

Electricity, chemistry and a connected world

ENG 151 · Lecture 7
Science and Technology
Mehmet Göktürk

Cooling without an electrical socket



MAKE PROFITS NOW WITH THIS AMAZING REFRIGERATOR FOR RURAL HOMES

Every Crosley dealer can have extra profits by pushing the amazingly new Crosley Icyball refrigerator now. Ideal for rural or small town homes, summer camps, roadside stands, dairies, or any place without electricity. Provides the advantages and conveniences of mechanical refrigeration, without using gas or electricity. Has no moving parts, requires no oiling, has no odor and is absolutely noiseless. Upkeep cost is only a few cents a day.

Gross capacity is 4.3 cubic feet. Freezing tray makes 14 ice cubes. Interior of 24-gauge galvanized iron. Gleaming white lacquer exterior with black trimmings.

\$59.95 Outside dimensions: 28 1/16" high (including hardware), 41 1/2" wide (including ball), 24 5/16" deep.

F. O. B. Factory

Price includes Cabinet, Stove, Icyball Unit, Stabilizer and Tub

The new **CROSLEY ICYBALL**
REFRIGERATOR

Can heating produce cooling?

This 1920s refrigerator used heat to drive a cooling cycle.

The question takes us back to an industrial transformation in energy, materials and everyday life.

What must exist around an invention before it becomes useful?

1850–1914: overlapping transformations

Coal and steam continued to expand as electricity and oil gained new uses.

Steel, chemicals and precision manufacturing supported larger and more varied industries.

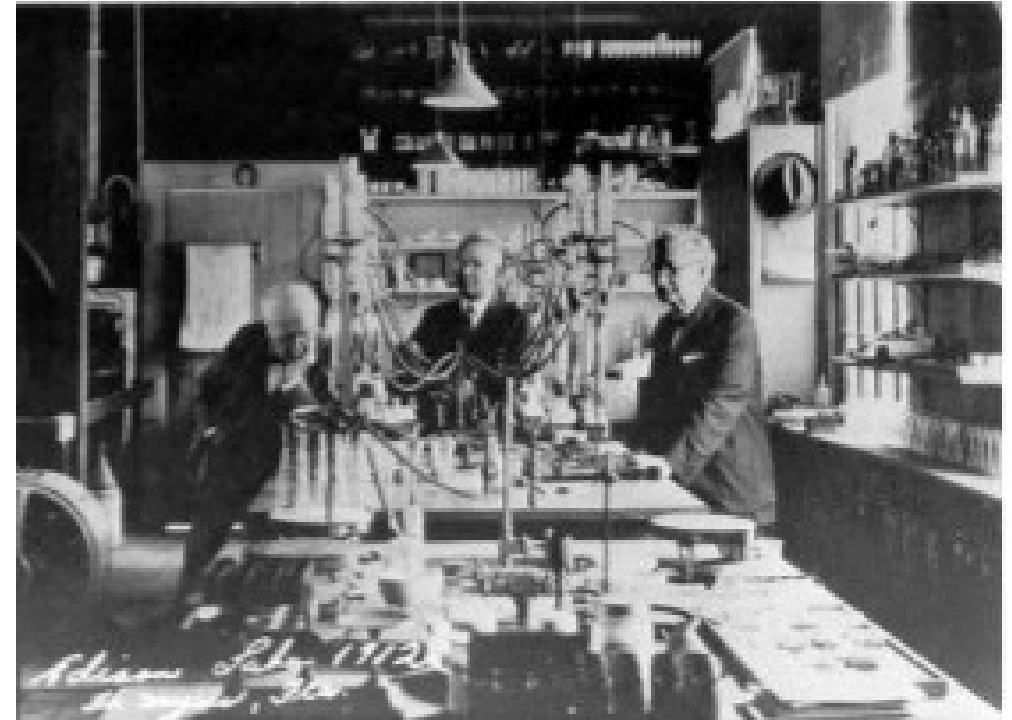
New systems connected factories, households, cities and distant markets.

Research becomes organized work

Industrial laboratories brought experiments, skilled technicians and commercial problems together.

Universities trained chemists and engineers.
Companies financed research and production.

Workshop knowledge remained essential alongside scientific theory.



Edison laboratory at Fort Myers, 1912

1820s–1850s: a much older natural world

Buckland's 1824 description of Megalosaurus helped establish the study of ancient reptiles.

Lyell's Principles of Geology, beginning in 1830, explained past changes through natural processes.

Geological time widened the setting in which people understood life.



An early reconstruction of prehistoric reptiles

1856: the Neanderthal discovery

Fossil remains raised new questions about the history of humanity.

Early reconstructions often projected contemporary prejudice onto fragmentary remains.

Neanderthals belong to a branching human history.



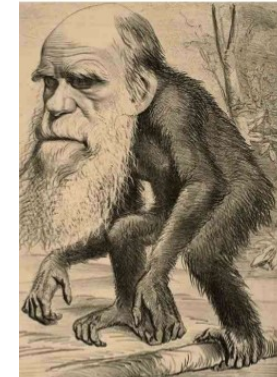
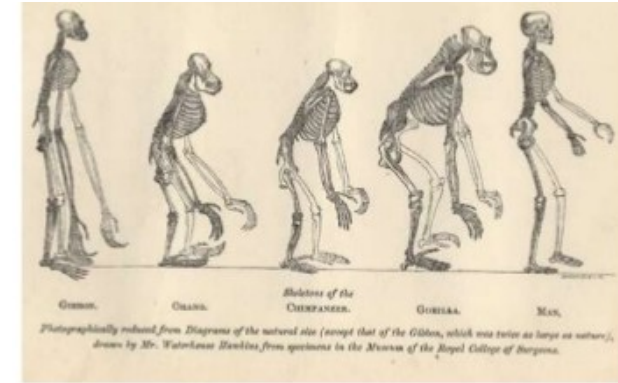
Historical Neanderthal reconstruction, 1909

1859: evolution and public debate

Darwin's On the Origin of Species explained evolution through natural selection.

Variation and differential reproduction can change populations over generations.

Evolution branches. Living apes are relatives, rather than steps on a ladder leading to humans.

