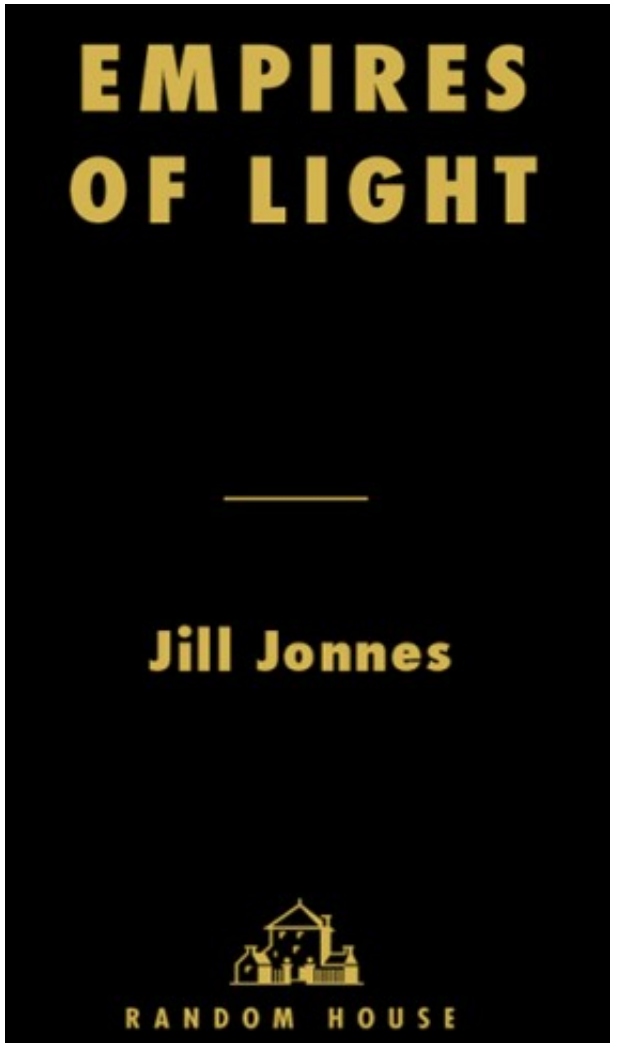
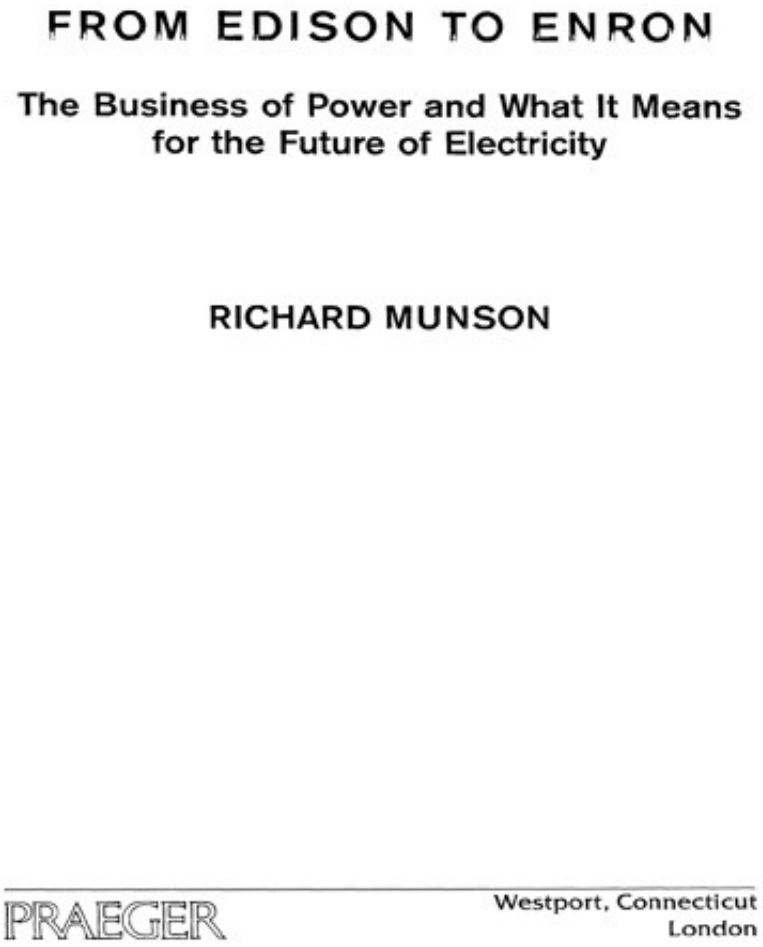
ETM521

Lecture 2 – Historical Developments

Barış Sanlı

Resources


EMPIRES
OF LIGHT
Jill Jonnes
RANDOM HOUSE

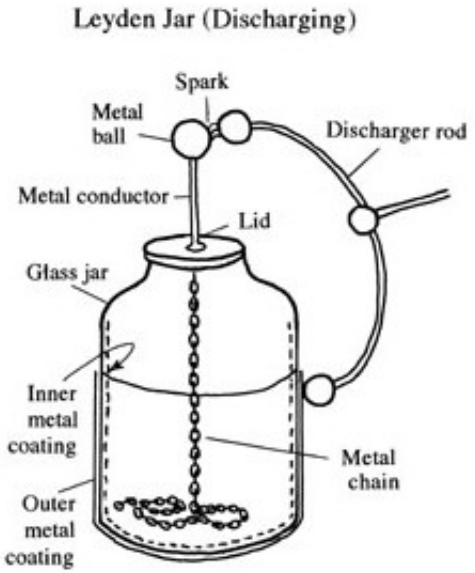

FROM EDISON TO ENRON
The Business of Power and What It Means
for the Future of Electricity
RICHARD MUNSON
PRAEGER
Westport, Connecticut
London

Why history?

