
- English people could freely travel from the countryside to the cities
- Enclosure Acts – caused many small farmers to lose their lands, and these former farmers increased the labor supply

England's Resources: Merchant Marine

- World's largest merchant fleet
- Merchant marine built up from the Commercial Revolution
- Vast numbers of ships could bring raw materials and finished goods to and from England's colonies and possessions, as well as to and from other countries

England's Resources: Geography

- England is the political center of Great Britain, an island
- Great Britain (as the entire island was called beginning in 1707) did not suffer fighting on its land during the wars of the 18th century
- Island has excellent harbors and ports
- Damp climate benefited the textile industry (thread did not dry out)
- Government stable
- No internal trade barriers

“Necessity Is the Mother of Invention”

Spinning machine

Need to speed up weaving

Power loom created

“Necessity Is the Mother of Invention”

Power loom

Increased demand for raw cotton

Invention of the cotton gin

“Necessity Is the Mother of Invention”

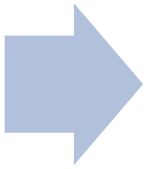
Cotton gin

Demands for stronger iron

Improvements in iron smelting and the development of steel (Bessemer process)

“Necessity Is the Mother of Invention”

As more steam-powered machines were built, factories needed more coal to create this steam



Mining methods improved to meet the demand for more coal

- The process of inventing never ends
- One invention inevitably leads to improvements upon it and to more inventions

The Textile Industry

- Textiles – cloths or fabrics
- First industry to be industrialized
- Great Britain learned a lot about textiles from India and China

The Birth and Growth of the Textile Industry

John Kay (English)	
Flying shuttle, 1733	Hand-operated machine which increased the speed of weaving

James Hargreaves (English)	
Spinning jenny, 1765	Home-based machine that spun thread 8 times faster than when spun by hand

Richard Arkwright (English)	
Water frame, 1769	Water-powered spinning machine that was too large for use in a home – led to the creation of factories

The Birth and Growth of the Textile Industry

Samuel Crompton (English)	
Spinning mule, 1779	Combined the spinning jenny and the water frame into a single device, increasing the production of fine thread

Edward Cartwright (English)	
Power loom, 1785	Water-powered device that automatically and quickly wove thread into cloth

Eli Whitney (American)	
Cotton gin, 1793	Device separated raw cotton from cotton seeds, increasing the cotton supply while lowering the cost of raw cotton

Elias Howe (American)	
Sewing machine, 1846	Speed of sewing greatly increased

Development of Steam Engines

- Early water power involved mills built over fast-moving streams and rivers

- Early water power had problems

  - Not enough rivers to provide the power needed to meet growing demand
  - Rivers and streams might be far removed from raw materials, workers, and markets
  - Rivers are prone to flooding and drying

Steam Power

- Humans tried harnessing steam power for millennia
  - Hero of Alexandria, Egypt – created a steam-driven device in the 1st century B.C.E.
- Thomas Newcomen, England (1704)
  - Created a steam engine to pump water from mines
- James Watt, Scotland (1769)
  - Improved Newcomen's engine to power machinery

Steam Engines

- By 1800, steam engines were replacing water wheels as sources of power for factories
- Factories relocated near raw materials, workers, and ports
- Cities grew around the factories built near central England's coal and iron mines
  - Manchester, Liverpool

Coal and Iron

- Vast amounts of fuel were required to smelt iron ore to burn out impurities
- Abraham Darby (1709)
  - Discovered that heating coal turned it into more efficient coke
- John Smeaton (1760)
  - Smelted iron by using water-powered air pumps to create steam blasts
- Henry Cort (1783)
  - Developed the puddling process which purified and strengthened molten iron

Increases in Coal and Iron Production, 1770-1800

- Coal production doubled
  - 6 million to 12 million tons
- Pig iron production increased 250%
  - 1800 – 130,000 tons
- Great Britain produced as much coal and iron as every other country combined

Bessemer Process and Steel

- Prior to the Industrial Revolution, steel was difficult to produce and expensive
- Henry Bessemer, 1856
  - Developed the Bessemer process
  - Brought on the “Age of Steel”
  - Steel is the most important metal used over the past 150+ years
- Other improvements in steel production
  - Open-hearth furnace
  - Electric furnace
  - Use of other metals to produce various types of steel