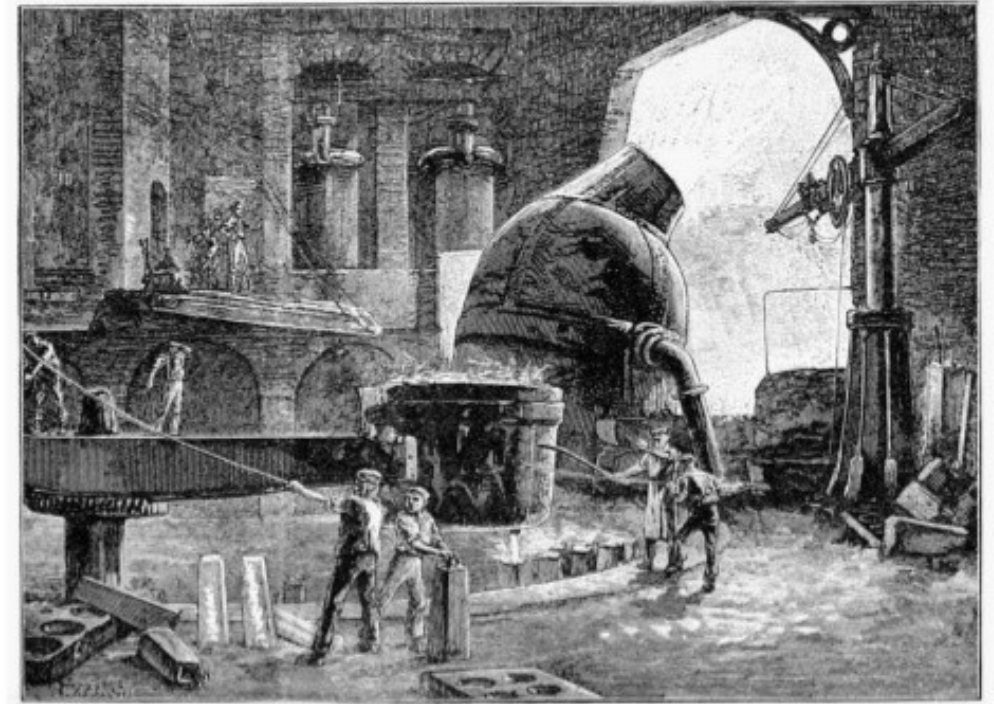


1856: steel in larger quantities

The Bessemer converter blew air through molten pig iron to remove carbon and other impurities.

Steelmaking required control of composition and process conditions.

Cheaper steel widened the possibilities for rails, machines, ships and structures.



Bessemer converter and industrial steelmaking

Iron and steel in the built environment

Metal frames allowed new forms of construction and larger loads.

The Home Insurance Building in Chicago helped develop the metal-framed skyscraper.

The Eiffel Tower of 1889 used puddled iron. Different materials coexisted.



Steelmaking becomes a major industry

Large plants needed ore, fuel, transport, investment and trained workers.

Britain, Germany and the United States developed major steel industries.

An expanding steel supply also supported military production.



Historical view of an American steelworks

Chemistry changes manufactured goods

Perkin's synthetic purple dye of 1856 showed the commercial possibilities of organic chemistry.

Chemical firms developed dyes, acids, medicines and other products through continuing research.

Laboratory results had to become reliable and economical factory processes.



BASF chemical works at Ludwigshafen, 1881

1867 and 1869: different chemical advances

Nobel patented dynamite in 1867, making an explosive easier to handle than liquid nitroglycerin.

Mendeleev published his periodic table in 1869, organizing chemical elements and their relationships.

Industrial products and scientific classification developed through different kinds of work.



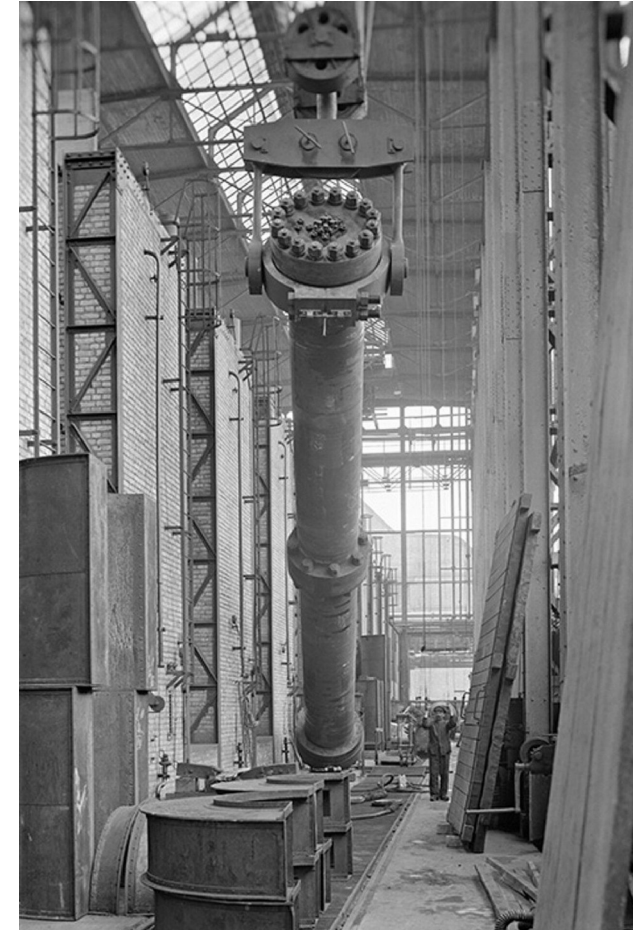
Nobel dynamite branding and cartridge illustration

1913: industrial ammonia production

The Haber–Bosch process converted nitrogen and hydrogen into ammonia at industrial scale.

Fertilizer production connected chemistry with agriculture and food supply.

The same nitrogen chemistry also mattered for explosives.



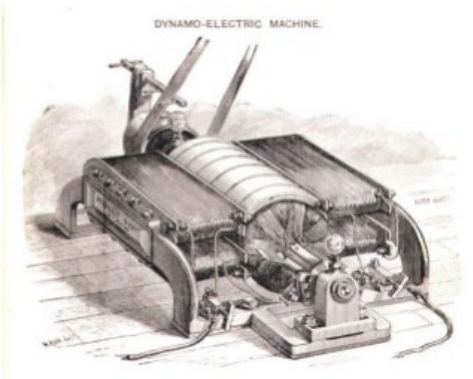
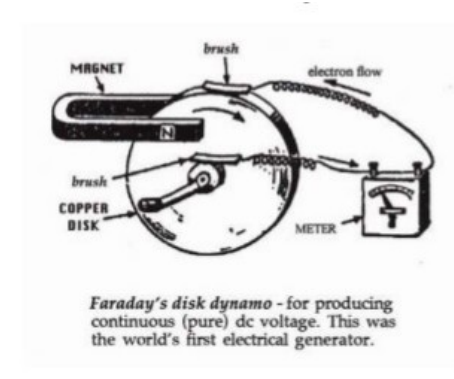
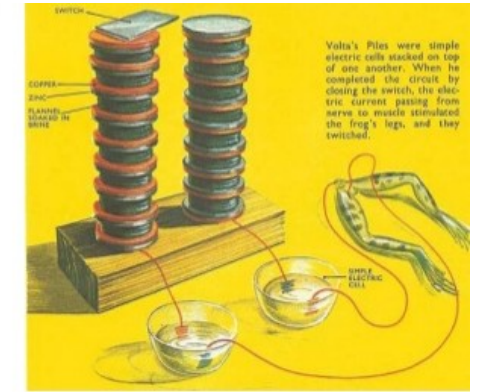
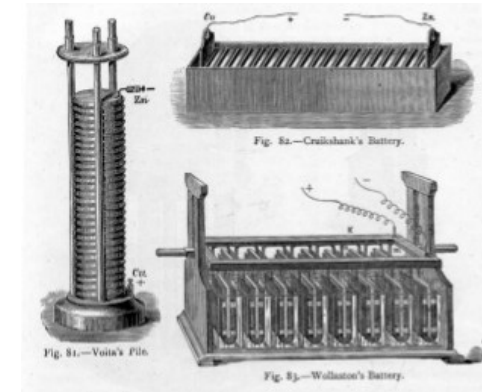
Assembly of an ammonia reactor at Oppau, 1920. BASF Corporate History, CC BY-SA 3.0

1800–1831: electricity before the power station

Volta's battery supplied continuous current through chemical reactions.