- Knowing historical context and pathways
- History does not repeat itself, but it rhymes (Mark Twain)
- Markets can be made but not happen overnight
- Regulation changes when technology changes

Leyden Jar

- Lawyer Andreas Cuneus, 1746
- Filling a jar with water and electrifying it by touching a wire sitting in the water with an electrified glass vial
- Electricity generated by electrostatic machines charged metal foil and water



Louis XV

- For amusement
- 180 gendarmes in a big circle in Grande Gallerie
- Holding next man’s hand
- Surprised by the shock
- King and his men found the leaping gendarmes both marvelous and hilarious

Benjamin Franklin

- 1744 saw in Boston, Electrified Boy experiment
- 1747 wrote “I never before was engaged in any study”
- To a friend in London “If there is no other use discovered of electricity, this however is considerable, that it may make a vain man humble.”
- Hundreds of experiments
- 1749, “A turkey is to be killed for our dinner by the electrical shock, and roasted by the electrical jack, before a fire kindled by the electrified bottle; when the health of all the famous electricians in England, Holland, France, and Germany are to be drank [sic] in electrified bumpers, under the discharge of guns from the electrical battery.”

Lightning

- Franklin suspected lightning was simply a massive jolt of electricity
- 1750, proposed tall pointed metal poles to conduct the lightning down to ground
- Lightning could be collected into Leyden jars
- While trying to kill a turkey with electricity shocked himself: a universal blow throughout my whole body from head to foot
- 1752, kite experiment
  - the loose threads of the hempen string rising as if electrified
  - Once the string was wet, the electricity from the passing lightning storm flowed steadily down it

Benjamin Franklin

Benjamin Franklin conducting his kite experiment to demonstrate that lightning is electrical. Note Leyden jar at boy's feet, to be charged from kite key.

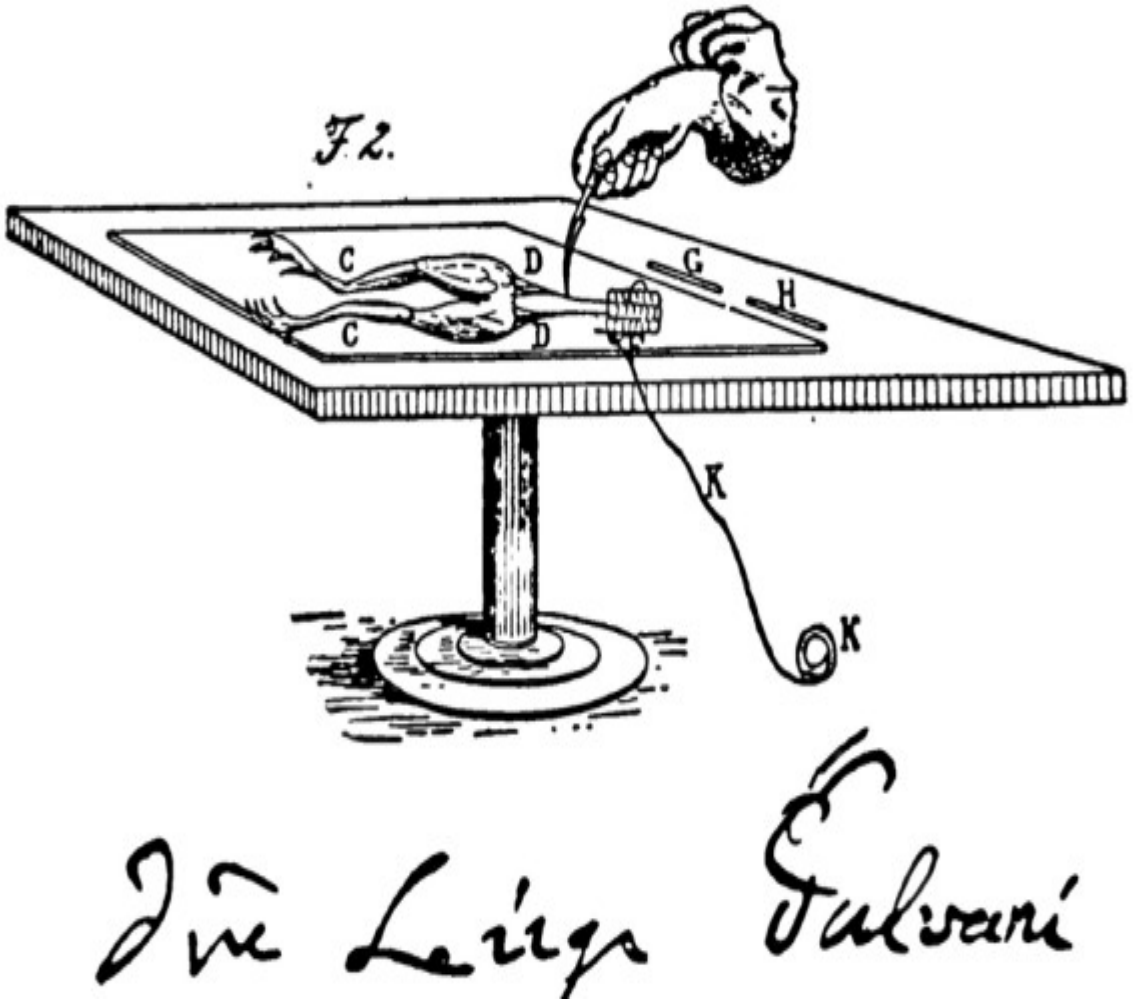
Experiment with Lightning

- 1752, May 10 French stored lightning in jar
- 1753, Georg Richman, a Swedish scientist in St Petersburg tried to replicate, electrocuted

