



The David Sarnoff Library

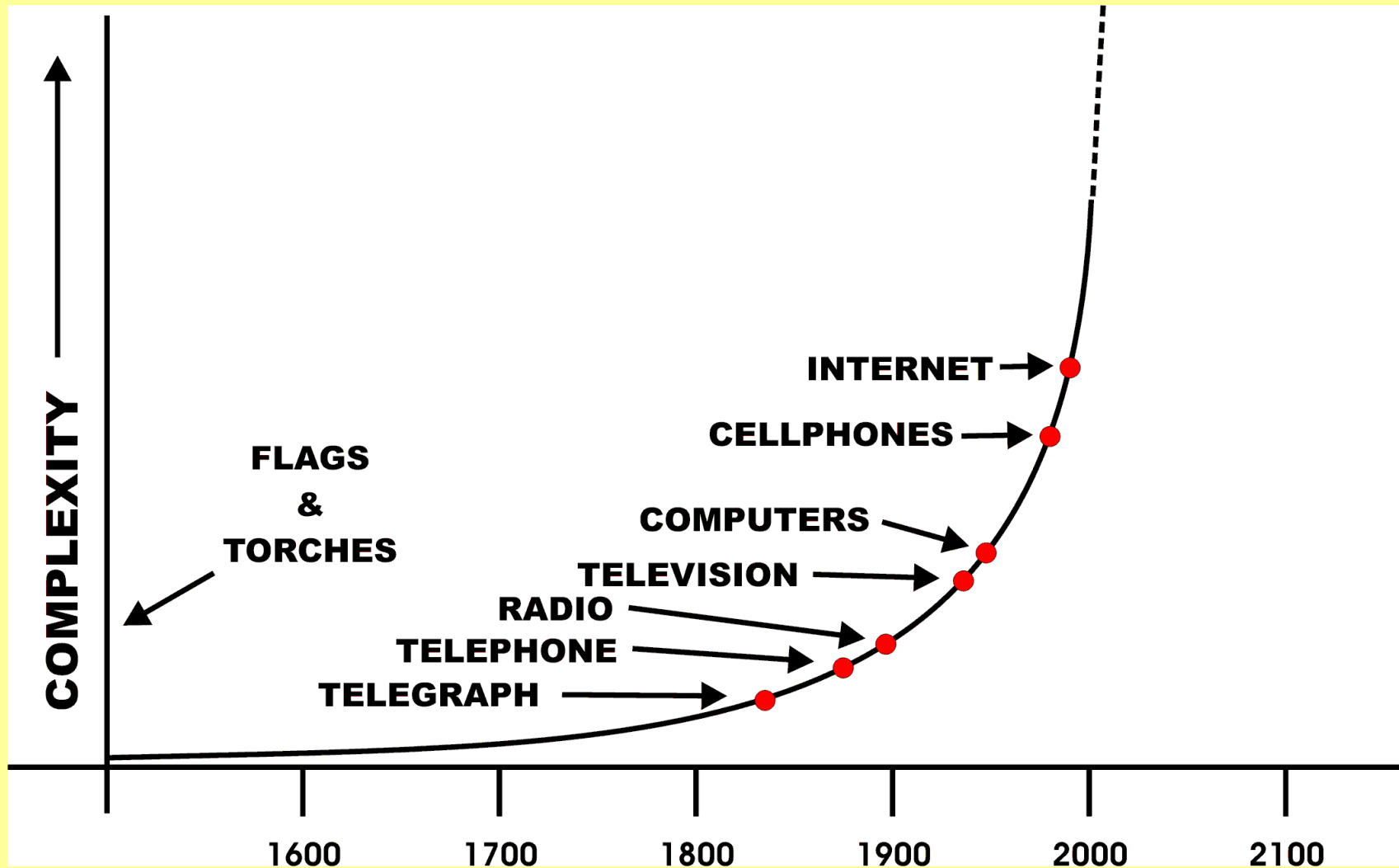
A History of Radio Technology

Demystifying Telecommunications

By: Al Klase

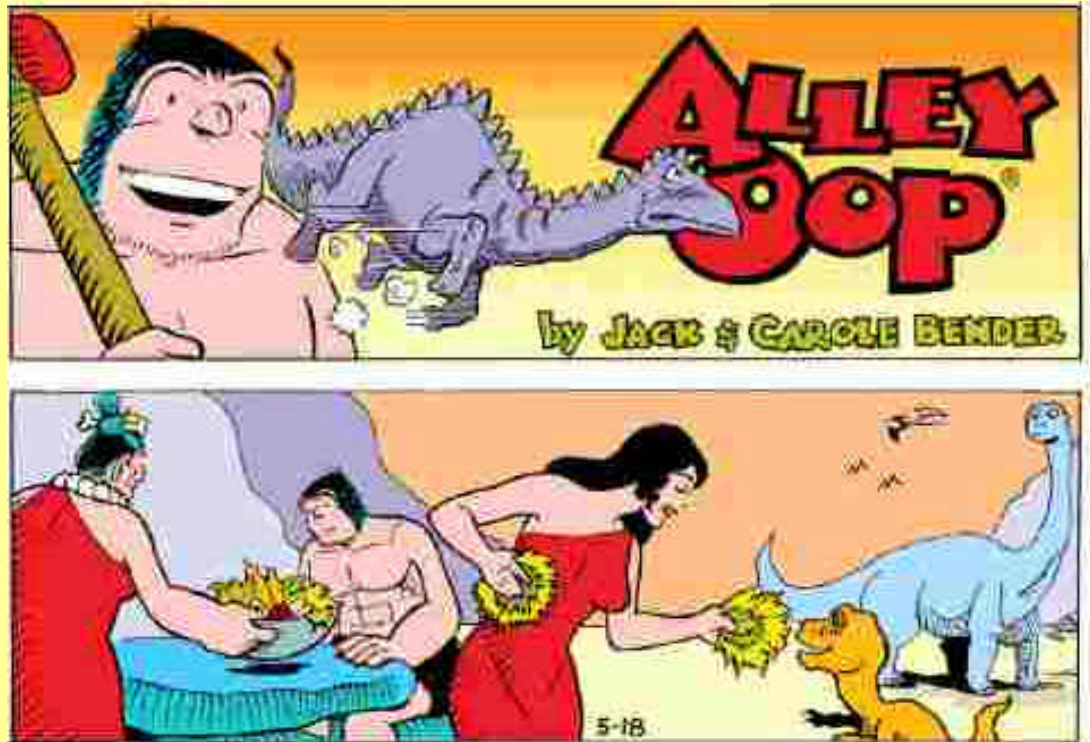


Timeline



A Mysterious Force

- Start at the beginning
- In the Stone Age
 - Sticks
 - Stones
 - Animal Parts

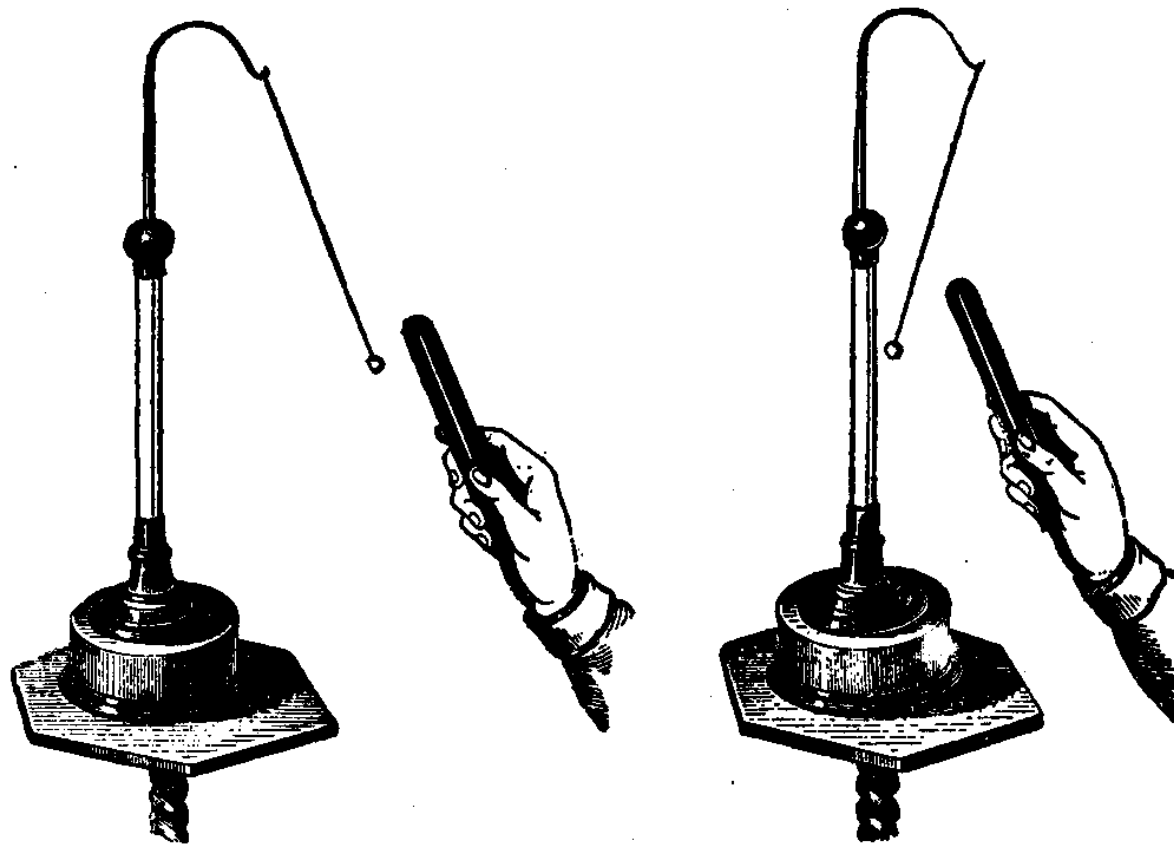


Amber

- Naturally polymerized tree resin
- Greeks called it **elektron**



Electrostatic Experiments



FIGS. 2 and 3.—Pith ball pendulum or electroscope; the figures illustrate also electrical attraction and repulsion.

The Electroscope

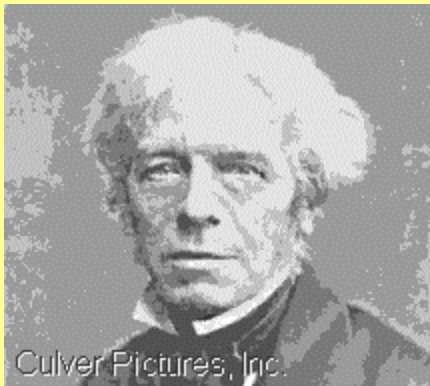