Faraday's work on electromagnetic induction showed how motion could produce electrical effects.

Later engineers developed generators suitable for sustained power production.



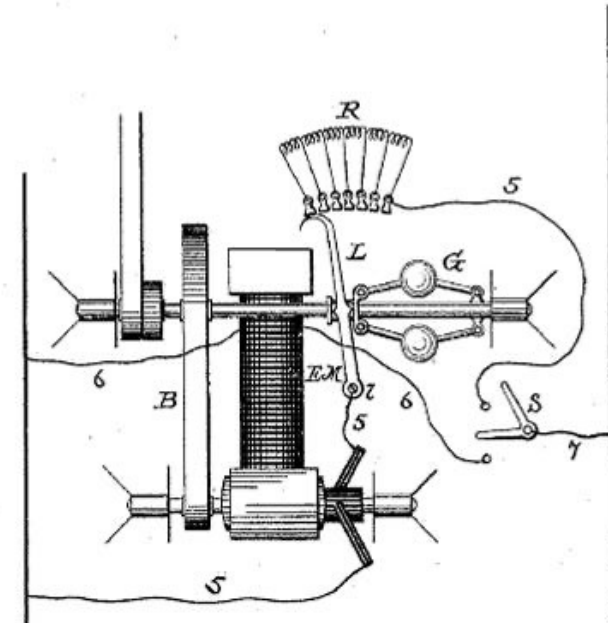
Generators and motors

A generator receives mechanical work and supplies electrical energy.

A motor receives electrical energy and supplies mechanical work.

Electricity carries energy between different locations and uses.

T. A. EDISON.
ELECTRIC MOTOR.
No. 248,429. Patented Oct. 18, 1881.

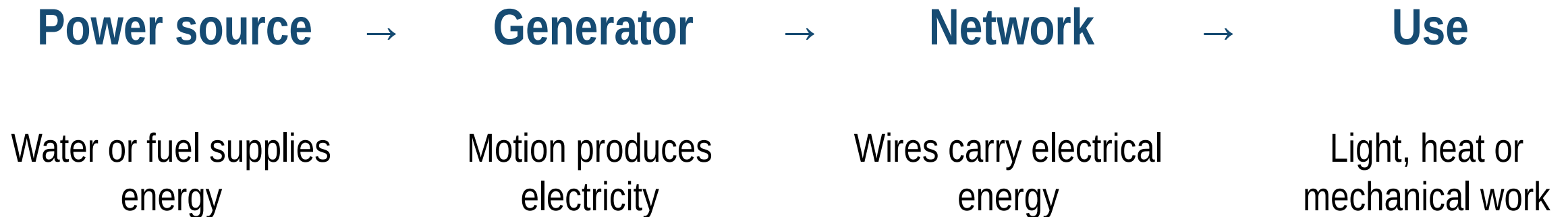


Edison electric-motor patent drawing, 1881

Electricity as a connected service

A working lamp depends on much more than its filament.

Generation, distribution and useful devices must operate together.



1879–1882: practical lighting systems

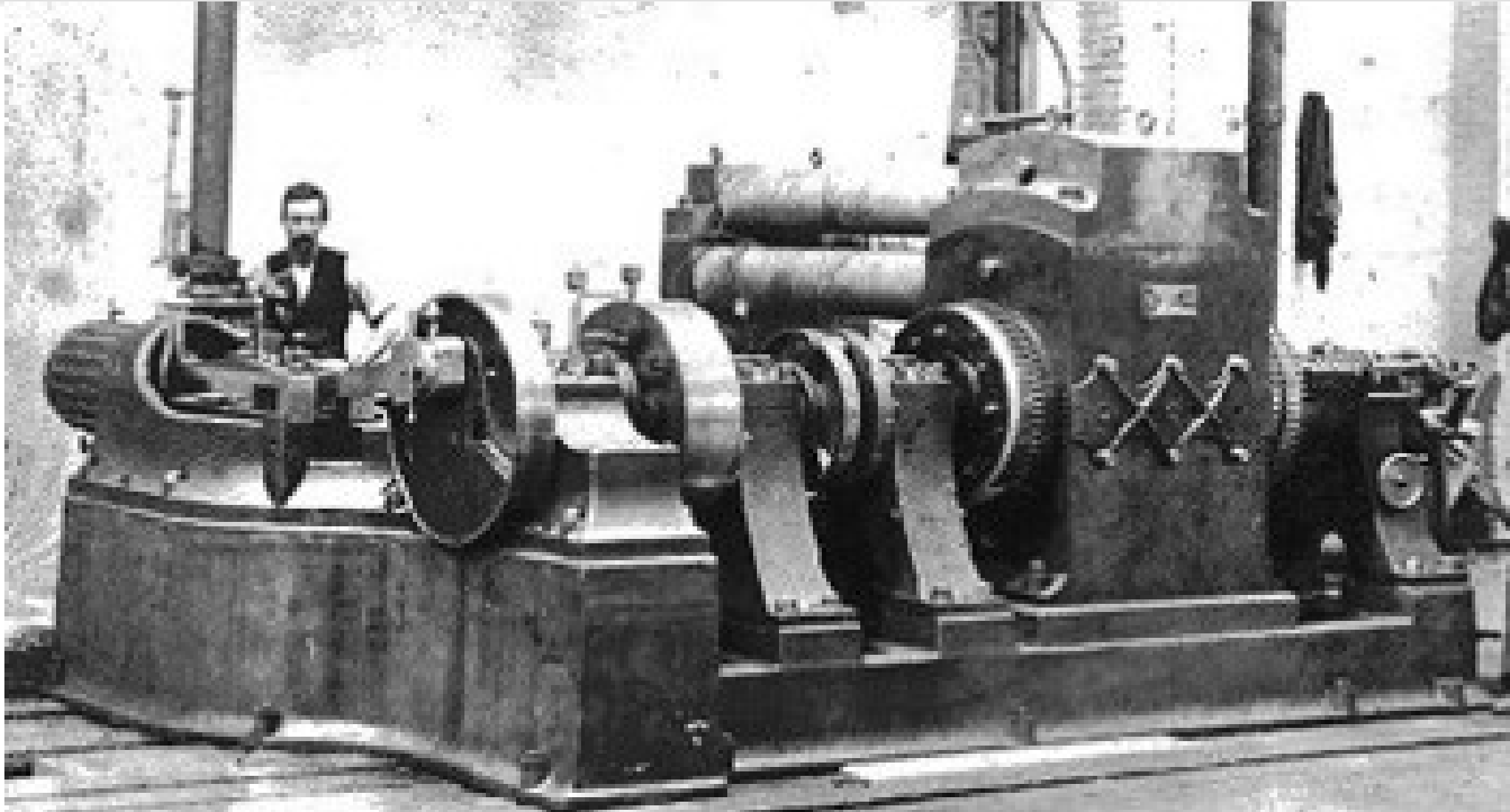
Edison and his team developed durable incandescent lighting within a complete supply system.

Other inventors, including Joseph Swan, also developed practical lamps.

Pearl Street station began supplying customers in New York in 1882.