Galvani and Volta

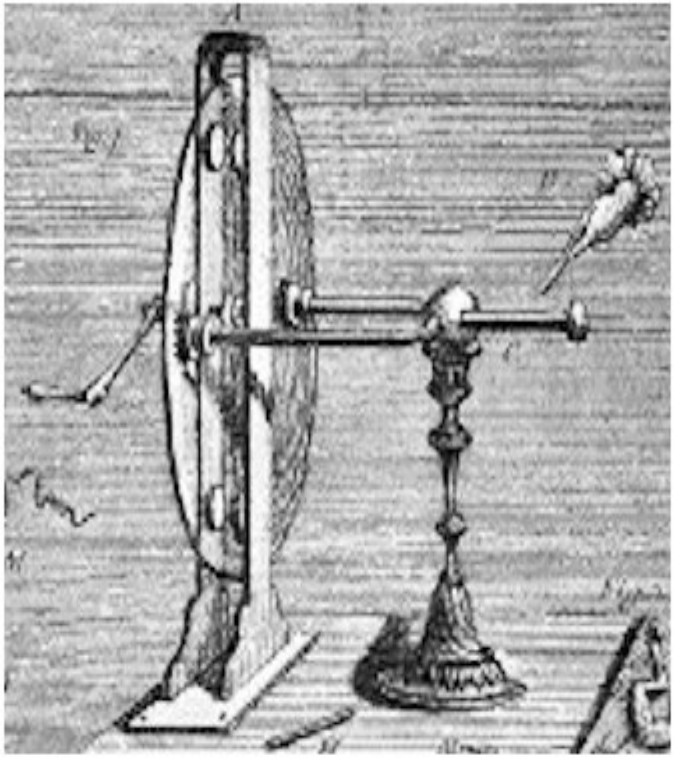
- Luigi Galvani, University of Bologna, physician and anatomist
- Alessandro Volta, University of Pavia, prof of physics
- Galvani -> role of electricity in the workings of the body’s nerves and muscles
- Volta-> looking at the basic nature of electricity and its chemical reactions

Galvani



Dr Luigi Galvani

Galvani



Galvani's Dollond electrical machine. Hand at upper right demonstrates how to elicit a spark.

Galvani and the frog

- 26 Jan 1781, Galvani while dissecting a large frog's leg. Nearby an electrostatic machine turned on.
- When touched leg jerked
- "I immediately repeated the experiment. I touched the other end of the crural nerve with the point of my scalpel, while my assistant drew sparks from the electrical machine. At each moment when sparks occurred the muscle was seized with convulsions."
- "animal electricity"
- Published papers 1791, "On the Effect of Electricity on the Motion of the Muscles."

Volta

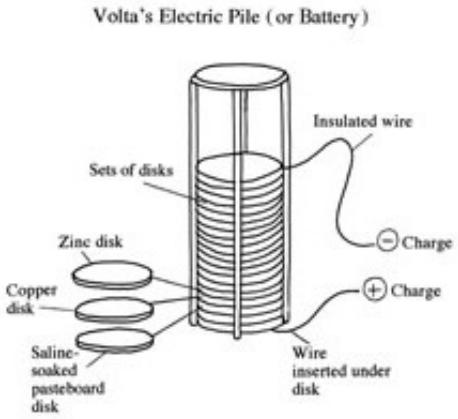
- Already inducted into Royal Society, son of a nobleman
- Condensing electroscope that measured charge
- First applauded “fine and grand discovery of animal electricity”
- 1794, he was convinced electricity was actuall metallic.... “animal versus metallic electricity”

Napoleon

- 1796 Napoleon Bonaparte
- Luigi Galvani refused to oath to new government
- Expelled in April 1798 from Unversity, died in December penniless
- Volta, accepted and contiued as professor

Volta continued experimenting

- Tested dissimilar metals and measured charges with his electroscope
- Effect was stronger when he touched the metals, “effect of saline moisture”
- 1800, March 20, wrote a letter to president of Royal Society “no apology... electricity excited by the mere mutual contact of different kinds of metals”
- Copper and zinc disks seperated by pasteboard soaked with salt water



