Lecture 3

The Brief History of Electricity

Ancient Greeks – Static Electricity

The science of electricity has its roots in observation, known in 600 BC that a rubbed piece of amber will attract a bit of straw

Static Electricity (cont.)

Around 600 BC Greeks found that by rubbing a hard fossilized resin (Amber) against a fur cloth, it would attract particles of straw. This strange effect remained a mystery for over 2000 years.

Static Electricity (cont.)

Around 1600, William Gilbert, a physician who lived in London at the time of Queen Elizabeth I and Shakespeare, studied magnetic phenomena; the attraction produced when materials were rubbed.

Coined the word "**electricity**" from the Greek word **electron** meaning amber.

Towards to Electronics

During the 1800s it became evident that electric charge had a natural unit, which could not be subdivided any further, and in 1891 Johnstone Stoney proposed to name it "**electron**."

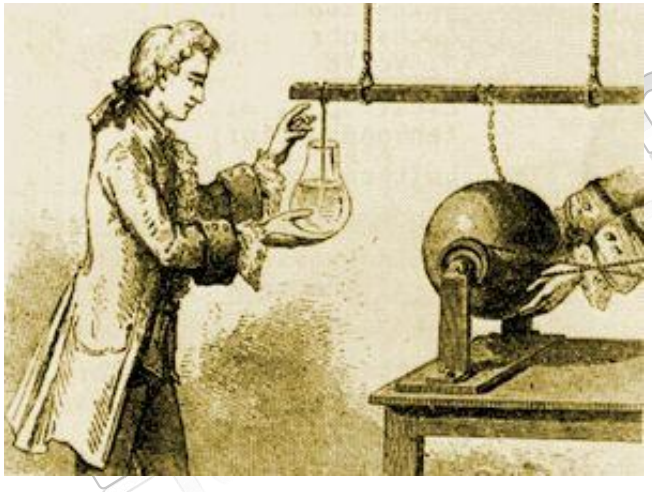
When J.J. Thomson discovered the particle which carried that charge, the name "electron" was applied to it. He won the Nobel Prize in 1906 for his discovery.

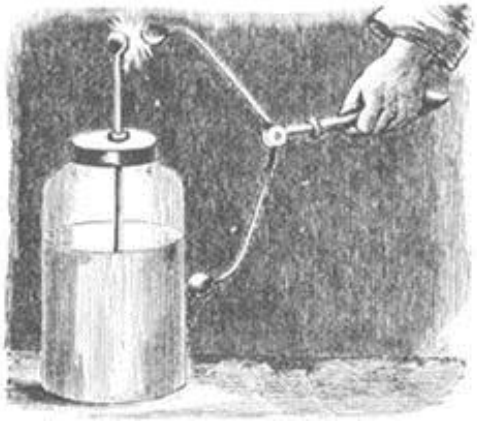
Some Electrical Pioneers

- Pieter van Musschenbroek
- Benjamin Franklin
- Charles Coulomb
- Alessandro Volta
- Hans Christian Oersted
- Georg Simon Ohm
- Andre-Marie Ampere
- Michael Faraday
- Joseph Henry
- James Clerk Maxwell
- Heinrich Hertz
- J. J. Thomson

Pieter van Musschenbroek (1692 – 1761)

Dutch physicist from Leiden, Netherlands, who discovered *capacitance* and invented the *Leyden jar*.





Leyden jar (also called *condenser*)

Benjamin Franklin (1706 – 1790)

Conducted many experiments on static electricity from 1746 – 1751 (including his lightning experiment) and became famous throughout Europe by describing these experiments in a series of letters to Peter Collinson.

Benjamin Franklin (cont.)

In 1752, Franklin proved that lightning and the spark from amber were one and the same thing. This story is a familiar one, in which Franklin fastened an iron spike to a silken kite, which he flew during a thunderstorm, while holding the end of the kite string by an iron key.

When lightening flashed, a tiny spark jumped from the key to his wrist. The experiment proved Franklin's theory, but was extremely dangerous - he could easily have been killed.

Charles Coulomb (1736 – 1806)

Using a torsion balance, Coulomb in 1784 experimentally determined the law according to which charged bodies attract or repel each other.