The power station and its customers



Distribution needs coordination

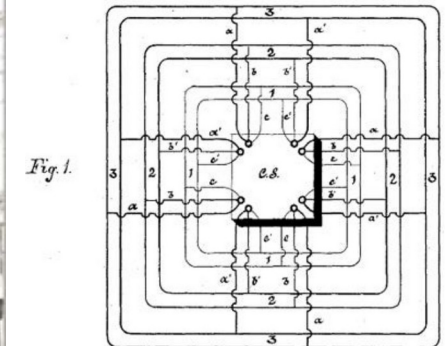
Wires, switches, meters and protective devices made supply usable.

Customers needed compatible equipment and someone to maintain the service.

A fault in one part could interrupt many activities.



(No Model.)
T. A. EDISON.
System of Electric Lighting.
No. 239,147. Patented March 22, 1881.



AC, transformers and distance

A transformer changes the voltage of alternating current.

Higher transmission voltage allows lower current for the same power, reducing losses in wires.

Engineers could connect distant generation with local supplies for customers.

Electricity enters daily life

Lighting extended usable hours in streets, shops and homes.

Motors powered fans, machinery and eventually many domestic appliances.

Access depended on price and infrastructure.
Household adoption spread unevenly.



Domestic electrical equipment in a historical interior

Industry and military power in Europe

Britain's shipyards and Germany's steel, chemical and electrical industries illustrate different industrial strengths.

Railways moved supplies and troops. Telegraphs coordinated decisions over distance.

Military power depended on production, skilled labor and continuing supplies.

Rubber and personal mobility

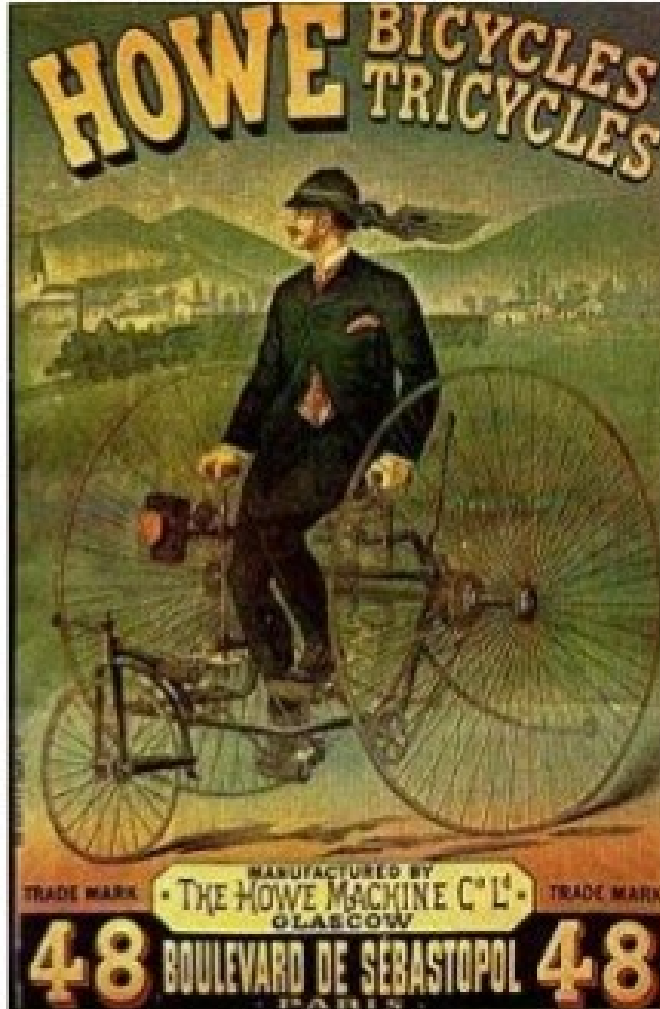
Vulcanization made rubber more useful across changing conditions.

Bicycles combined materials, metalworking and increasingly reliable components.

Personal transport changed opportunities for work, leisure and travel.



The bicycle in public life



1876–1890s: internal combustion

Otto's 1876 four-stroke engine was an important gas-engine milestone.

Benz and Daimler developed early automobiles during the 1880s.

Diesel's work led to a practical compression-ignition engine in 1897.



Engines find many uses

Internal combustion allowed power to travel with a vehicle.

Diesel engines also served stationary and marine applications.

Fuel supply, repair shops and roads shaped adoption.



Historical motor vehicle illustrating later road transport

1863–1900: moving through the city

London's Underground opened in 1863. Paris's Métro opened in 1900.

Urban railways changed the relation between housing, work and distance.

The earliest underground trains used steam before widespread electrification.



Early underground railway scene

The Métro becomes part of Paris



Electric traction

Electric motors could move vehicles along fixed urban routes.

The Lichterfelde electric tram began operating near Berlin in 1881.

Rails and electrical supply required planning and continuing maintenance.



Lichterfelde electric tram, historical image dated 1882

Imagining a city of connected levels



Canals and global routes

Suez opened in 1869, Kiel in 1895 and Panama in 1914.

Canals changed routes, travel times and strategic geography.

Control of a passage could become a source of commercial and military power.



Historical illustration of the opening of the Suez Canal

1912: scale and vulnerability at sea

Large ships combined metal construction, engines and global transport services.

Titanic's maiden voyage ended in disaster in April 1912.

Technical ambition also created demands for safety, communication and emergency planning.



Refrigeration connects distant markets

Refrigerated railcars and ships carried perishable food over longer distances.

Producers needed reliable cooling during transport and storage.

A break in the chain could spoil the value of the whole journey.



Historical refrigerated railway car

A connected cold chain

Keeping food cold requires coordination across several locations.

Production



Transport



Storage



Market

Prepare and cool the
food

Maintain suitable
conditions

Keep cooling at the
destination

Deliver usable food

An IcyBall heated by sunlight



Heat-driven refrigeration

Heating separates ammonia from water during the charging stage.

Later evaporation absorbs heat, cooling the refrigerated space.

Absorption lets the working fluid return to the other vessel.

Naval technology and state power

Battleships required steel, large engines, precision machinery and trained crews.