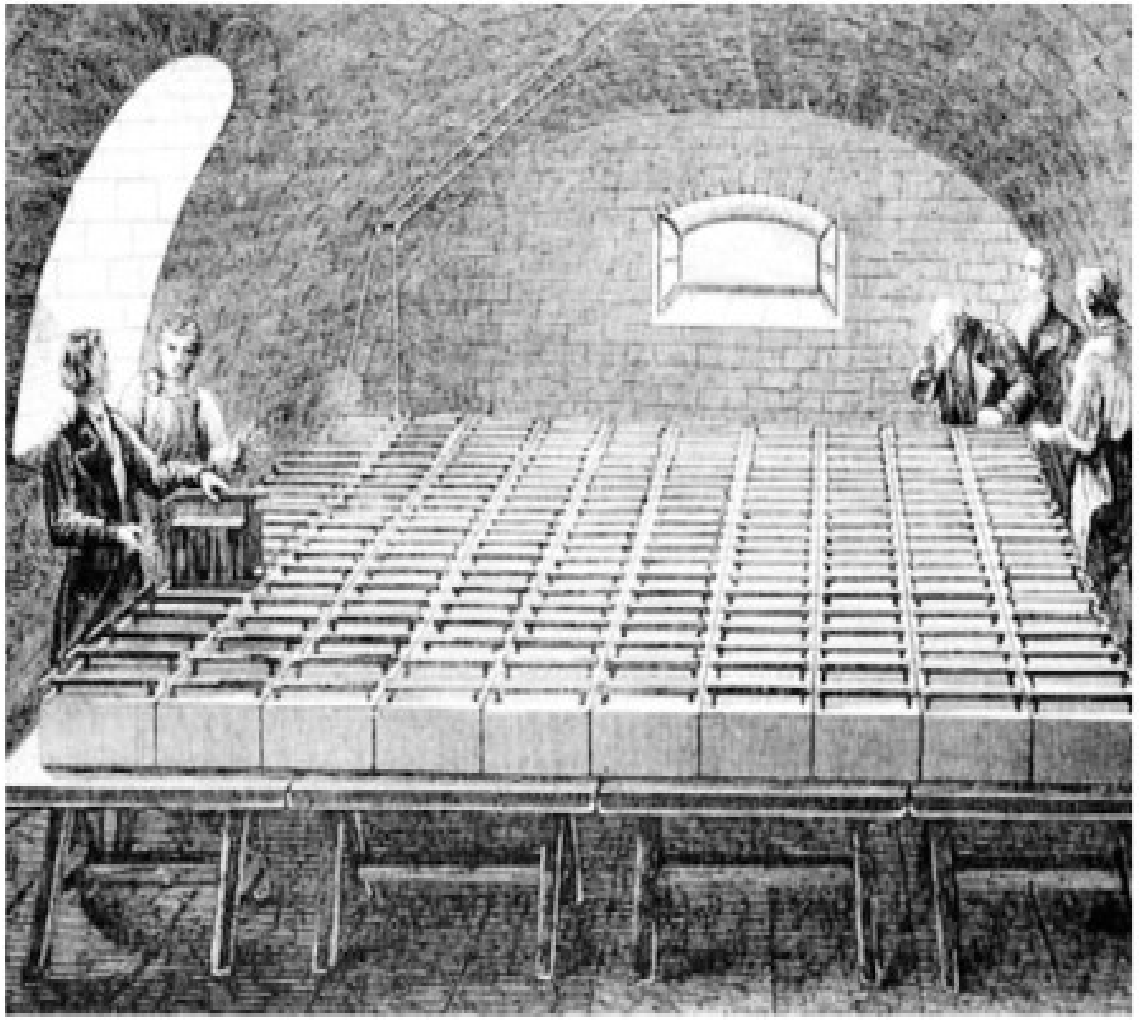
Battery

- Letter reached Royal Society 26 June 1800
- Battery is declared : “the most wonderful apparatus that has ever come from the hand of man, not excluding even the telescope or the steam engine.”
- Volta’s electrical pile
- Steady current of electricity is known as Galvani

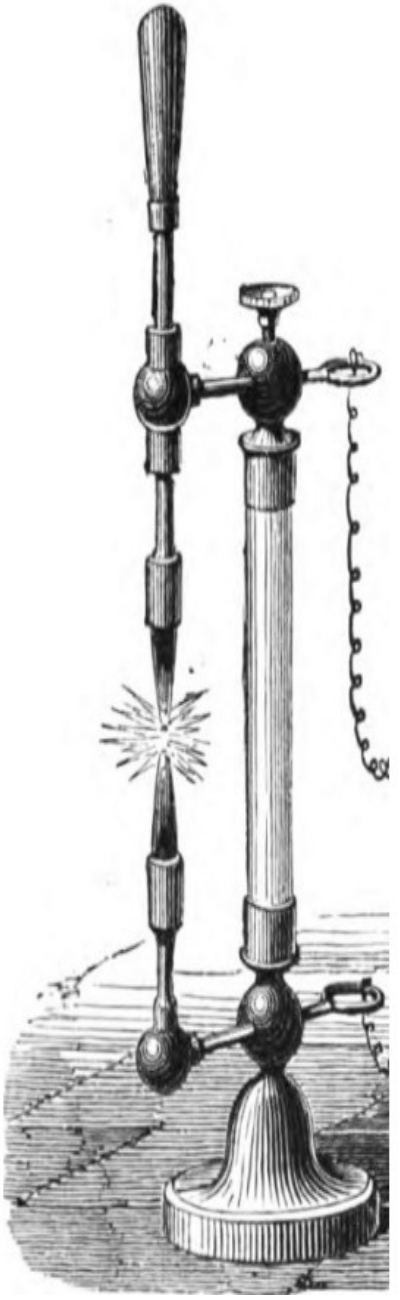
Humphry Davy

- Chemist
- October 1807, demonstrated compounds could be decomposed into thei basic elements by electricity
- Alkalies -> potash and soda ash... entirely new elements potassium and sodium
- Later more new elements
  - Magnesium, calcium, barium, strontium