Transportation

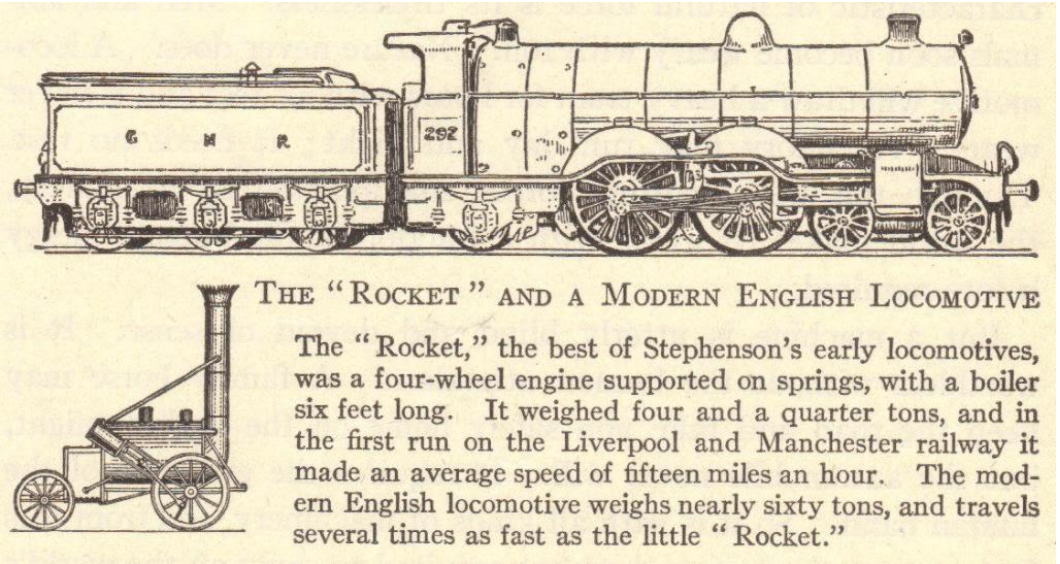
Increased production → Search for more markets and raw materials → Better and faster means of transportation

Before the Industrial Revolution

- Canal barges pulled by mules
- Ships powered by sails
- Horse-drawn wagons, carts, and carriages

After the Industrial Revolution

- Trains
- Steamships
- Trolleys
- Automobiles



THE "ROCKET" AND A MODERN ENGLISH LOCOMOTIVE

The "Rocket," the best of Stephenson's early locomotives, was a four-wheel engine supported on springs, with a boiler six feet long. It weighed four and a quarter tons, and in the first run on the Liverpool and Manchester railway it made an average speed of fifteen miles an hour. The modern English locomotive weighs nearly sixty tons, and travels several times as fast as the little "Rocket."