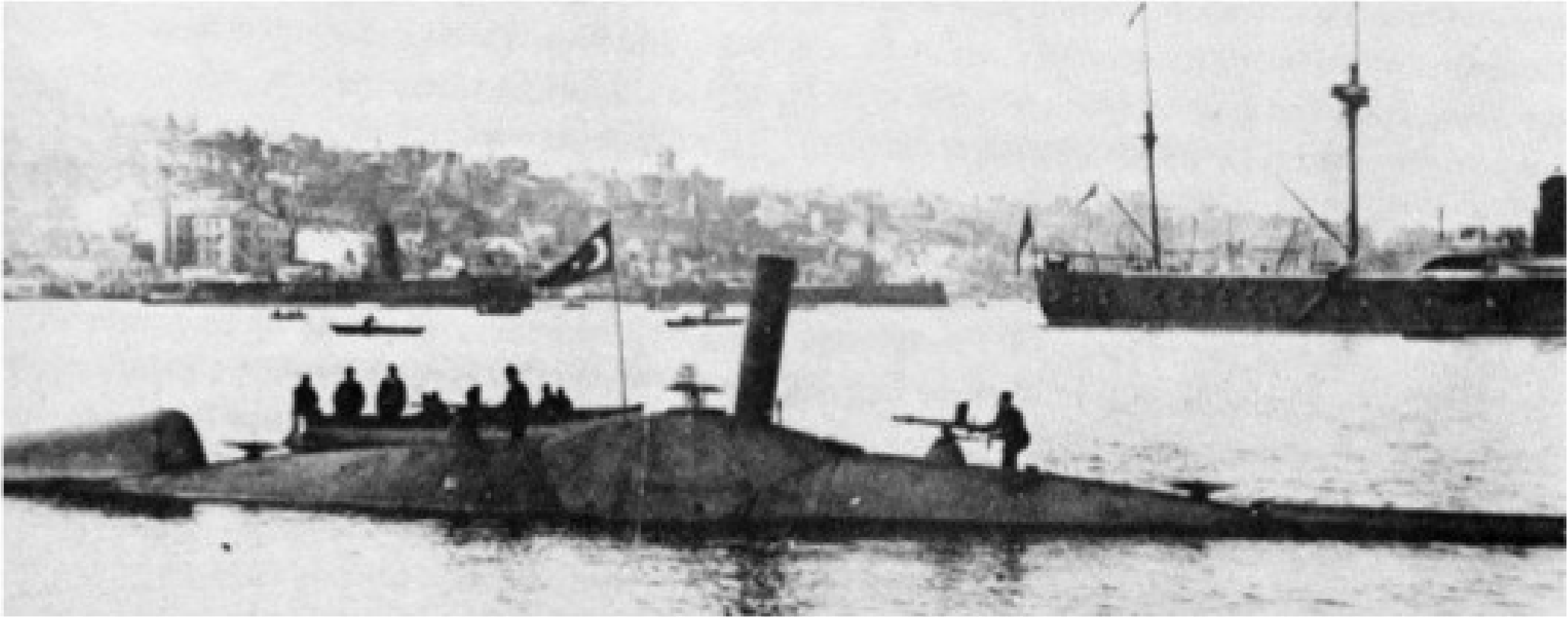
Dreadnought, launched in 1906, became a symbol of naval competition.

A fleet also depended on dockyards, fuel, ammunition and repair capacity.



HMS Dreadnought, 1906

An Ottoman submarine



Japan: industry as a state priority

After 1868, Meiji reforms expanded technical learning and industrial development.

Foreign expertise and imported machinery supported shipyards, mines and factories.

Domestic skills and production capacity grew through adaptation.



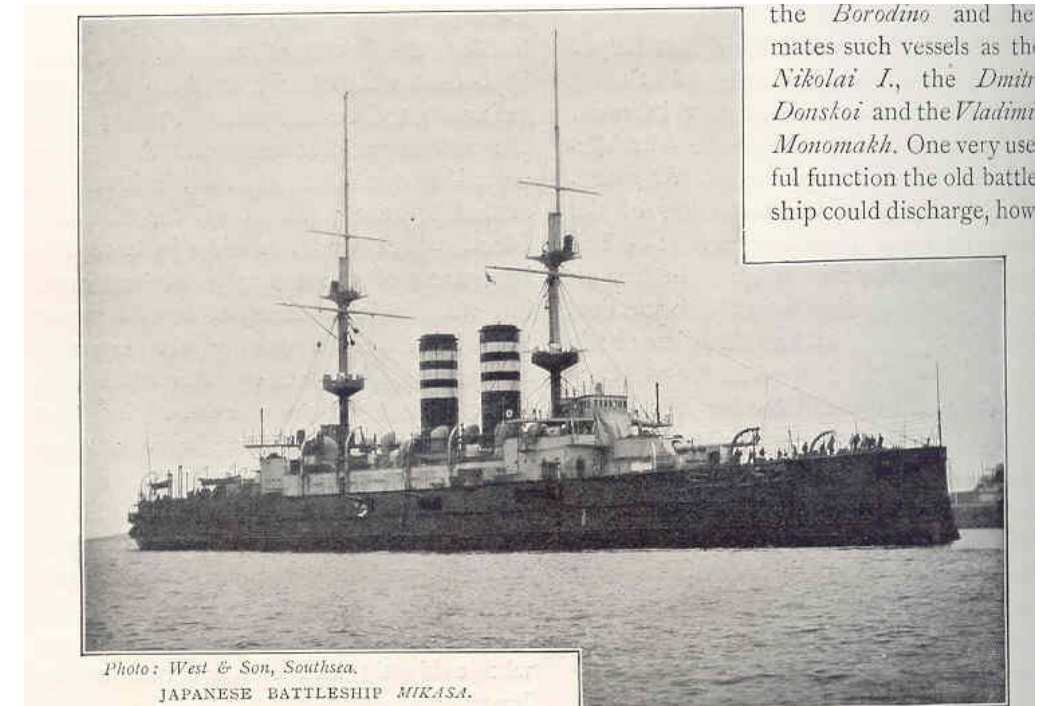
Government Yawata steelworks, historical photograph dated 1900

1894–1905: war in East Asia

Japan defeated Qing China in the war of 1894–95 and Russia in 1904–05.

The results reflected organization, logistics and training as well as equipment.

Military power supported Japan's expanding empire.



Japanese battleship Mikasa, 1905. West & Son, Southsea

China: Self-Strengthening reforms

Qing reformers established arsenals and shipyards and promoted technical translation.

Modern equipment coexisted with difficulties in finance, coordination and military organization.

Defeat in 1894–95 did not erase the industrial knowledge already acquired.



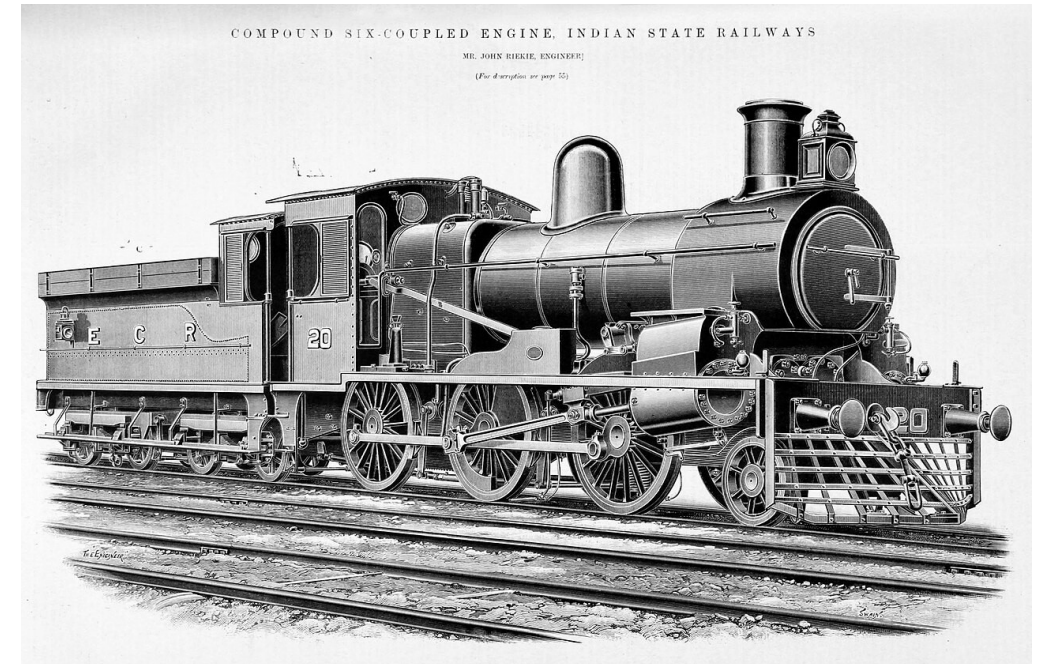
Foochow arsenal, photograph by John Thomson

India: infrastructure under colonial rule

Railways and telegraph supported commerce, administration and military movement.