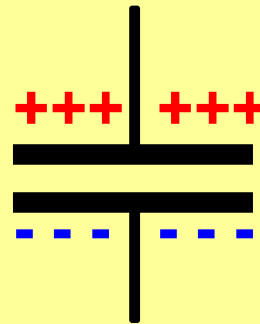


FIG. 11.—Gold leaf electroscope; it consists of two strips of gold foil suspended from a brass rod within a glass jar. Used to detect the presence and sign of an electric charge.

Ca. 1746

The Condenser or Capacitor

Stores Energy as electrostatic charge.

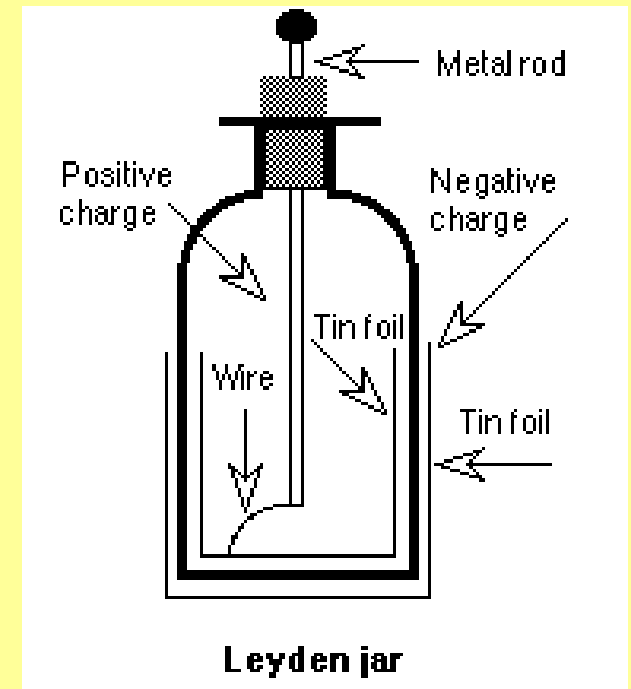


Faraday, Michael
(1791-1867)

$$C = Q / V$$

Q = charge in Coulombs

V = EMF in Volts



Luigi Galvani (1737-1798)

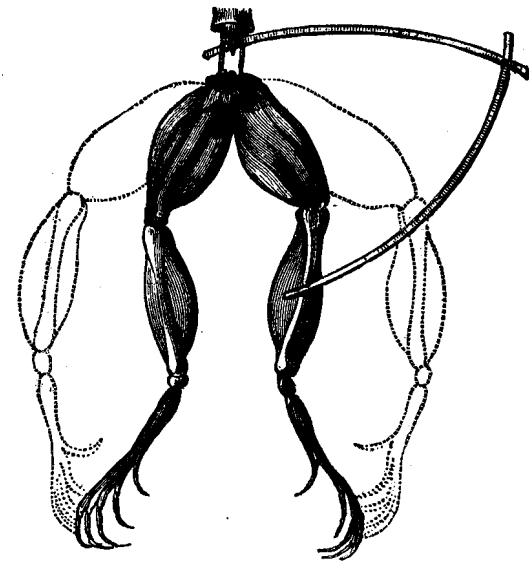
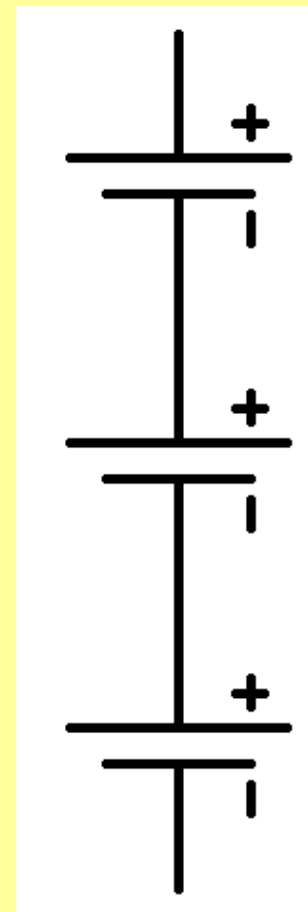


FIG. 92.—Effect of the electric current on a frog's legs; discovered in 1678 by Galvani.