Humphry Davy – Battery, 1809



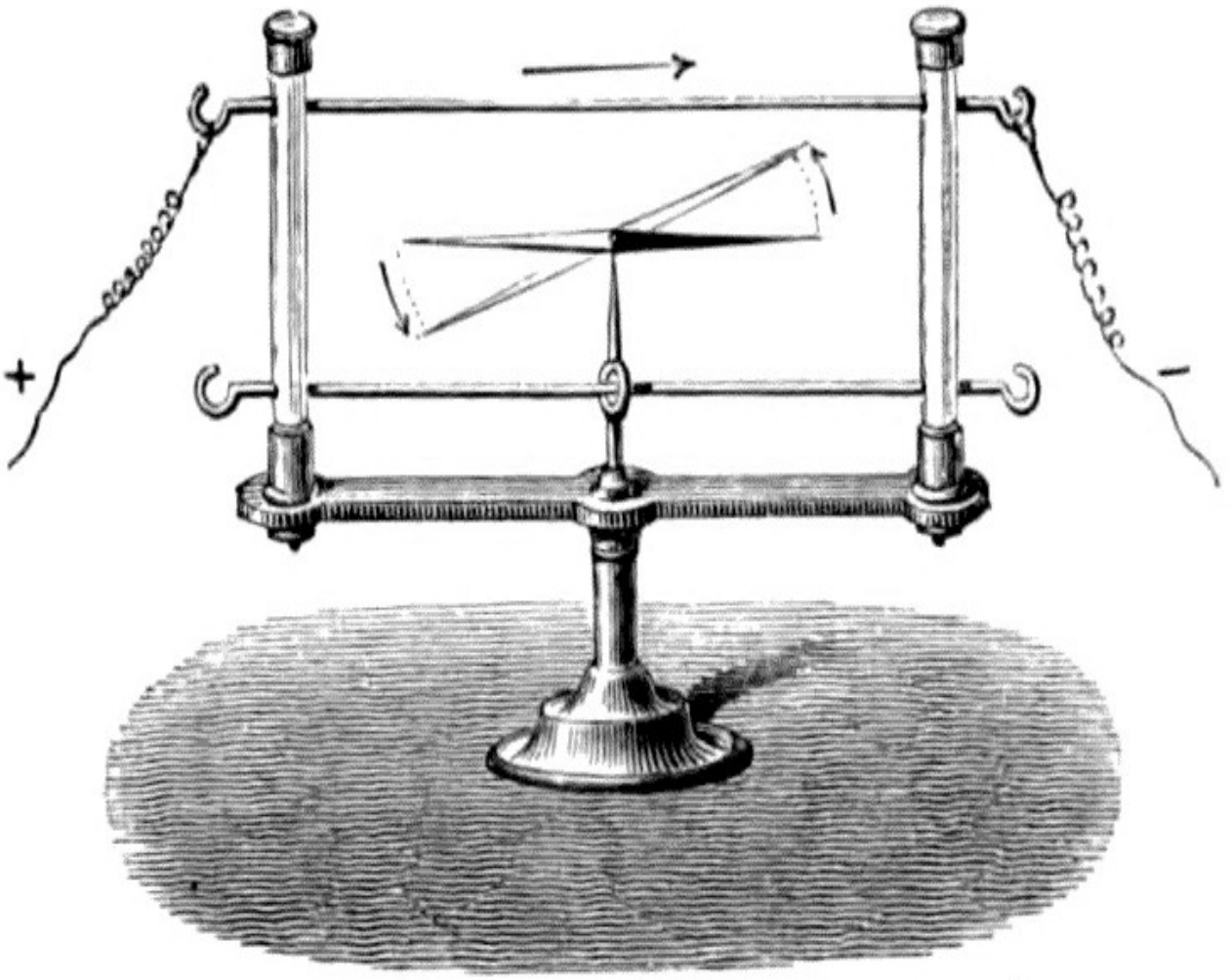
The two-thousand-cell Davy battery assembled in the basement of the Royal Institution.



Oersted

- 1820 Spring, Hans Christian Oersted, physics prof at the Uni of Copenhagen during a lecture
- A small Voltaic Battery
- Intended to heating platinum wire by electricity
- Wildly swinging magnetic needle
- He moved wire around and needle responded strongly as if to a magnet
- Strived to establish relationship between magnetism and electricity
- Needle right angle to charged wire

Oersted



Oersted's historic experiment demonstrating an electric field deflecting a magnetic compass.

Electromagnetism

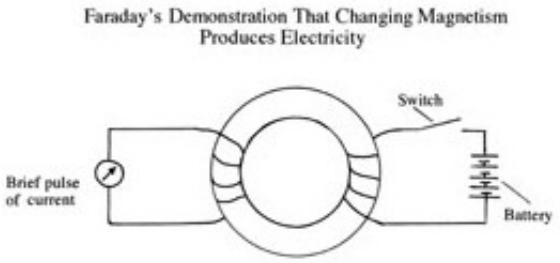
- 21 July 1820, Oersted announced “electromagnetism” in a four page paper in latin
- Experiments on the effect of an electric current on the magnetic needle”
- Parisian prof of math Andre Marie Ampere read the experiment and was sceptical
- Replicated experiment
  - Strength of the magnetic field intensified with the rise of the electric current
- More powerful electromagnets