Colonial control shaped investment and the distribution of benefits.

Indian enterprise also expanded. Tata began producing steel at Sakchi in 1912.



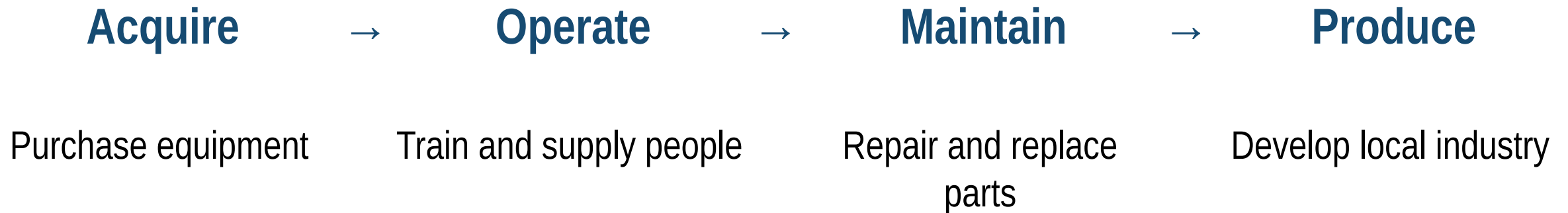
East Coast Railway locomotive No. 20, India, 1900

Buying equipment and building capability

Operating imported machinery requires trained people and reliable supplies.

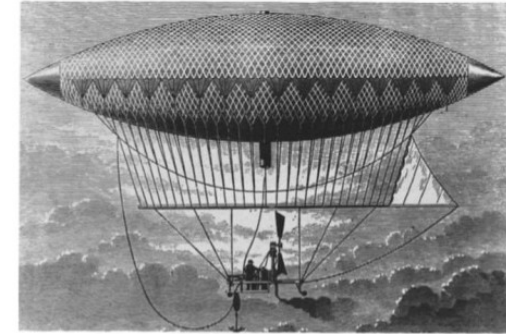
Maintenance requires workshops, parts and practical knowledge.

Domestic production adds manufacturing skills, capital and supporting industries.

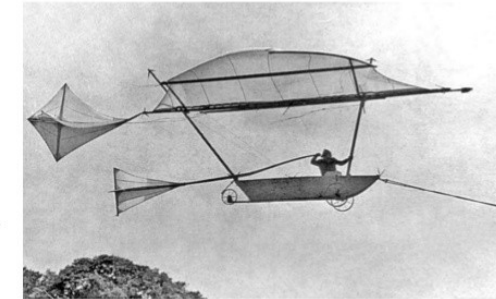


Flight: lift, power and control

Balloons used buoyancy. Giffard's 1852 airship added powered propulsion.



Cayley investigated heavier-than-air flight and glider design.



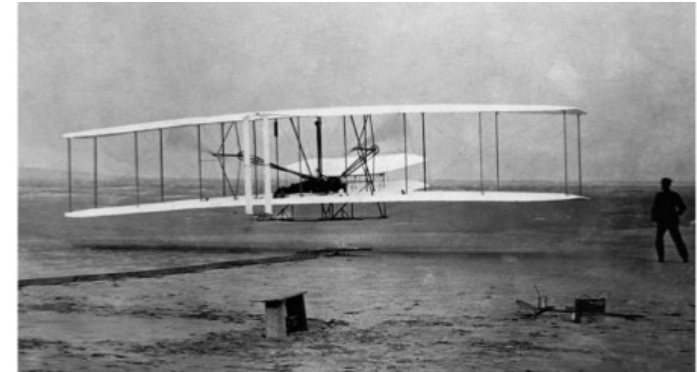
Powered flight required a workable combination of lift, propulsion and control.

Airships and airplanes

Zeppelin's first airship flew in 1900. The photograph shows Graf Zeppelin, first flown in 1928.



The Wright brothers achieved controlled powered flight in 1903.



Airships and airplanes offered different solutions, with different limits.

Print reaches a wider public

Steam printing increased the number of copies presses could produce.

Cheaper publications widened access to news and information.

Literacy, distribution and price shaped the audience.



The Penny Magazine, an inexpensive illustrated publication

Newspapers and public opinion

Investigative reporting could expose abuses and pressure authorities.

Sensational headlines also competed for attention and sales.

The industrial press influenced how people understood politics, crime and war.



Historical press titles and sensational crime reporting

1840: a simpler postal service

Britain's Uniform Penny Post used a standard low charge for ordinary letters.

Prepaid postage simplified use and helped widen access.

Transport and administration made the service work.



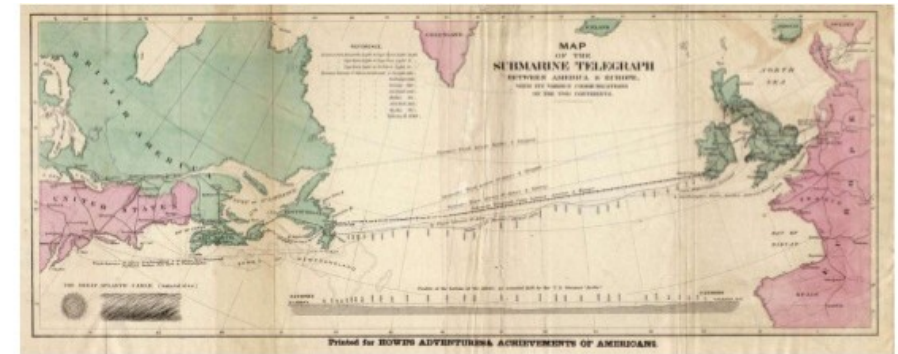
Penny Black postage stamp, 1840

1844–1866: messages cross distance

Morse's 1844 demonstration helped establish electrical telegraphy in the United States.

Submarine cables connected countries and continents.

The 1858 Atlantic cable failed quickly. A durable connection followed in 1866.