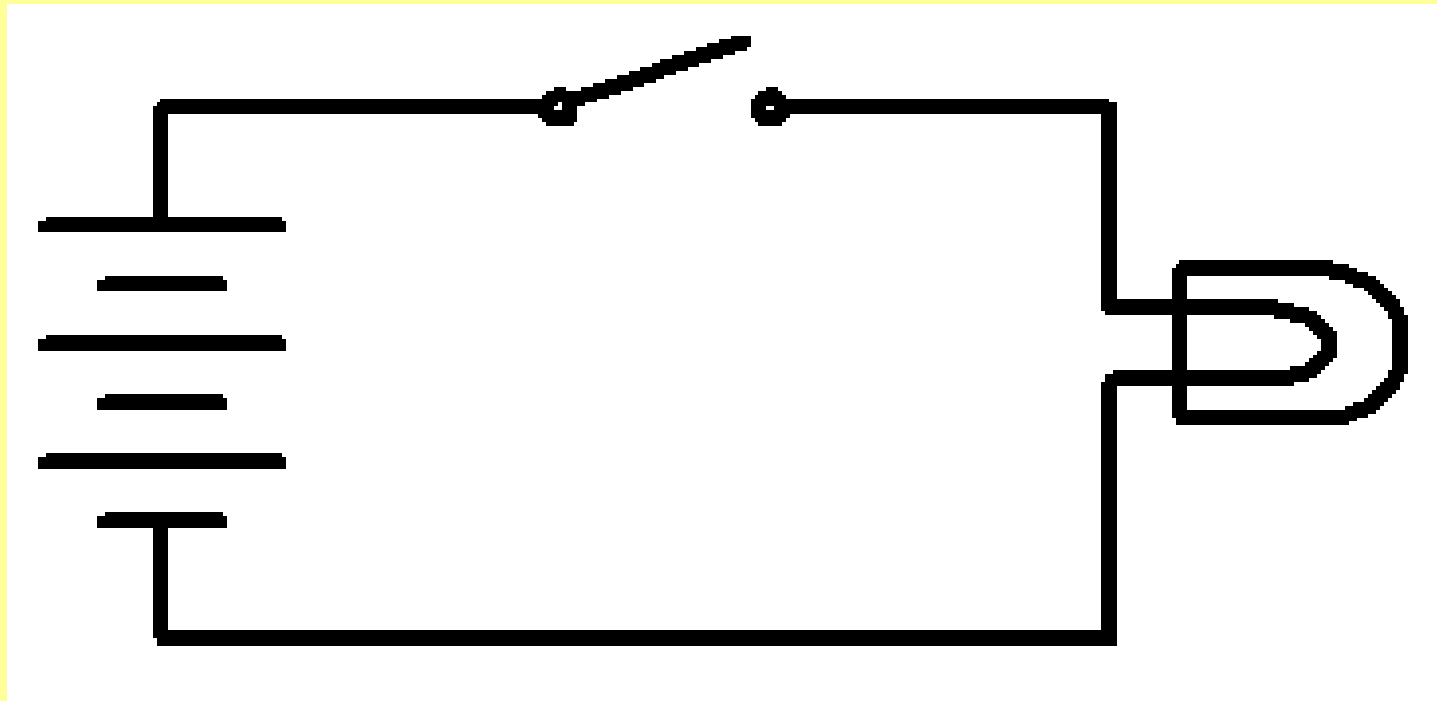
Alessandro Volta (1745-1827)



Ca. 1774



Circuits and Schematics



Yet Another Mysterious Force

- Heavy black rock
- Lodestone
- Proved to be iron ore
- Greeks found theirs in Magnesia



The Compass

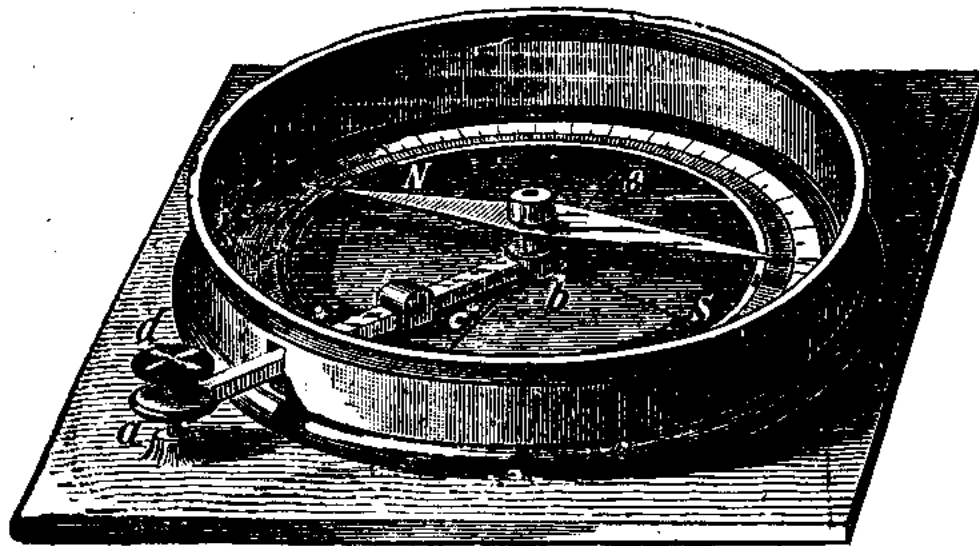
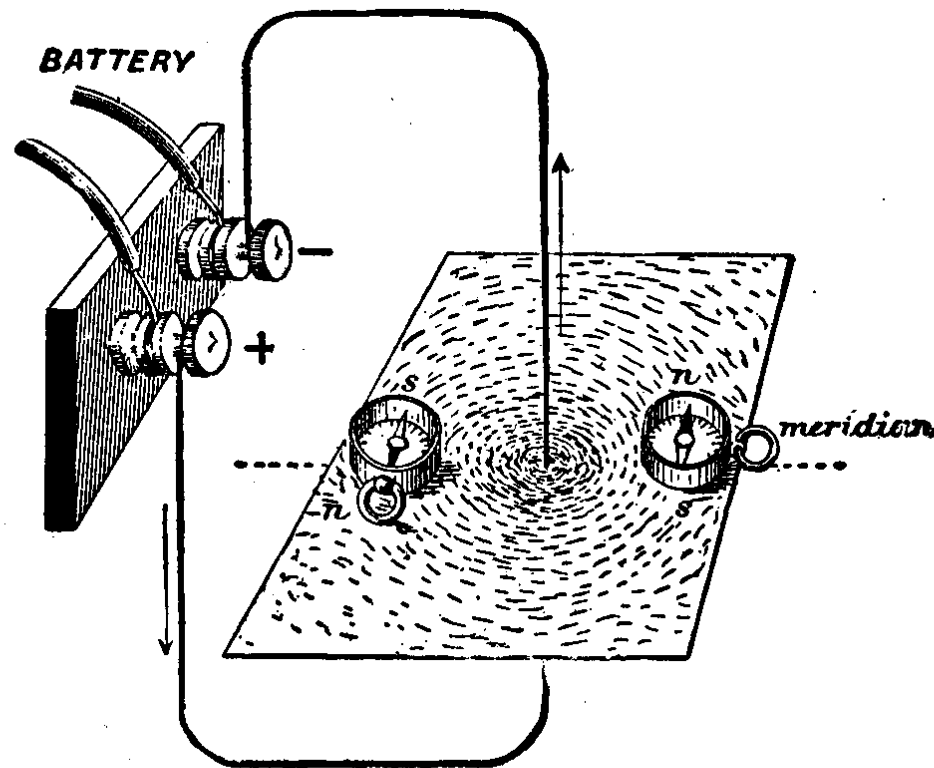