Coulomb's Law

$$\mathbf{F}_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}^2}\mathbf{e}_{12}$$

$$\frac{1}{4\pi\varepsilon_0} = 10^{-7}c^2 = 9.0\times10^9$$

Alessandro Volta (1745 – 1827)

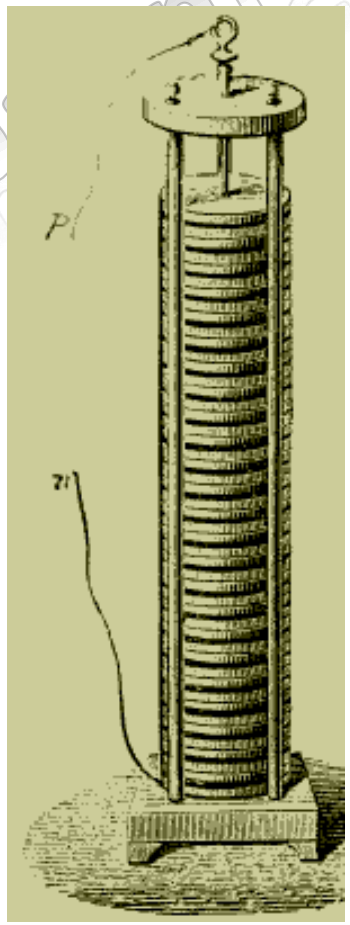
Italian scientist who interpreted another Italian professor of medicine Galvani's experiment. In 1786, Galvani found that when the leg of a dead frog was touched by a metal knife, the leg twitched violently. He thought that the muscles of the frog must contain electricity.

Alessandro Volta, disagreed: he realized that the main factors in Galvani's discovery were the two different metals - the steel knife and the tin plate - upon which the frog was lying.

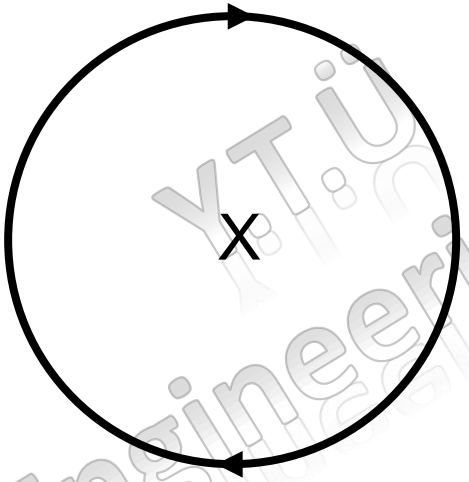
Alessandro Volta (cont.)

Volta showed that when moisture comes between two different metals, electricity is created. This led him to invent the first electric **battery** (**the voltaic pile**) that generated current from the chemical reaction of zinc and copper discs separated from each other with cardboard discs soaked in a salt solution.

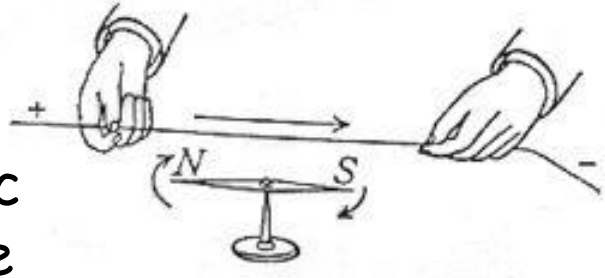
The energy in *joules* required to move a charge of one *coulomb* through an element is 1 *volt*.



Hans Christian Oersted (1777 - 1851)



In 1820 Danish scientist showed that a current produces a magnetic field. an electric current in a wire will affect a compass needle