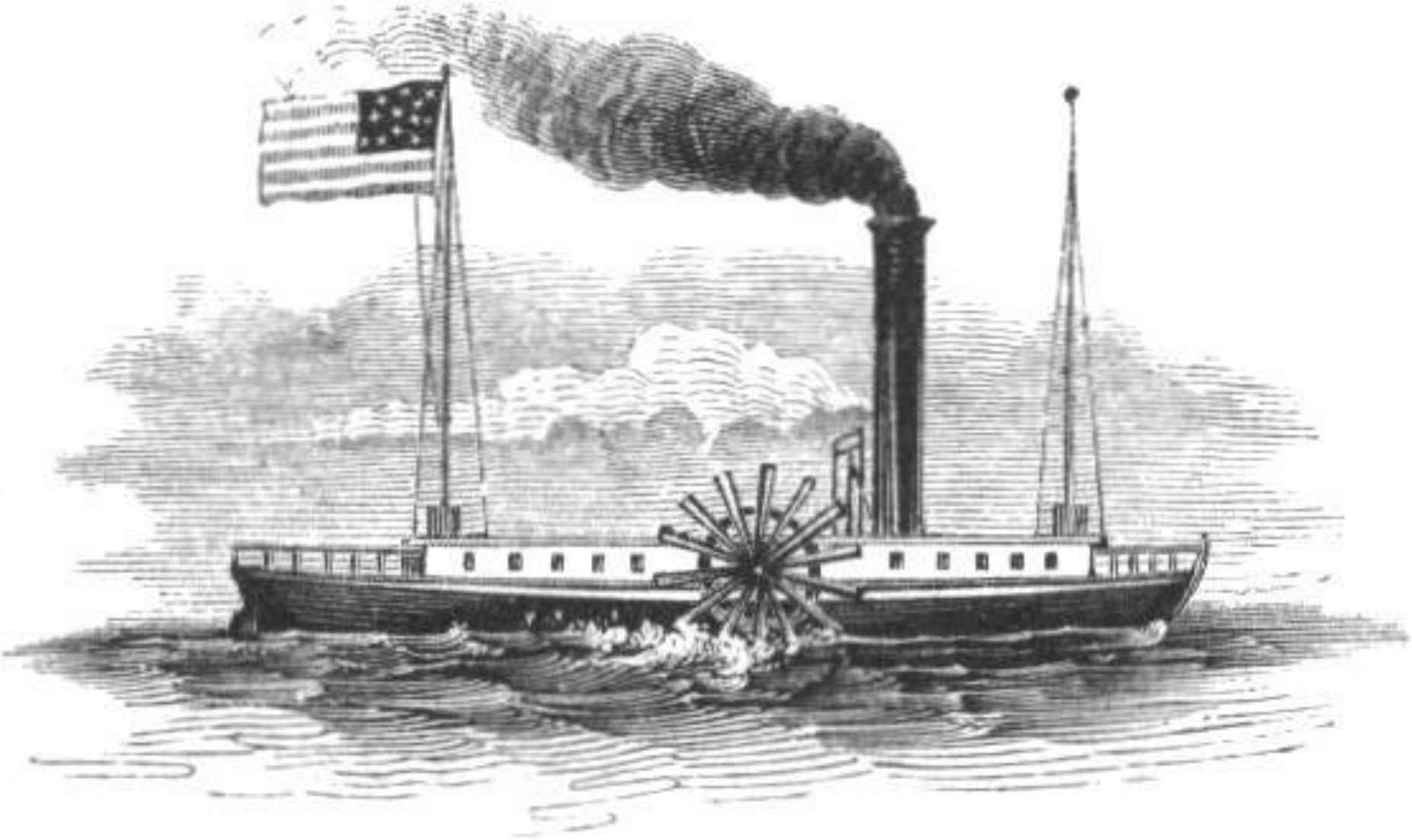
Transportation Revolution

Robert Fulton (American)	Thomas Telford and John McAdam (British)	George Stephenson (English)
• Steamboat (1807) • Sped water transportation	• Macadamized roads (1810-1830) • Improved roads	• Locomotive (1825) • Fast land transport of people and goods

Gottlieb Daimler (German)	Rudolf Diesel (German)	Orville and Wilbur Wright (American)
• Gasoline engine (1885) • Led to the invention of the automobile	• Diesel engine (1892) • Cheaper fuel	• Airplane (1903) • Air transport

Steamboats

- Robert Fulton invented the steamboat in 1807
- The *Clermont* operated the first regular steamboat route, running between Albany and New York City
- 1819 – the *Savannah* used a steam engine as auxiliary power for the first time when it sailed across the Atlantic Ocean
- 1836 – John Ericsson invented a screw propeller to replace paddle wheels
- 1838 – the *Great* Western first ship to sail across the Atlantic on steam power alone, completing the trip in 15 days