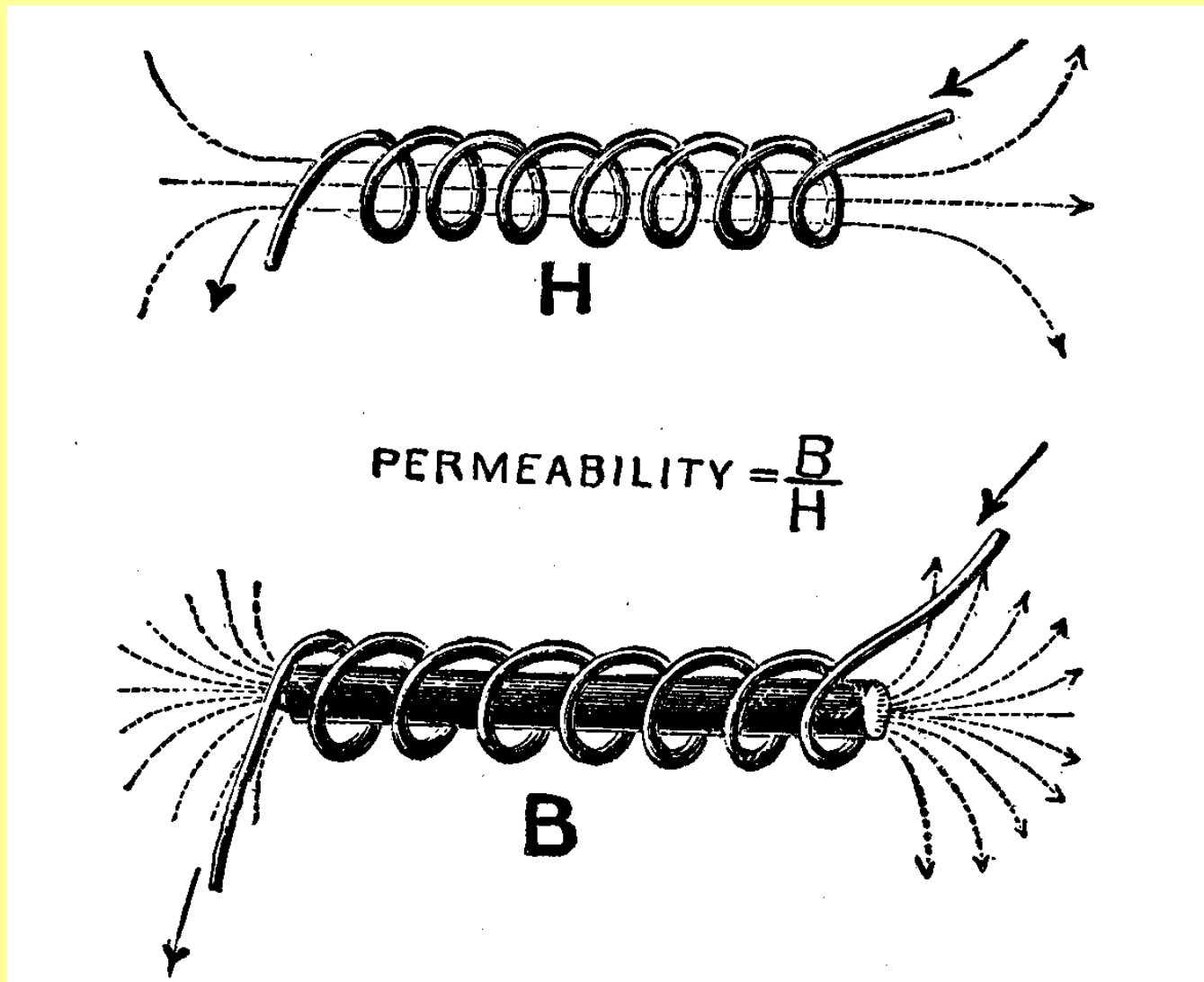
FIG. 93. — Simple compass. It consists of a magnetic needle resting on a steel pivot, protected by a brass case covered with glass, and a graduated circle marked with the letters N, E, S, W, to indicate the cardinal points; *a b* is a lever which arrests the needle by pushing it against the glass when the button *d* is pressed.

Magnetic Field due to Electrical Current



1831 - Michael Faraday
FIG. 113. Experiment showing direction of lines of force in the magnetic field surrounding a conductor carrying an electric current. A piece of copper wire is pierced through the center of a sheet of cardboard, and carried vertically for two or three feet then bent around to the terminals of a battery or other source of current. If iron filings be sprinkled over the card while the current is passing, they will arrange themselves in circles around the wire, thus indicating the form of the magnetic field surrounding the conductor. Compass needles may also be used to show the direction of the lines of force at any point.

Electro Magnets



Electro Magnet and Inductor

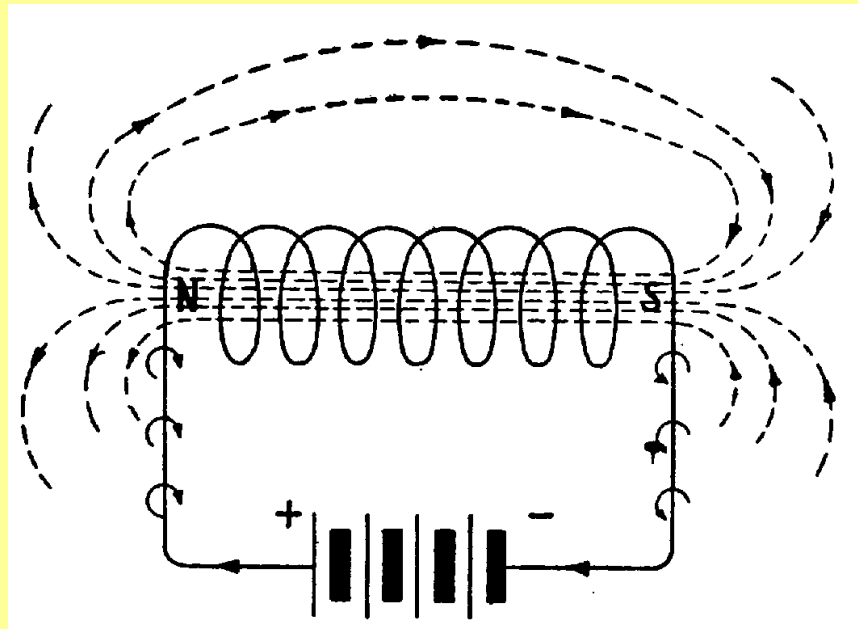
Stores energy as a magnetic field.



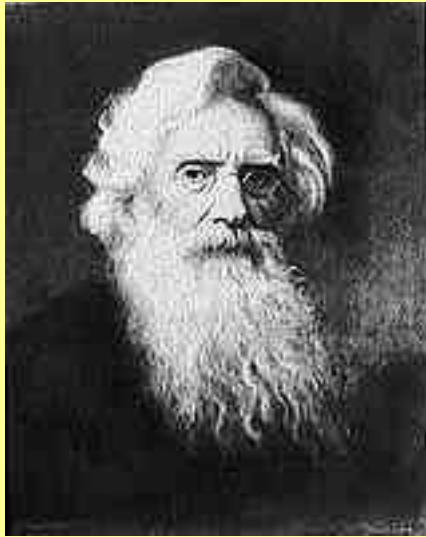
Taught and did
research at
Princeton.



Joseph Henry
1797 - 1878



Ca. 1824



Samuel Morse's Telegraph 1838 (Binary Serial Communications!)



Speedwell
Morristown.

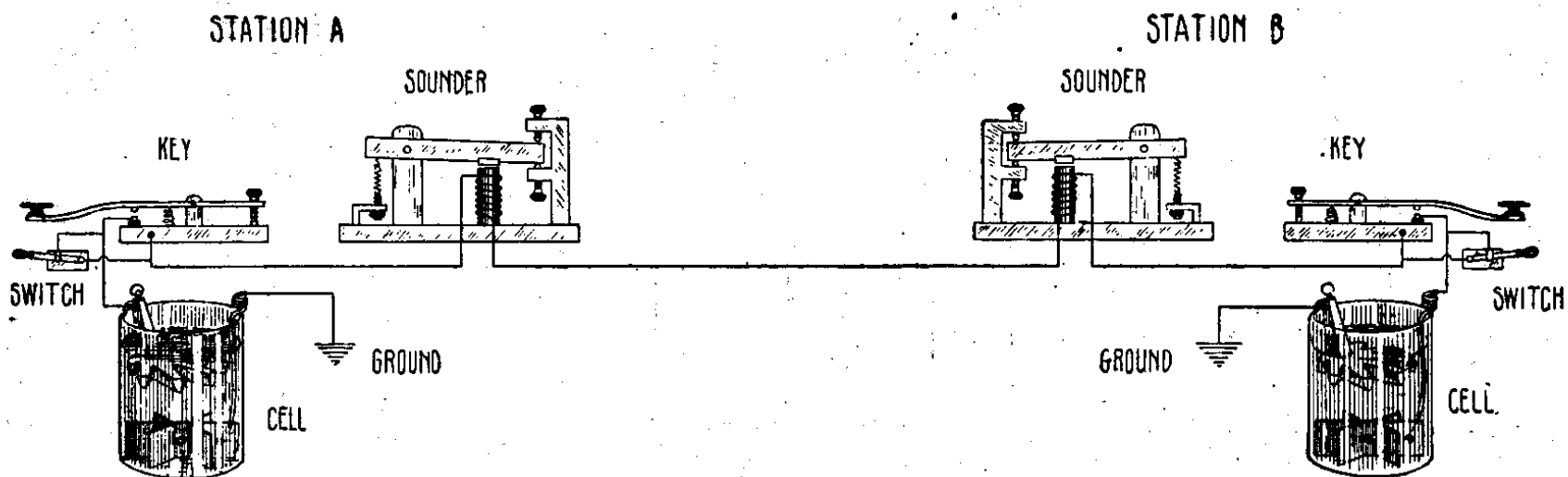


FIG. 3,052.—Elementary diagram showing a simple short line **closed circuit** system. It is called closed system from the fact that the circuit is normally closed with current on the line, that is to say, when not in operation the switches are closed and current flows which energizes the magnets and holds the instrument armatures in the down position. This necessitates the use of a closed circuit cell as for example the crow foot gravity type which is capable of supplying a very weak current for a long duration of time.