The unit of magnetizing field (H-field) is Oersted

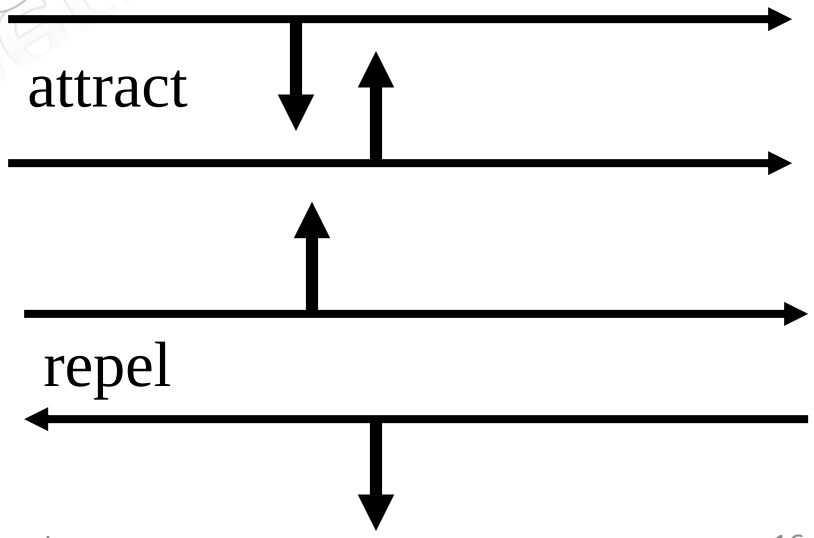
Georg Simon Ohm (1789 – 1854)

A German mathematician and physicist, was a college teacher in Cologne when in 1827 he published, "**The Galvanic Circuit Investigated Mathematically**". His theories were coldly received by German scientists, but his research was recognized in Britain and he was awarded the Copley Medal in 1841. His name has been given to the unit of electrical resistance.

Voltage = Current x Resistance

André-Marie Ampère (1775 – 1836)

French mathematics professor who only a week after learning of Oersted's discoveries in Sept. 1820 demonstrated that parallel wires carrying currents attract and repel each other.



A moving charge of 1 *coulomb* per second is a current of 1 *ampere* (amp).

Michael Faraday (1791 – 1867)

Self-taught English chemist and physicist. Faraday was greatly interested in the invention of the electromagnet, but his brilliant mind took earlier experiments still further. If electricity could produce magnetism, why couldn't magnetism produce electricity?

Michael Faraday (cont.)

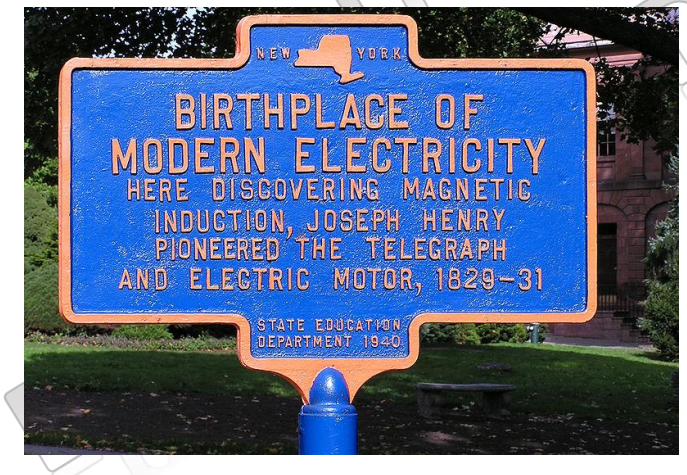
In 1831, Faraday found the solution. Electricity could be produced through magnetism by motion. He discovered that when a magnet was moved inside a coil of copper wire, a tiny electric current flows through the wire. He had discovered the first method of generating electricity by means of motion in a magnetic field.

Faraday's electromagnetic induction ring

A capacitance of 1 coulomb per volt is called a *farad* (F)

Joseph Henry (1797 – 1878)