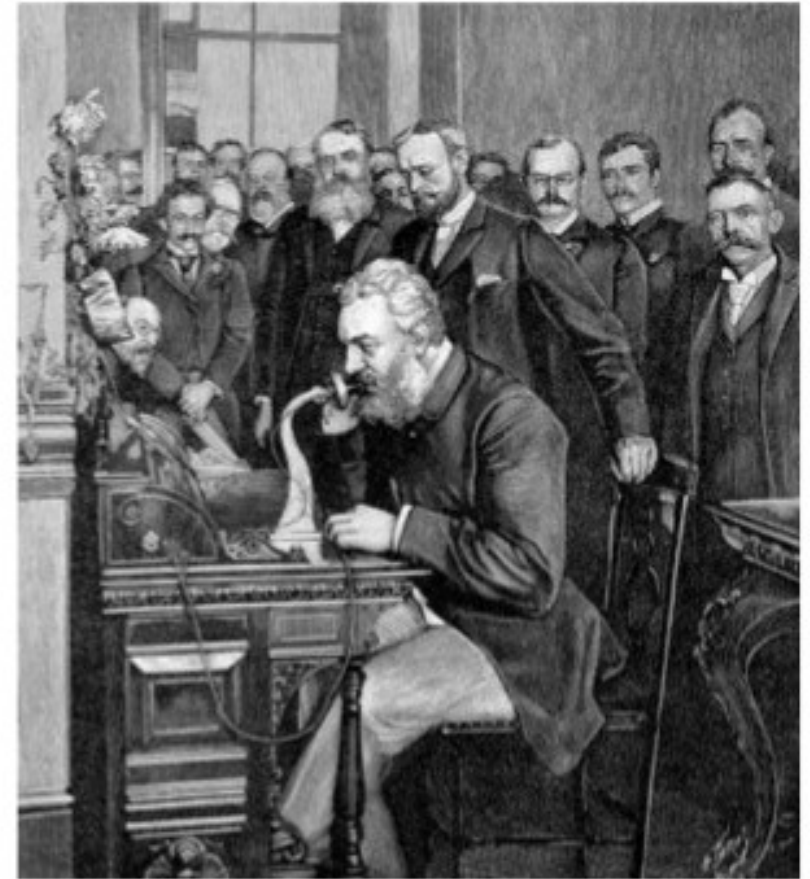
Historical map of an Atlantic telegraph route

1876: the telephone

Bell's telephone patent marked a major step in transmitting speech electrically.

Transmitters, receivers and switching arrangements made calls possible.

Networks required wires, operators and continuing investment.



Historical illustration of Bell demonstrating the telephone

The physical weight of communication



Recording sound and moving images

The phonograph recorded and reproduced sound through a physical trace.

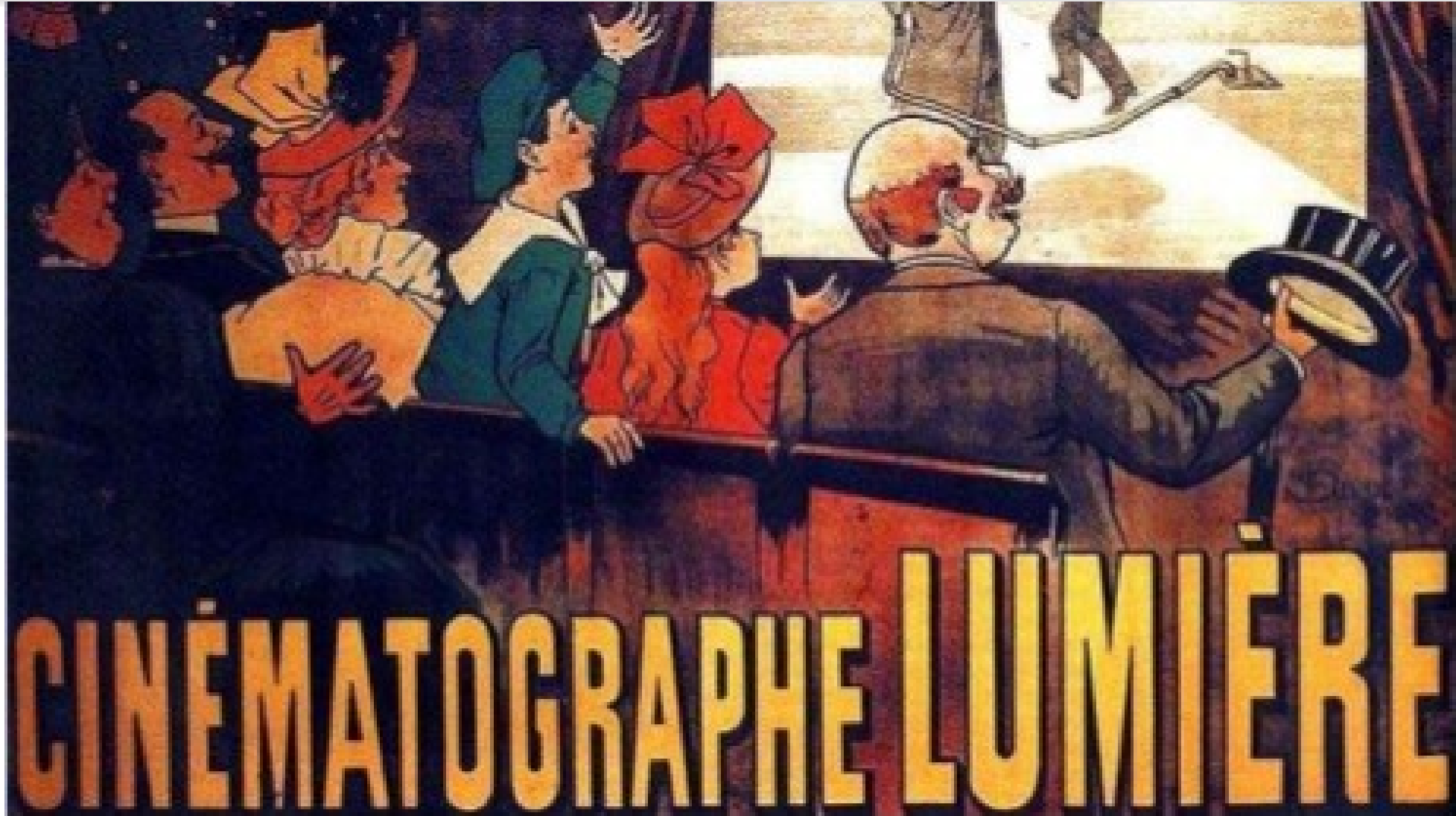
Motion-picture cameras recorded successive frames. Viewers and projectors displayed them.

Recording made performances available beyond their original place and time.



Edison with an early phonograph

1895: cinema and a public audience



1901: wireless across the Atlantic

Marconi reported receiving a transatlantic wireless signal in 1901.

Wireless offered communication without a continuous cable between stations.

Ships and military organizations became important users.



Marconi and wireless equipment

1860s–1905: microbes and health

Pasteur connected microorganisms with fermentation and disease research.

Lister applied antiseptic methods to surgery during the 1860s.

Koch's work on tuberculosis received the 1905 Nobel Prize in Medicine.