Alternating Current

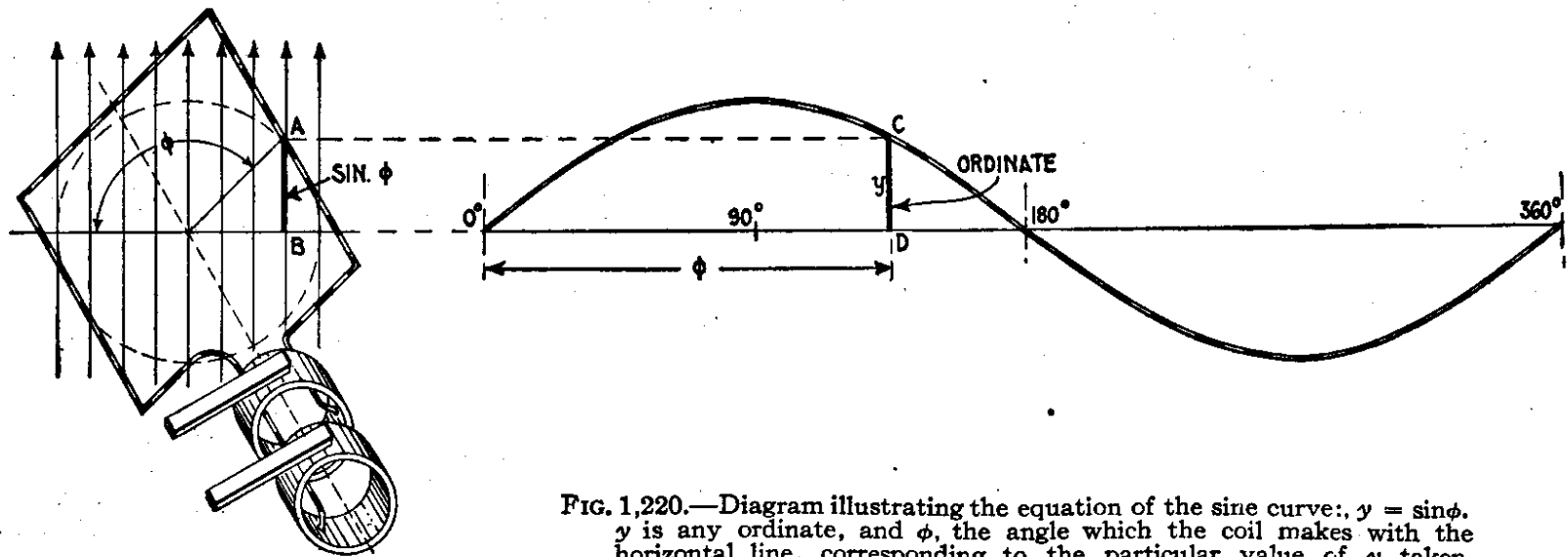
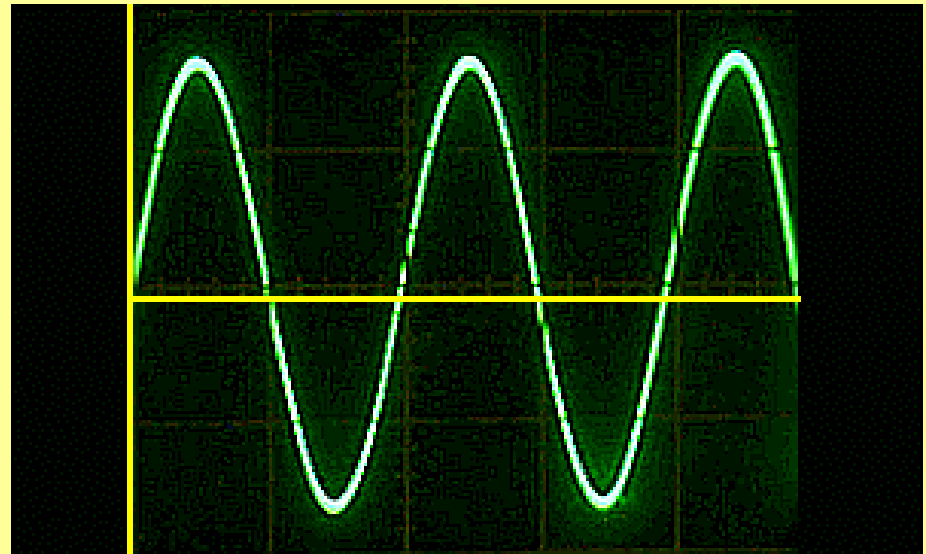
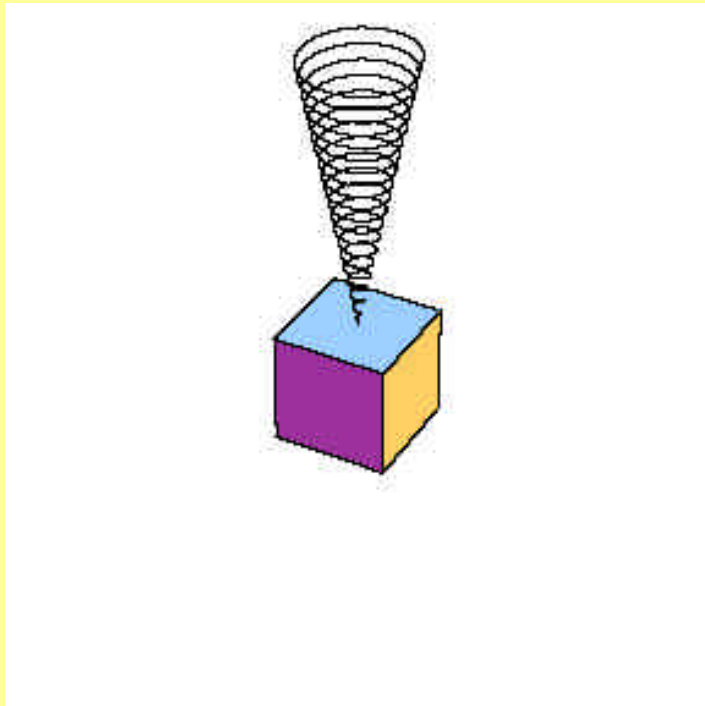


FIG. 1,220.—Diagram illustrating the equation of the sine curve: $y = \sin \phi$. y is any ordinate, and ϕ , the angle which the coil makes with the horizontal line, corresponding to the particular value of y taken.