American scientist, Princeton University professor. He discovered self-induction

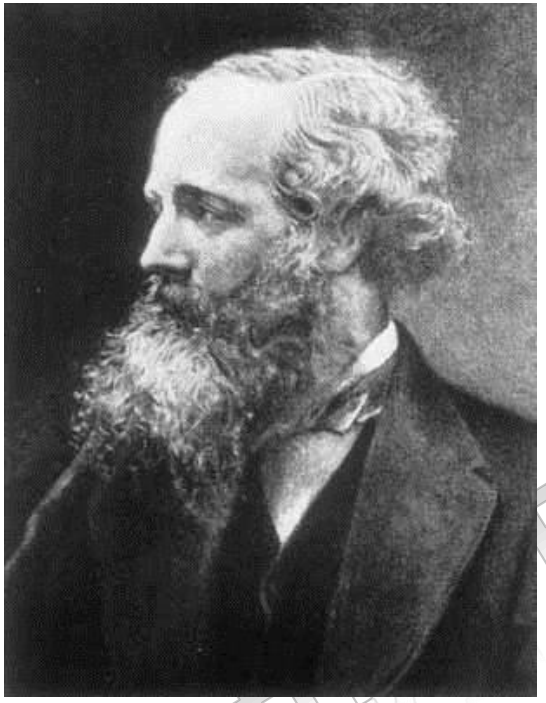


Historical marker in Academy Park (Albany, New York)

Built the largest electromagnets of his day

Unit of inductance, L, is the "Henry"

James Clerk Maxwell (1831 – 1879)



Born in Edinburgh, Scotland;
Taught at King's College in London (1860-1865) and was the first Cavendish Professor of Physics at Cambridge (1871-1879).

Provided a mathematical description of Faraday's lines of force.

Developed "Maxwell's Equations" which describe the interaction of electric and magnetic fields.

James Clerk Maxwell (cont.)

Maxwell's Equations are to electromagnetism what Newton's Laws are to gravity

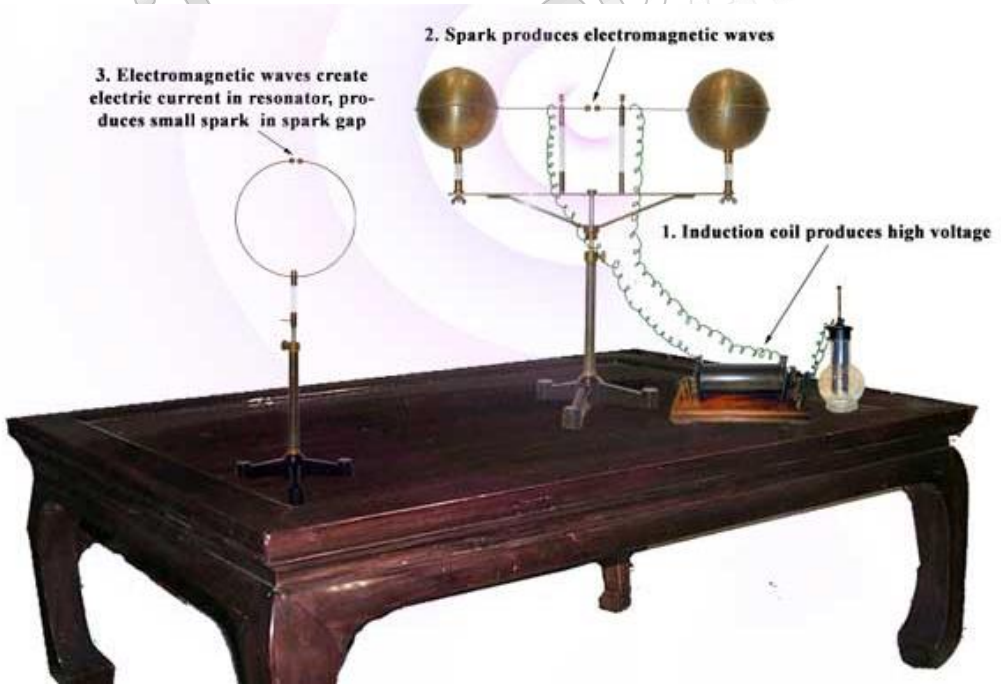
Predicted that light was a form of electromagnetic waves

Let There Be Light--Maxwell's Equations

Heinrich Hertz (1857 - 1894)