Faraday

- Education ended at age 12. Apprenticed for 7 years to a bookbinder
- A customer gave him the tickets to Humphry's highly popular series "The elements of Chemical Philosophy"
- He took extensive notes, compiled an index, bound it together into a book
- Wrote to Humphry
- Impressed by 22 year old Faraday, hired as assistant

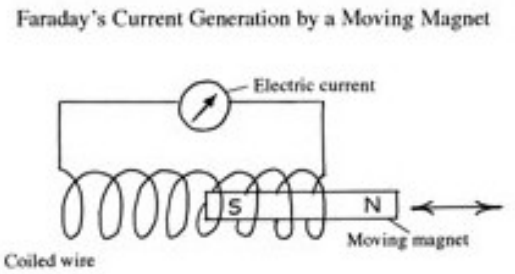
Faraday

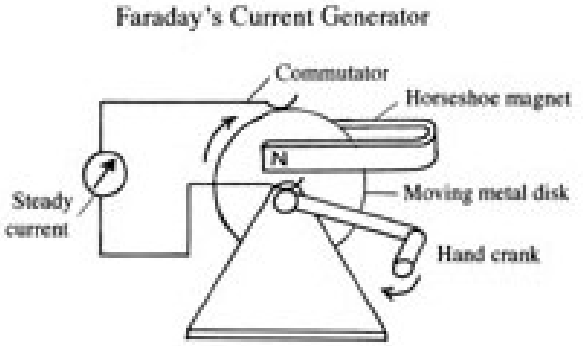
- 1822 wrote to lab book “Convert magnetism into electricity”
- 1824 became a Fellow of the Royal Society
- At 33, appointed director of the Royal Ins. Lab.
- 29 August 1831
  - Only on/off generated charge



Electricity by magnets

- Electric current is set up in a closed circuit by changing magnetic field
- 24 Nov 1831, world's first electric dynamo as "A new electrical machin to Royal Society
- Resolved long debate electricity produced by lightning, electrostatics batteries, and generator are the sam invisible entity.





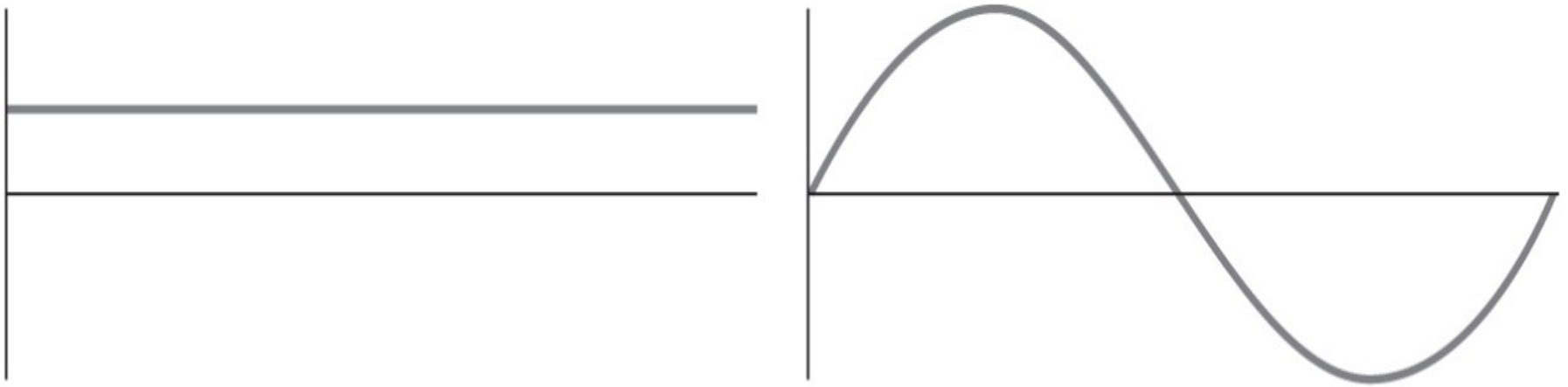
First applications

- Improving batteries
- 1840, a workable telegraph
- But gas was popular, 1875 there were more than 400 gas lighting companies in US
- Arc lighting : “One could in fact have believed that the sun had risen. This illusion was so strong that birds, woken out of their sleep, began singing in the artificial daylight.”
- Battery 20 times more expensive than supplied by steam engines

Generator and motor

- Early 1870s Belgian engineer Zenobe-Theophile Gramme designed a powerful direct current generator also an electric motor
- Advance of Werner von Siemens.. used electromagnet instead of regular magnets
- With dynamo, 1876 Russian military engineer Paul Jablochkoff came with a Jablochkoff candle
  - More gentle, carbon sticks seperated by kaolin cement, runs for 16 hours
- 1878 half mile of avenue de l'Opera – arc lighting

DC/AC



DIRECT CURRENT

ALTERNATING CURRENT

Two kinds of electric current. The midlines indicate zero charge, with positive above and negative below.

Enter the Edison

- Edison’s long time friend Prof George Barker
- Tried but no effect of interest in Edison
- First dynamo designed by Americans, Farmer and Wallace
- Barker escorted Edison to Wallace’s brass foundry
- 8 horsepower electric dynamo, “telemachon”
- Edison : “I believe I can beat you making the electric light. I do not think you are working in the right direction.”