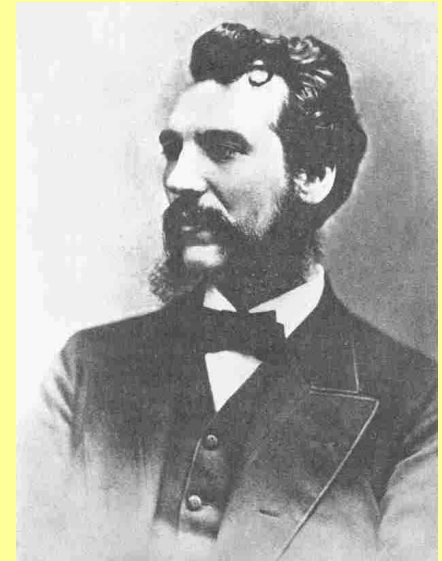
Oscillation and Resonance



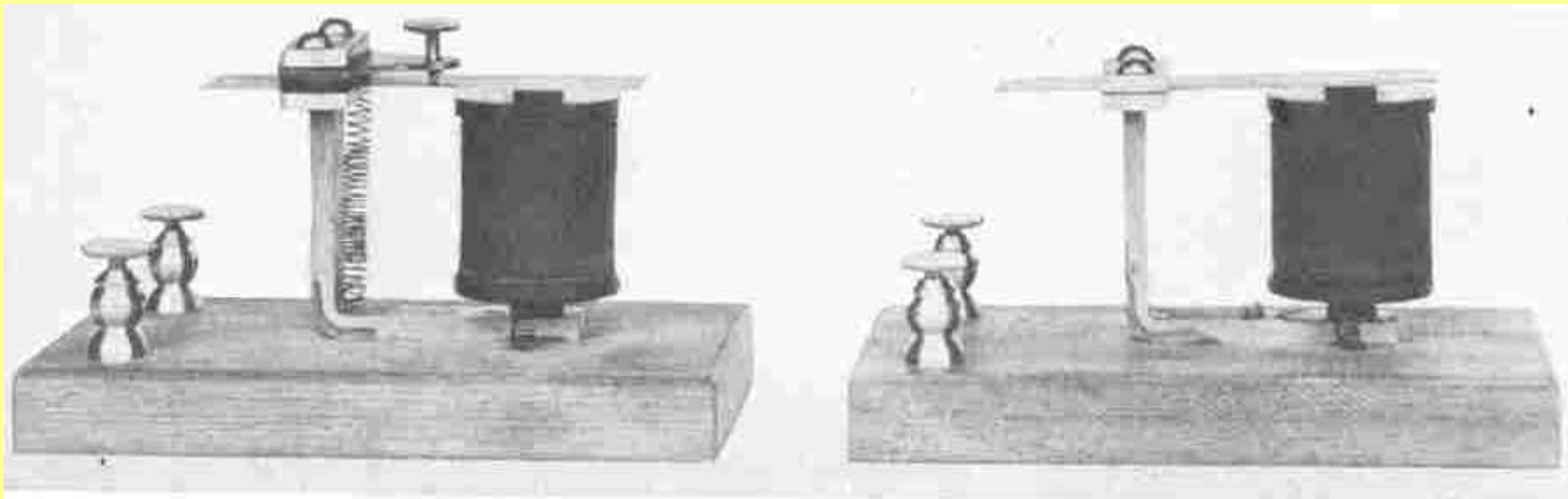


AT&T

Bell - 1875

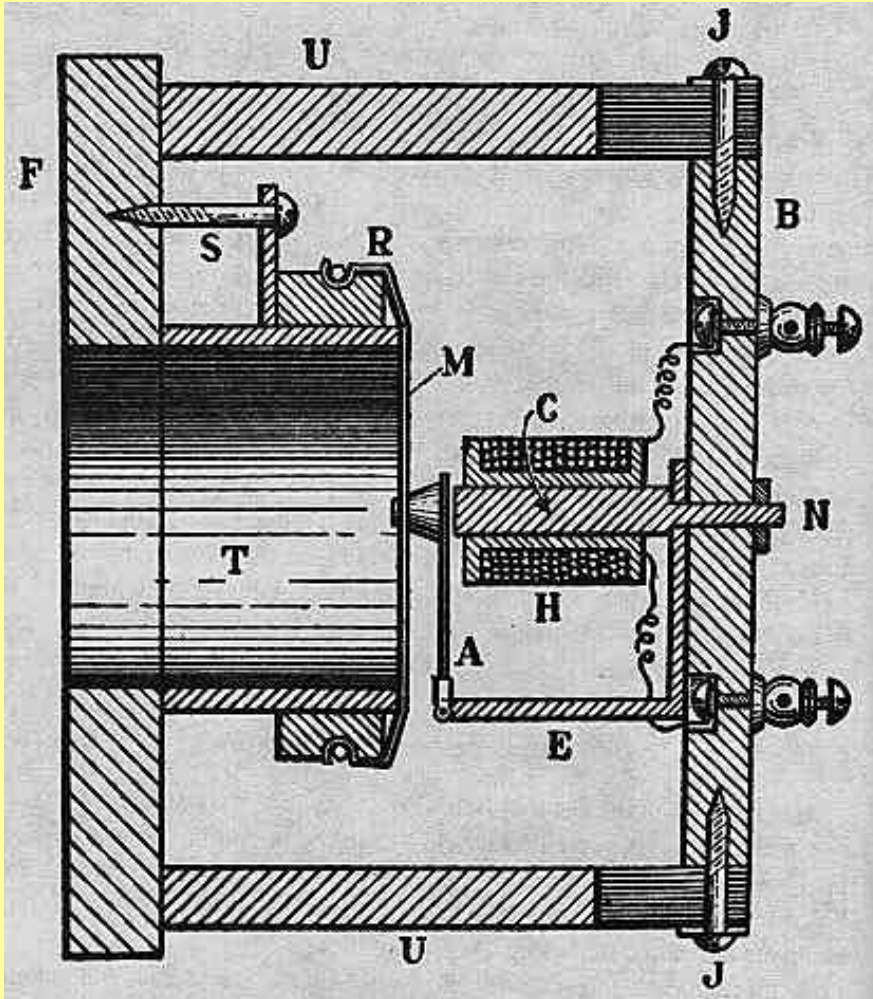


Alexander Graham Bell



Experimental multiplex telegraph apparatus.

The “Gallows” Telephone



Carbon Microphone

Thomas A. Edison



Visit the lab in West Orange

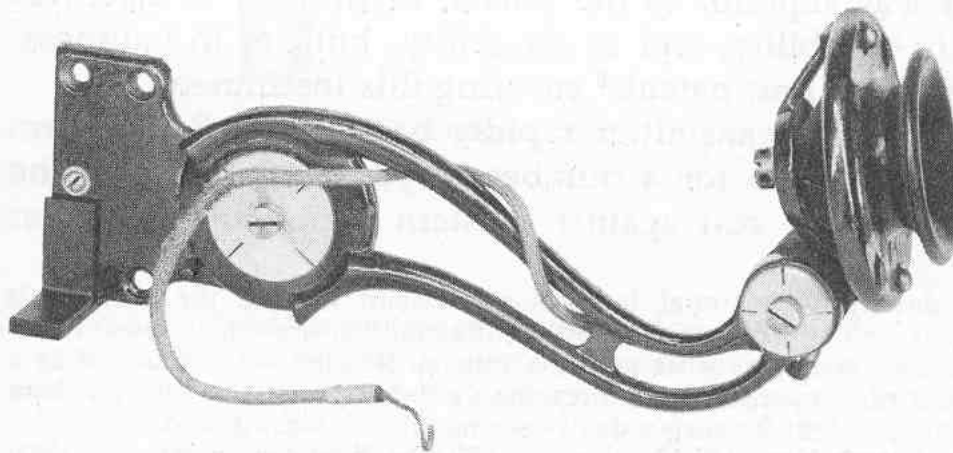


Fig. 3-4. Early Edison transmitter (1879).

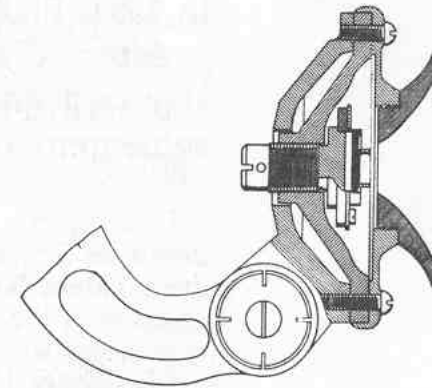


Fig. 3-5. Cross section of early Edison transmitter.

Maxwell

Treatise on Electricity and Magnetism
(1873)