Generates and detects electromagnetic waves in 1887

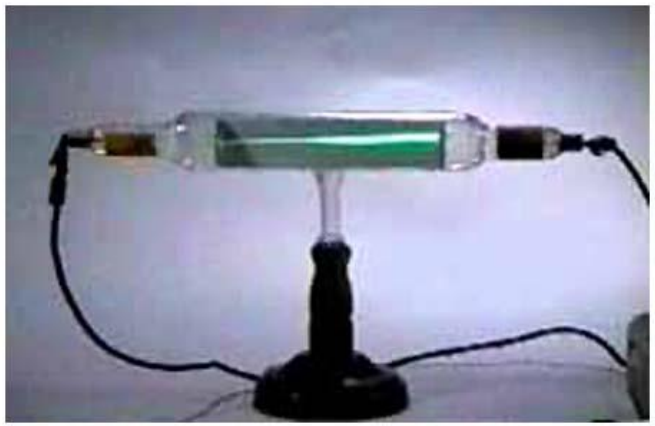

HEINRICH RUDOLF HERTZ
1847 - 1894



The frequency of electrical signals is measured in *hertz* (cycles/second)

Sir Joseph John Thomson (1856 – 1940)

Discovers the electron in 1898



Cathode Tube

J. J. Thomson

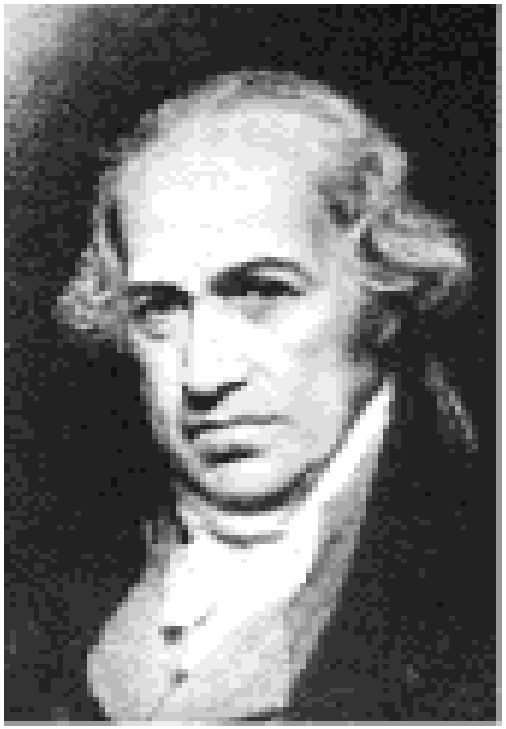
Cavendish Labs

Some Electrical Inventors

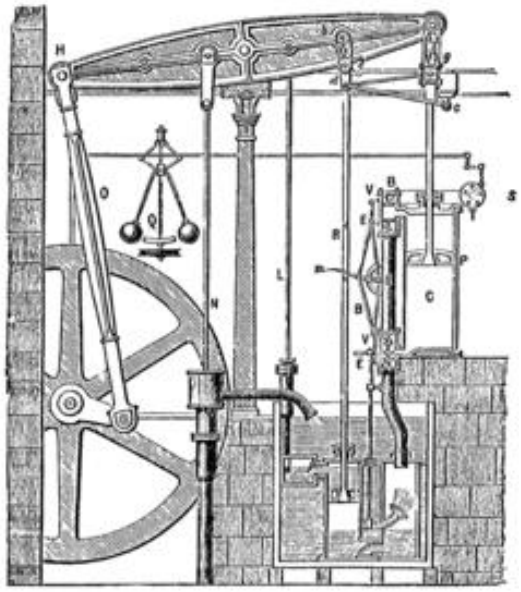
- James Watt (Steam engine)
- Samuel F. B. Morse (Telegraph)
- Guglielmo Marconi (Wireless telegraph)
- Thomas Edison (Electric lights …..)
- Nikola Tesla (A.C. generators, motors)
- John Bardeen, Walter Brattain, William Shockley (Transistor)
- Jack Kilby and Robert Noyce (Integrated Circuit, IC)

Steam Engine

James Watt
(1736 – 1819)