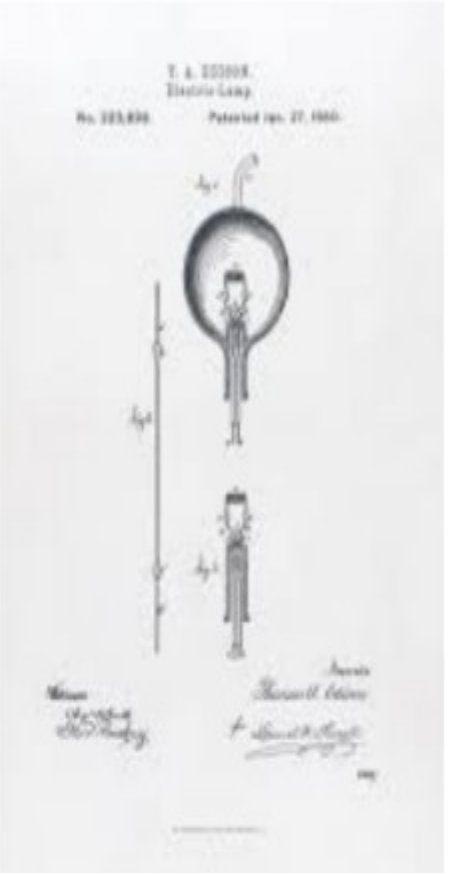
Electric car

- Scottish Robert Anderson, 1834-1835 first electric transportation
- 1842 no charging
- 1865 French Gaston Plante lead-acid battery
- 1879 First gas engine Carl Benz
- 1914 Ford

> Within a year, I hope, we shall begin the manufacture of an electric automobile. I don't like to talk about things which are a year ahead, but I am willing to tell you something of my plans.
>
> The fact is that Mr. Edison and I have been working for some years on an electric automobile which would be cheap and practicable. Cars have been built for experimental purposes, and we are satisfied now that the way is clear to success. The problem so far has been to build a storage battery of light weight which would operate for long distances without recharging. Mr. Edison has been experimenting with such a battery for some time.

How it all started

- Edison – Menlo Park - Light
- Oct 21, 1879 for 40 hours
- For several week silence
  - To design generator
- New York Herald
- Gas company securities plummetted

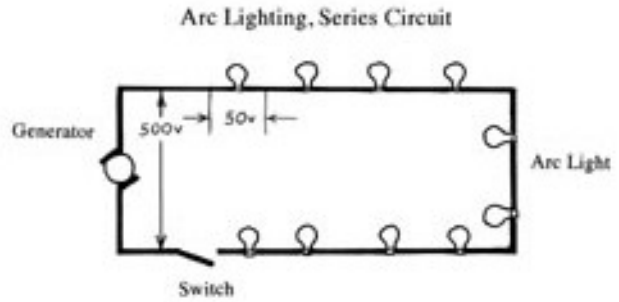


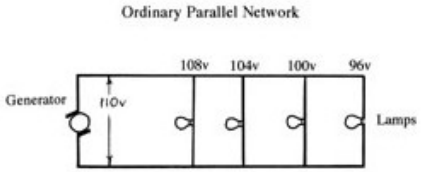
September 16, 1878, New York Sun, EDISON’S NEWEST MARVEL. SENDING CHEAP LIGHT, HEAR, AND POWER BY ELECTRICITY”

Early steps

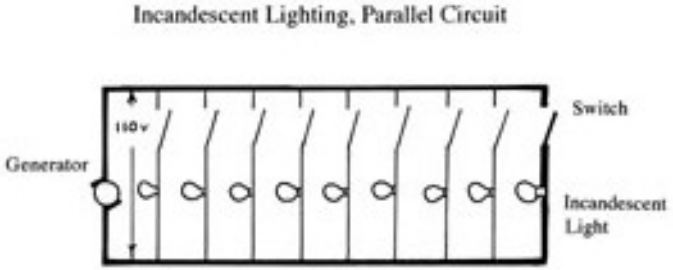
- Dec 1880, created EEI
- Pearl Street, 4 Sept 1882
- 1890, 30 firms manufactured lambs
- JP Morgan's own experience
- "sun's only rival"
- "My electric light inventions have brought me no profits only 40 years of litigation"

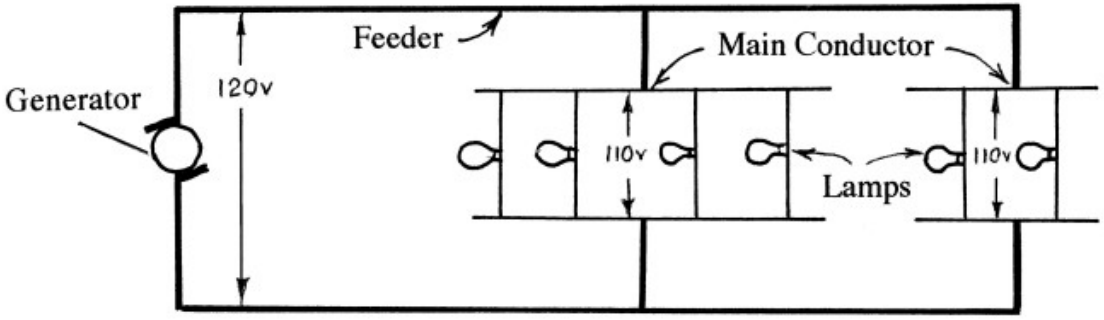
Edison’s Network





Edison’s Feeder Main Network





- Twenty electric light, telephone, telegraph companies seperate wires on poles
- Edison was a team: Samuel Insull (personal sec), Frank Sprague (Mathematician), Tesla
- Tesla working in Edison telephone company in Yugoslavia “His ideas are splendid, but they are utterly impractical”
- Tesla -> Westinghouse