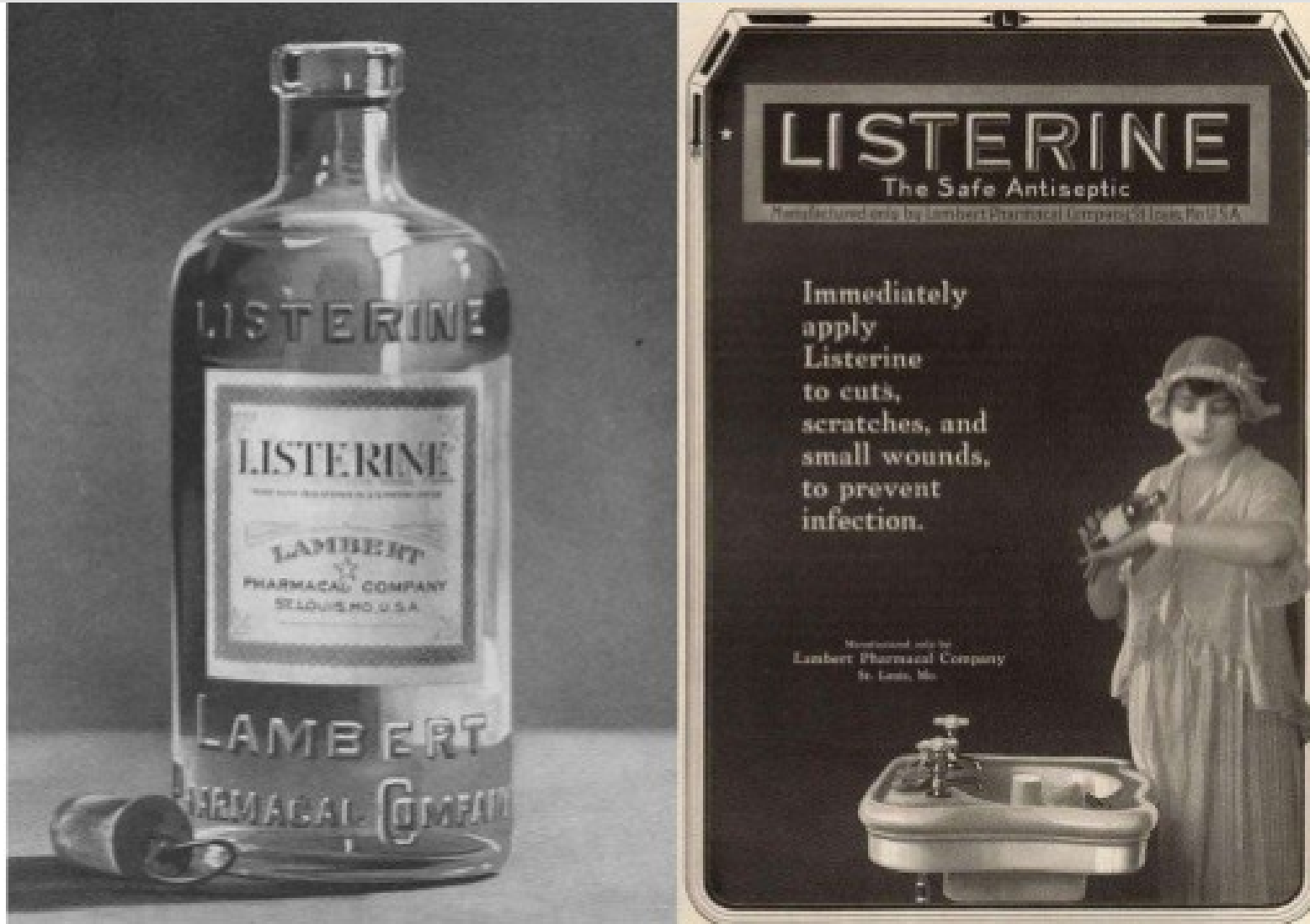


Historical soap advertisements linking cleanliness with daily life

Antiseptic surgery in popular illustration



Medicine becomes a household message



1914: connected industry, greater destruction

Steel, chemical production, transport and communications increased military capacity.

War redirected industrial output and imposed enormous human and material costs.

Technical capability alone did not determine how societies used it.

What turns an invention into a system?

Choose a lamp, telephone, refrigerator or battleship.

Which supporting activities must work reliably for it to be useful?

How do ownership, state policy and access change its effects?

A model explanation

A lamp needs generation, wiring, compatible fittings and maintenance.

Investment and institutions organize supply. Price and location affect access.

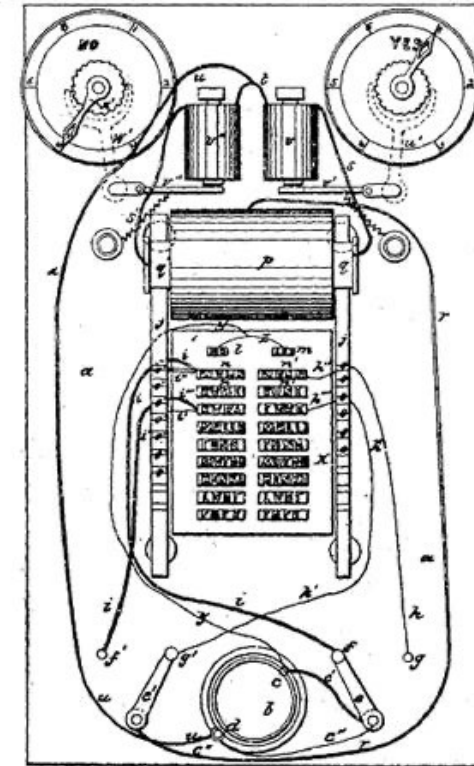
The invention becomes socially important through this continuing arrangement.

Edison: experiments beyond the lamp

Vote recording, telegraph improvements and stencil copying addressed communication and office work.

Ore separation and cement production connected invention with large industrial processes.

Some technically interesting projects proved commercially disappointing.



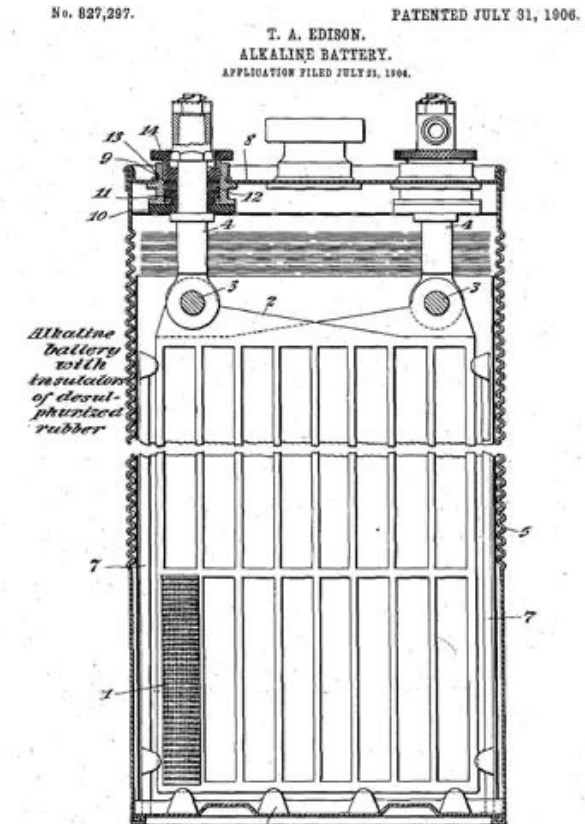
Edison vote-recorder patent illustration

Energy research and storage

Edison investigated direct conversion of coal into electricity during the 1880s.

His nickel–iron alkaline battery became a useful storage technology.

Experimental promise, safety and commercial success were separate questions.



Edison alkaline storage-battery patent illustration

Further reading

Joel Mokyr, The Second Industrial Revolution, 1870–1914.

Science and Technology in World History: nineteenth-century industry and science.

Edison Papers, museum collections and regional histories linked in the reading.