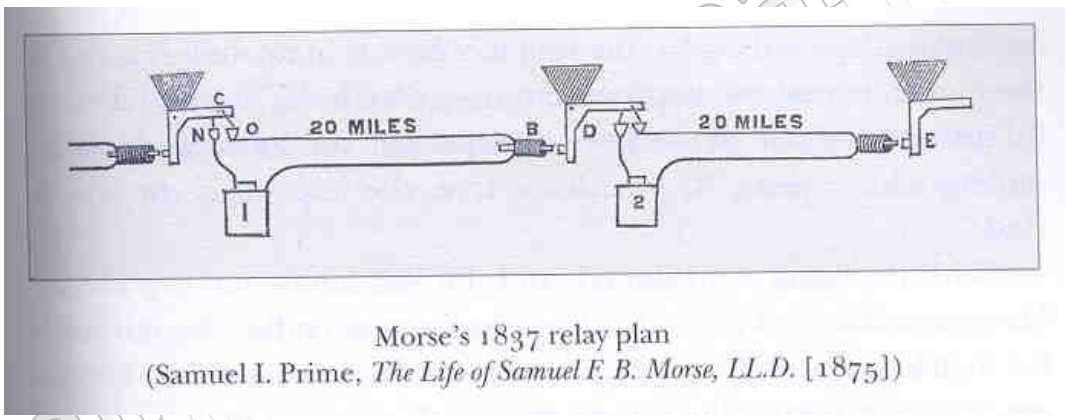
When Edison's generator was coupled with Watt's steam engine, large scale electricity generation became a practical proposition.



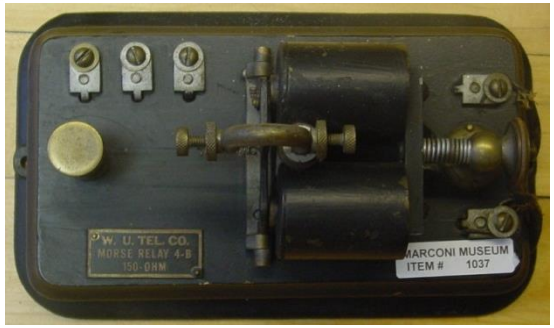
His name was given to the electric unit of power, the *Watt*.

The Telegraph

Samuel F. B. Morse
(1791 – 1872)

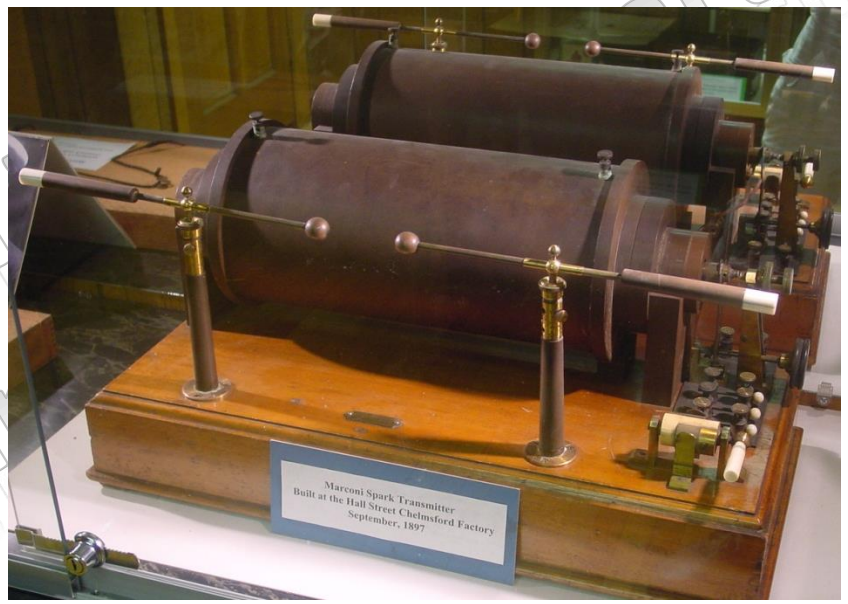


Morse's 1837 relay plan
(Samuel I. Prime, *The Life of Samuel F. B. Morse, LL.D.* [1875])



Wireless Telegraph

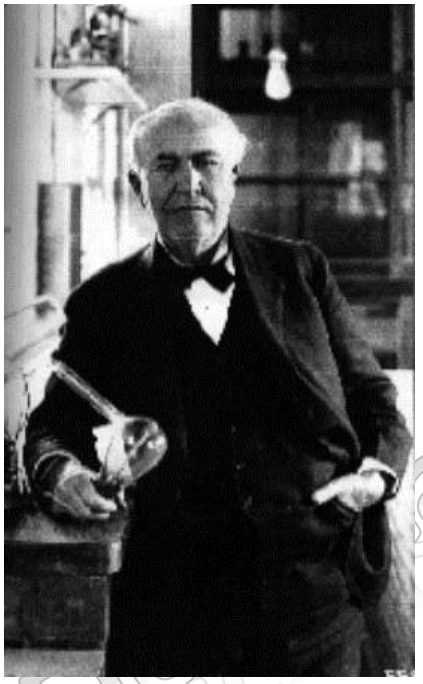
Guglielmo Marconi
(1874-1937)