War of Currents

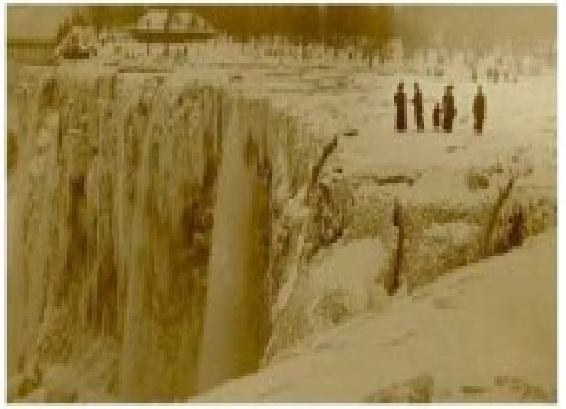
- Edison DC, Westinghouse AC
- AC -> effective transformer and motor
- DC -> generation should be close by
- By 1888 Edison & Westinghouse
- Edison : “AC is dangerous”, electromorty, “Westinghoused”
- Westinghouse “125 central stations of leading direct current company... numerous fires
- 700 V AC killed horse

Edison General Electric

- 1890 , Edison General Electric
- Financiers, consolidation
- JP Morgan
- General Electric

Niagara

- 1725- first saw mil
- 1891, 17 firms
- 1893, Tesla designed turbines
- 22 miles to Buffalo
- Voltage stepped up from 2000 V from 10000 V.
- Nov 16, 1896

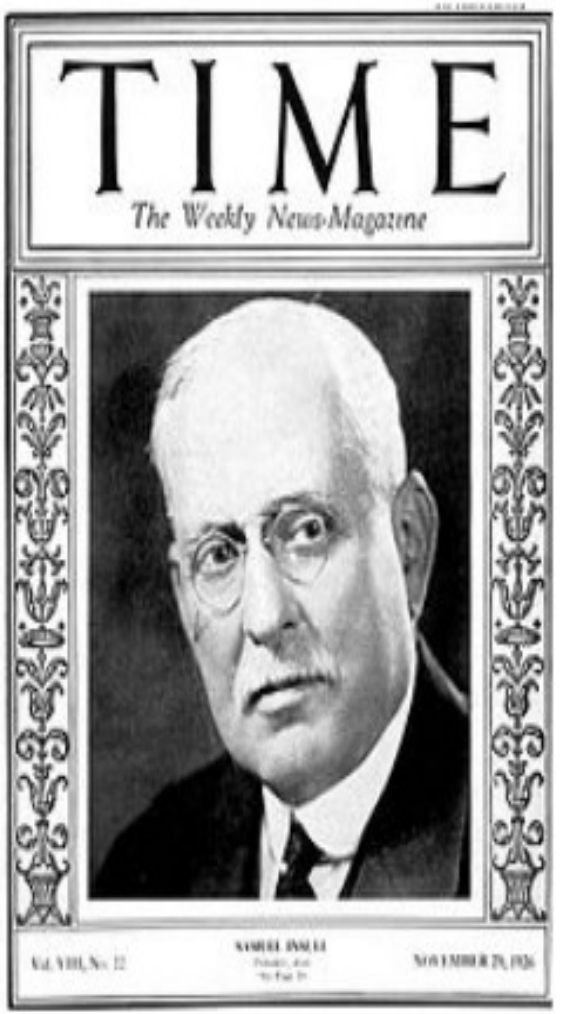


Monopolists

- Different systems
  - DC: 100, 110, 220, 600
  - AC freq: 40,60,66, 125, 133
- Enter Samuel Insull “realized AC enables larger generators”
- Envisioned creating giant monopolies
- Rejected GE’s 36000$ and for $12000 managin g Chicago Edison Company

Samuel Insull

- 1892 – Arrived at CEC
- Shutdown isolated street lighting demand and obtained night time demand
- Acquired coal mines, railroads
- 189 apartments 68.5 kW
- At any time max demand 20 kW
- Central power 20 KW will be enough



- 1912 , selling off-peak for half cent/kWh
- Charge according to consumption
- Selling lighting to marketing electricity
- Dual rate structure
- 1912 encompassed 400 communities, served 4 million customers

New Age - Regulation

- 1907, Wisconsin, “first power company regulation”
- Insull : “deal with only one state agency rather than hundreds of city councils”
- Chief proponent of Regulation and Monopoly
- “There is one great advantage that must follow regulation, and that advantage is protection”
- MIT launch first program for electrical engineers 1890

Scandal

- Insull, 1925, supported Frank Smith (head of Illinois Commerce Commission) against McKinley
- Federal Trade Commission (FTC) criticized utilities for “buying” elections, 30 million $ annualy
- New York Governor, Franklin Roosevelt : Insull network “kind of private empire within the nation”
- Sept 1931 – England abandoned gold standard

SEC

- Accused “stock watering and capital inflation, manipulation of subsidies and improper accounting principles”
- Escaped
- 1934 – arrived at New York harbour

Thank you

- For more info

  www.barissanli.com