$$\nabla \cdot \mathbf{E} = \rho / \epsilon_0$$

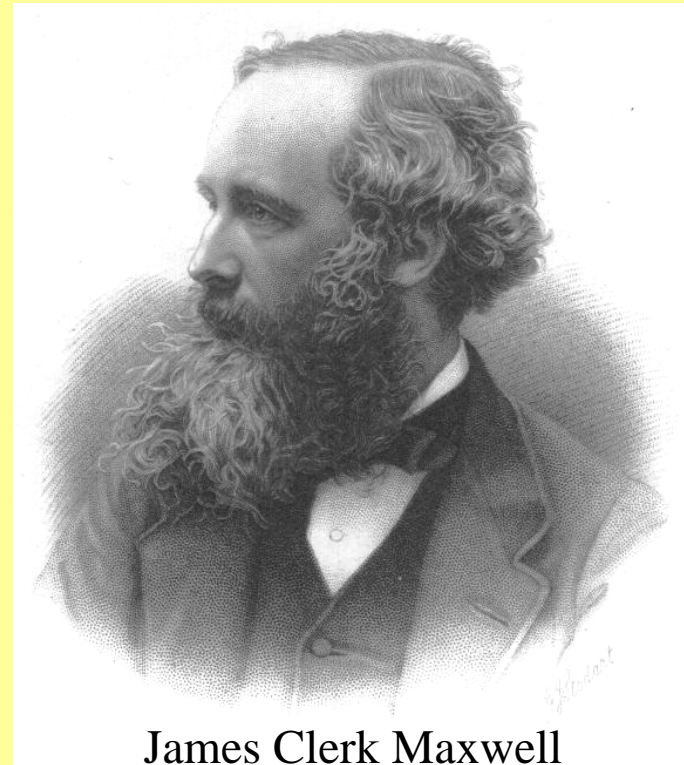
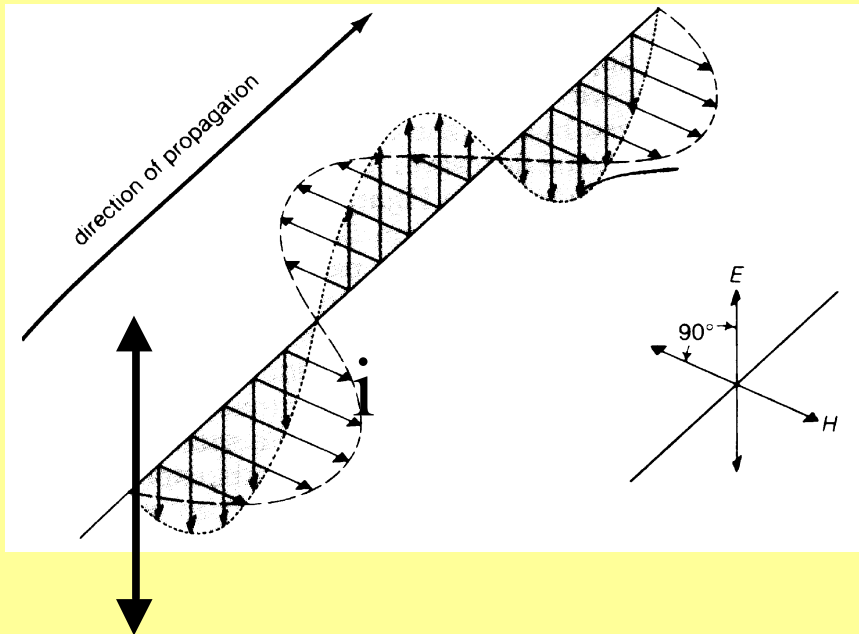
$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = - \frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \mathbf{j}_c$$

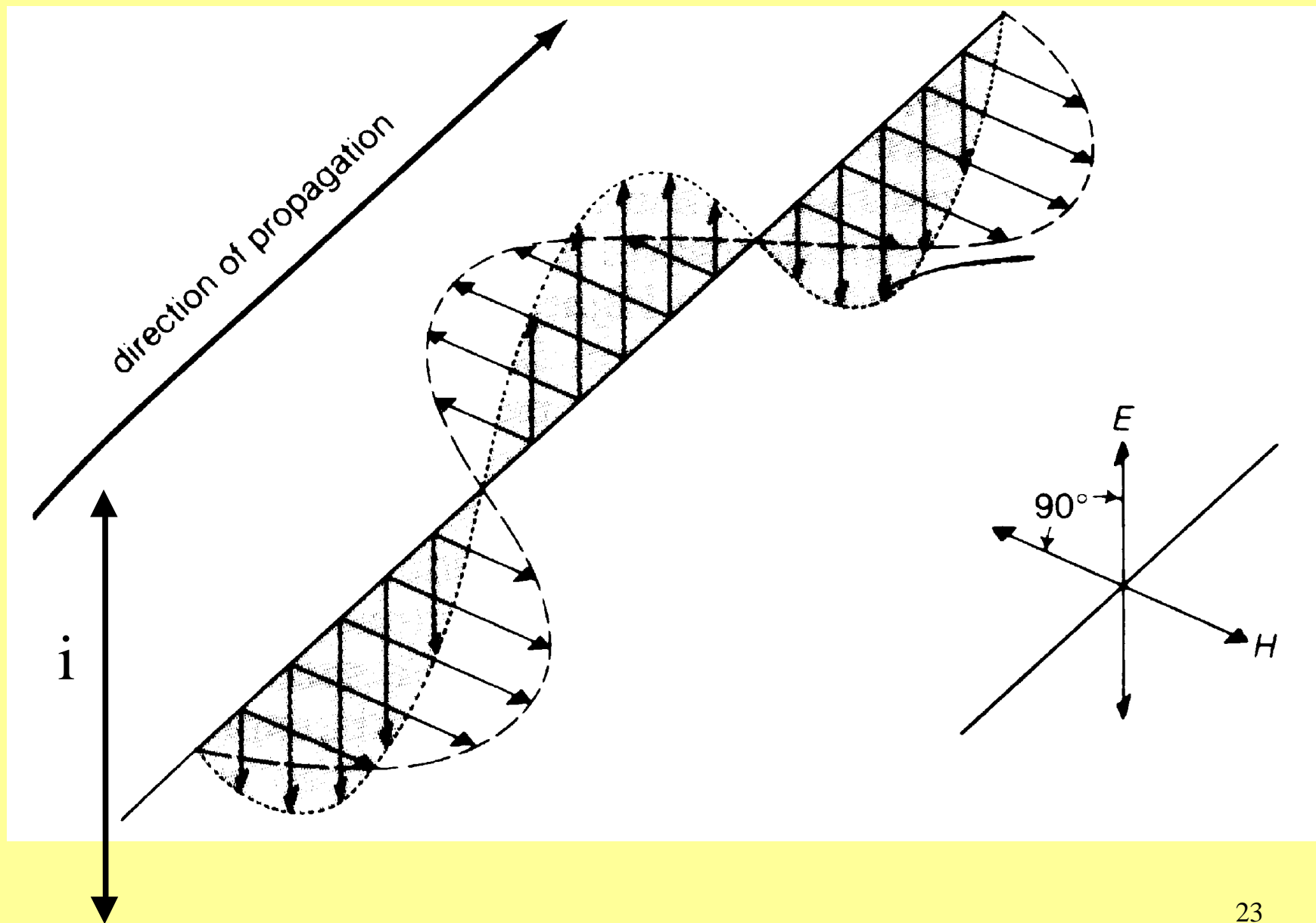
where

$$\nabla = \hat{\mathbf{i}} \frac{\partial}{\partial x} + \hat{\mathbf{j}} \frac{\partial}{\partial y} + \hat{\mathbf{k}} \frac{\partial}{\partial z}$$