Marconi Spark Transmitter
Built at the Hall Street Chelmsford Factory
September, 1897

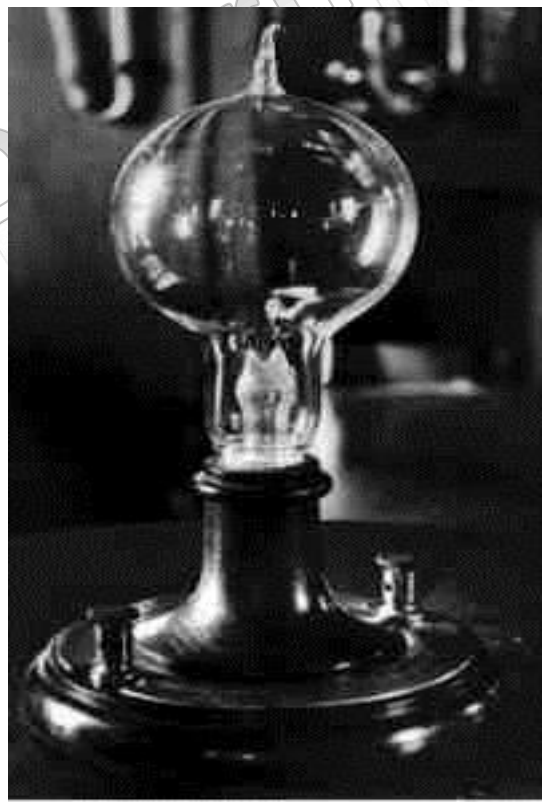
Electric Lights

Thomas Edison
1847 - 1931



Invented and developed complete DC electric generation and distribution system for city lighting systems

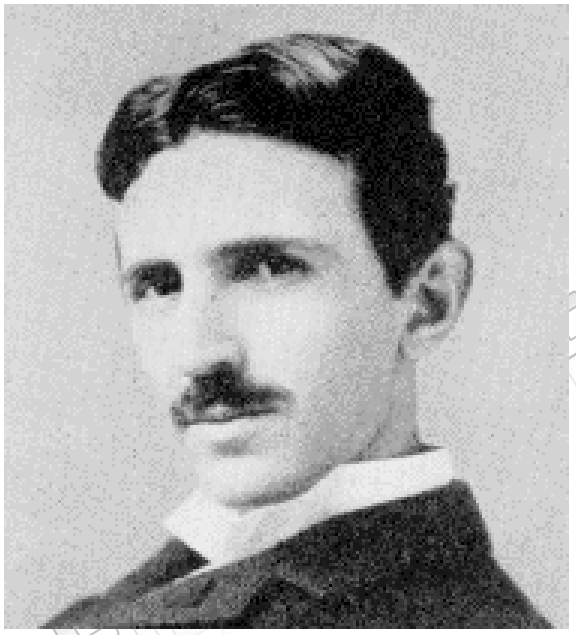
Carried on a major competition with George Westinghouse who developed an AC generation and distribution system