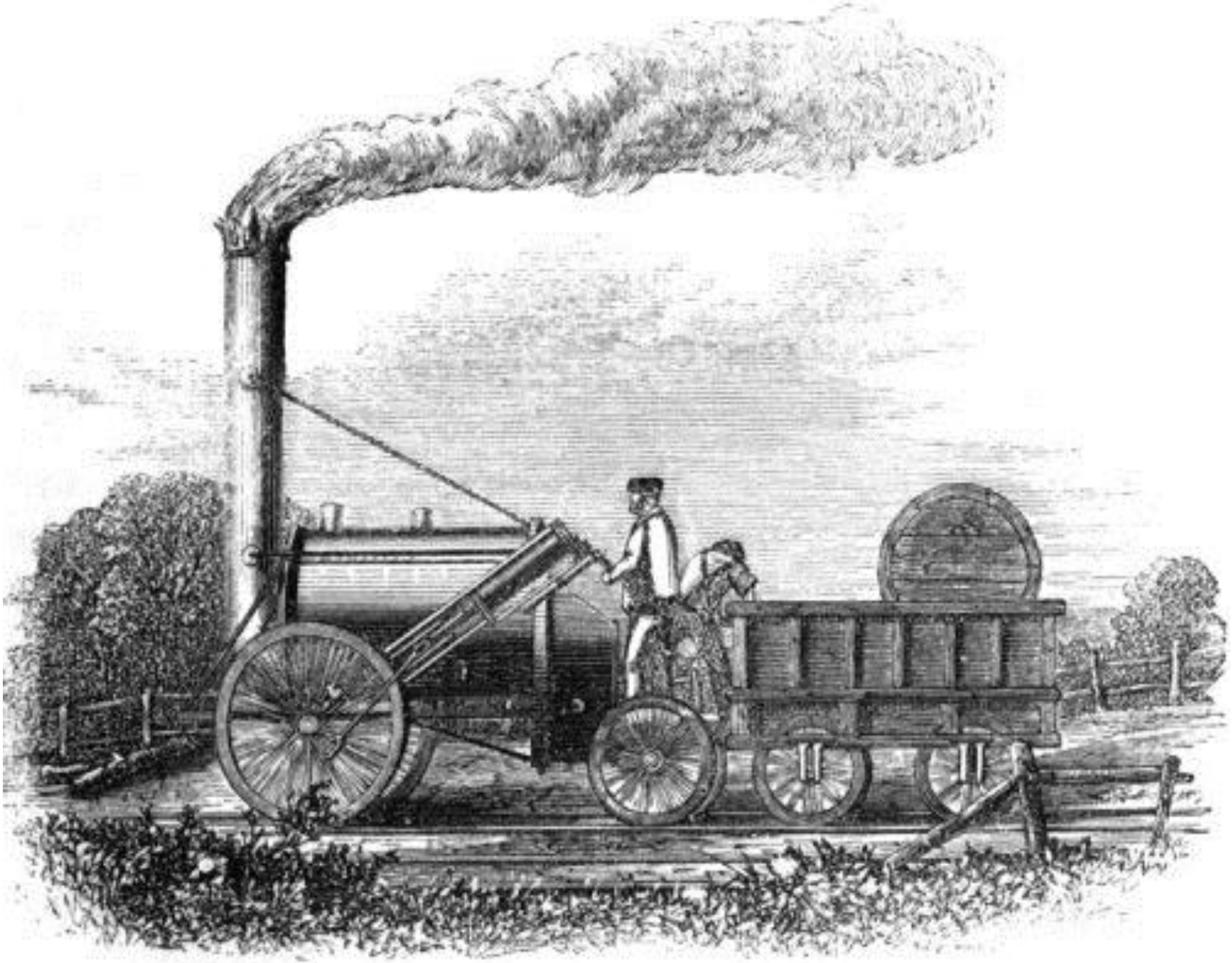


Macadamized Roads

- Strong, hard roads invented by Thomas Telford and John McAdam
- Improvement over dirt and gravel roads
- Macadamized roads have a smooth, hard surface that supports heavy loads without requiring a thick roadbed
- Modern roads are macadamized roads, with tar added to limit the creation of dust

Railroads

- 1830 – Stephenson's "Rocket" train traveled the 40 miles between Liverpool and Manchester in 1 ½ hours
- 1830-1870 – railroad tracks went from 49 miles to over 15,000 miles
- Steel rails replaced iron rails
- 1869 – Westinghouse's air brake made train travel safer
- Greater train traveling comfort – heavier train cars, improved road beds, and sleeping cars



The "Rocket."

Communications Revolution

Samuel F.B. Morse (American)

- Telegraph (1844)
- Rapid communication across continents

Alexander Graham Bell (American)

- Telephone (1876)
- Human speech heard across continents

Cyrus W. Field (American)

- Atlantic cable (1866)
- United States and Europe connected by

Guglielmo Marconi (Italian)

- Wireless telegraph, an early form of the radio (1895)
- No wires needed for sending messages

Lee de Forest (American)

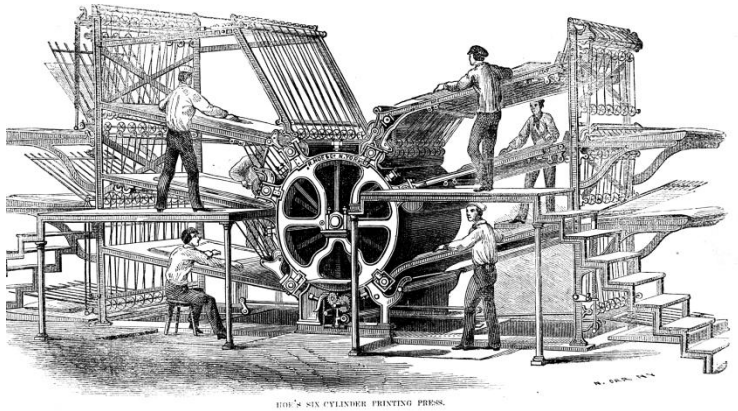
- Radio tube (1907)
- Radio broadcasts could be sent around the world

Vladimir Zworykin (American)

- Television (1925)
- Simultaneous audio and visual broadcast

Printing Revolution

- Printing – 1800-1830
  - Iron printing press
  - Steam-driven press
- Rotary press – 1870
  - Invented by Richard Hoe
  - Printed both sides of a page at once
- Linotype machine – 1884
  - Invented by Ottmar Mergenthaler
  - A machine operator could create a “line of type” all at one go, rather than having to individually set each letter
- Newspapers became much cheaper to produce
  - Cost of a newspaper plummeted
  - Number of newspapers increased



Review Questions

1. What was the Industrial Revolution?

2. Describe at least three developments of the Industrial Revolution.

3. Compare and contrast the domestic and factory methods of production.

4. Why did the Industrial Revolution begin in England?

5. Explain why one invention or development leads to another.

Review Questions

6. Explain how developments in the textile industry sparked the Industrial Revolution.

7. Describe at least three developments in the area of transportation.

8. Describe at least three developments in the field of communications.

9. Considering the conditions necessary for industrialization to occur, how well equipped is the undeveloped world for becoming industrialized? Are modern undeveloped nations in a better or worse position than 18th- and 19th-century England?