Replica of original lightbulb

Alternating Current (AC) Systems

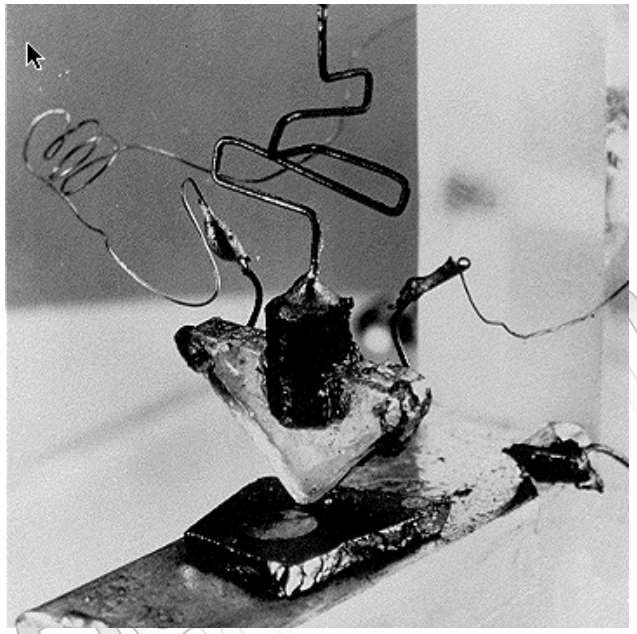
Nikola Tesla
1856 - 1943



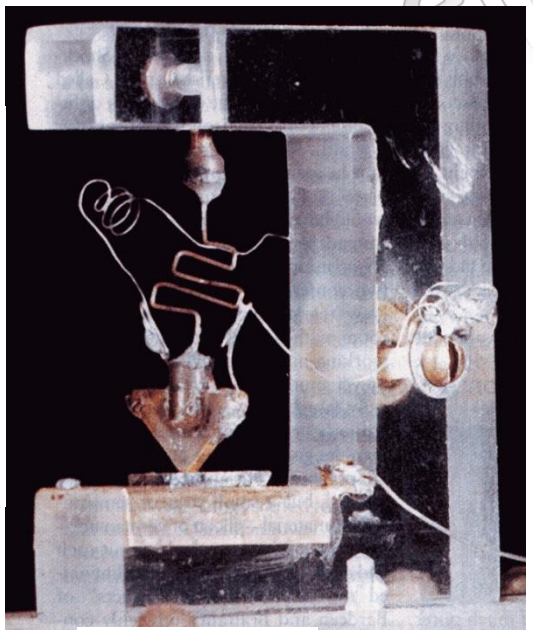
Over 700 patents
- Rotating magnetic field principle
- Polyphase alternating-current system
- Inducton motor
- AC power transmission
- Telephone repeater
- Tesla coil transfromer
- Radio
- Fluorescent lights

Transistor

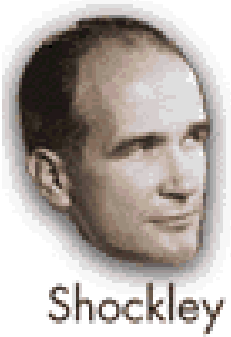
The First
Point-Contact Transistor
1947



Bardeen



Brattain

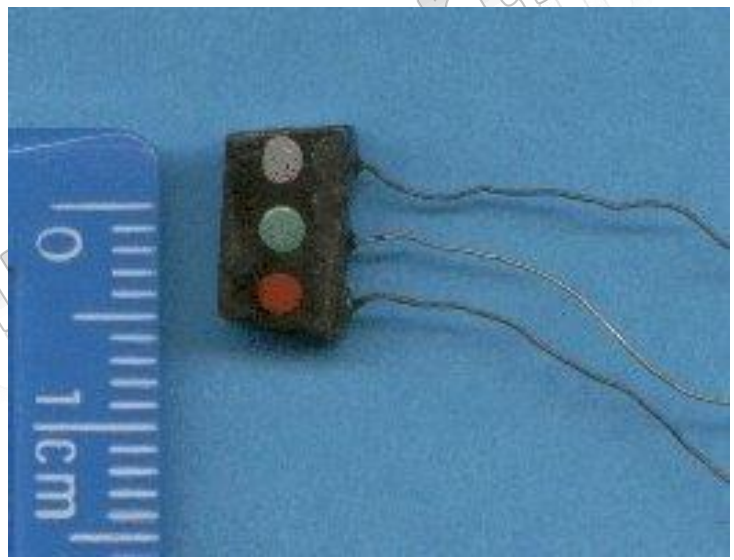


Shockley

Transistor (cont.)

The First
Junction Transistor
1951

Lab model



M1752
Outside the Lab

Integrated Circuit (IC)

Robert Noyce

Jack Kilby

Texas Instrument's First IC -- 1958