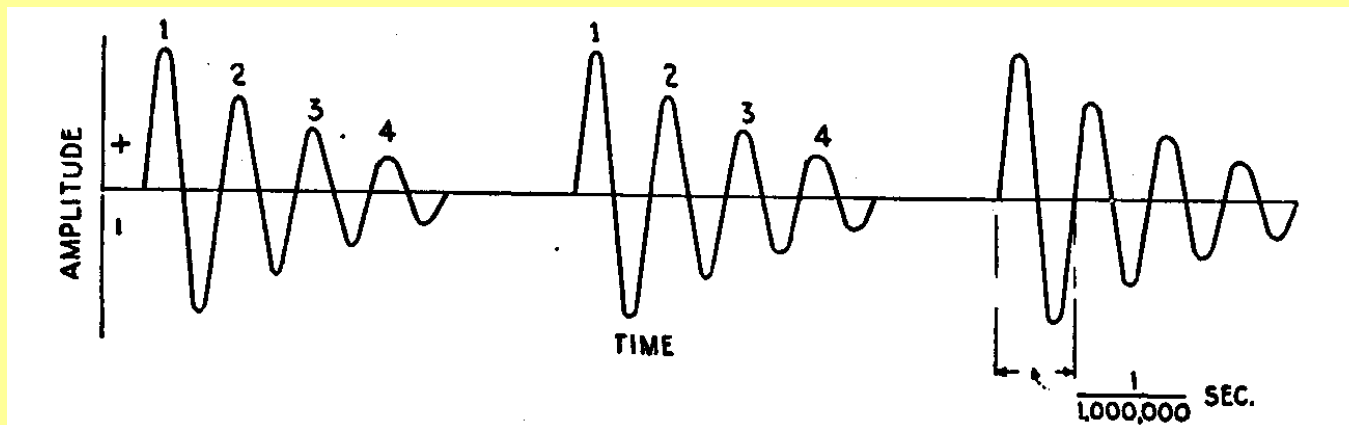
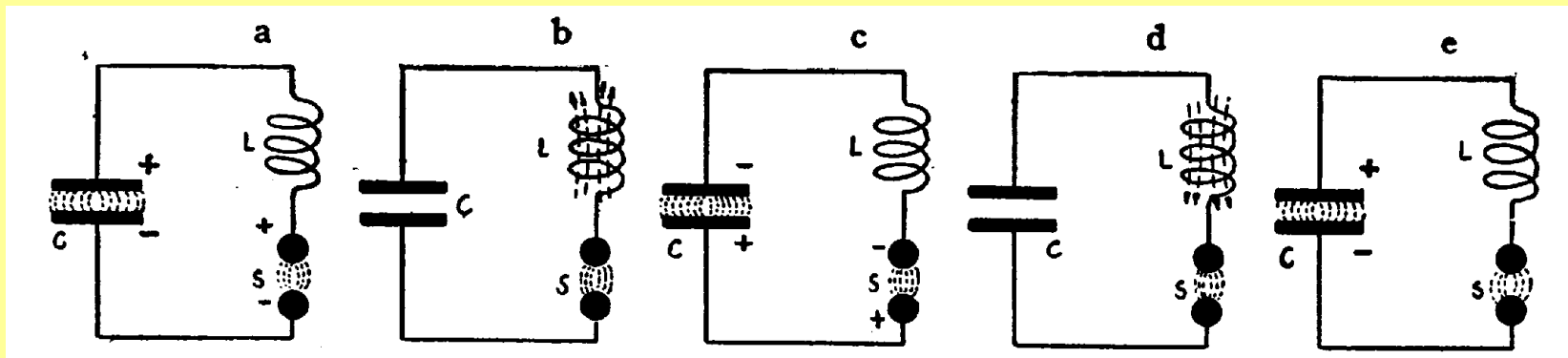
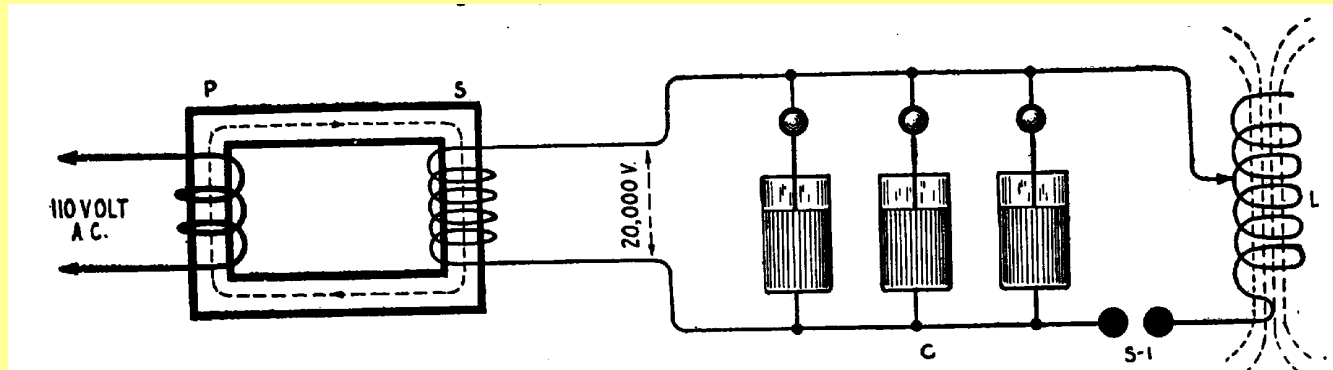


James Clerk Maxwell

1831 - 1879



High-frequency AC Oscillator



Eureka!

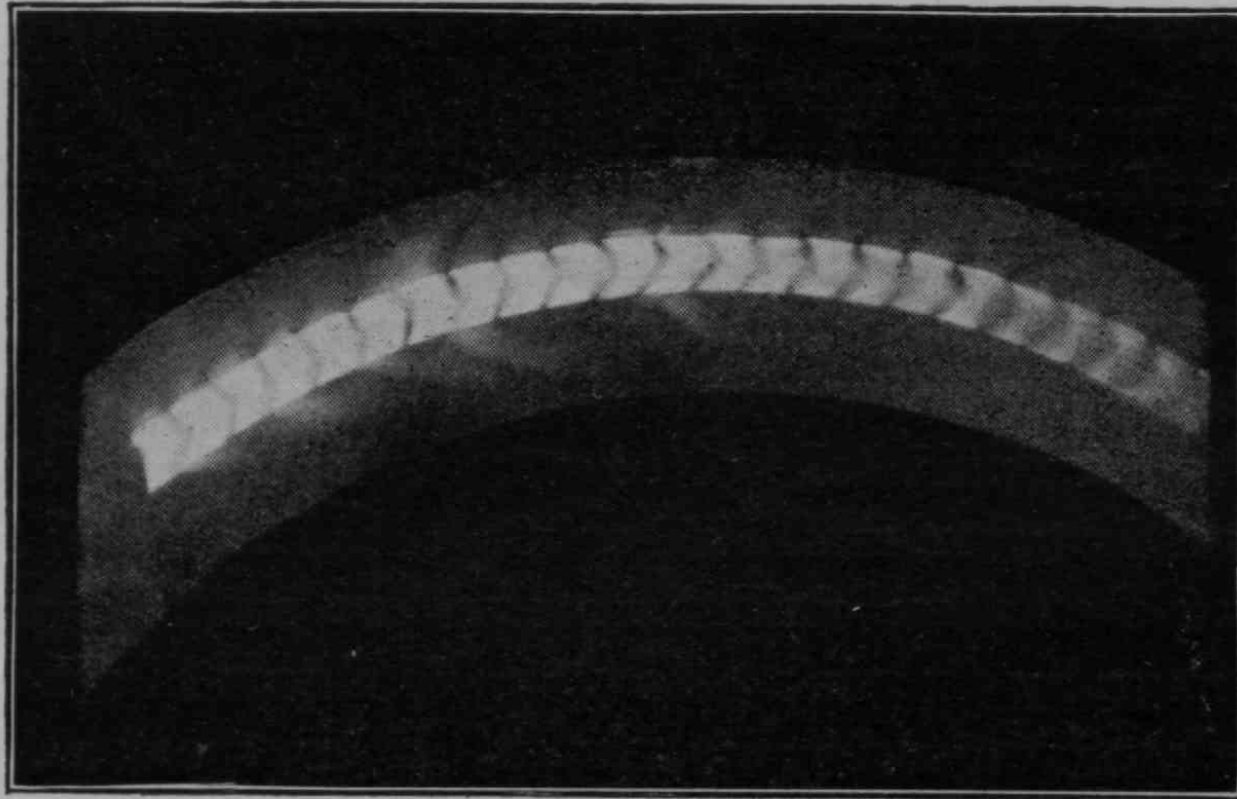


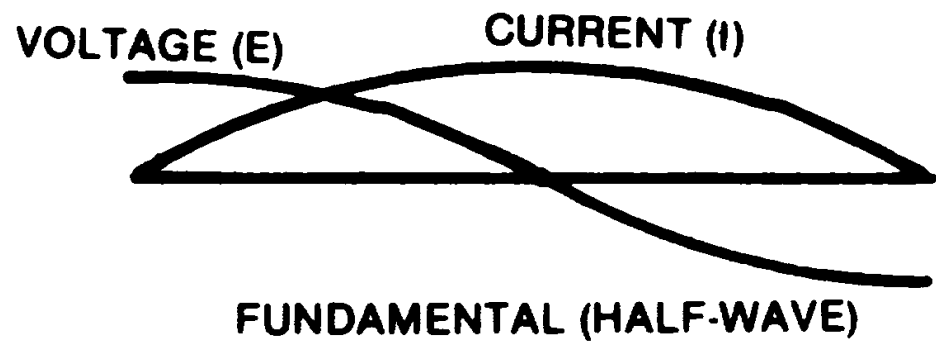
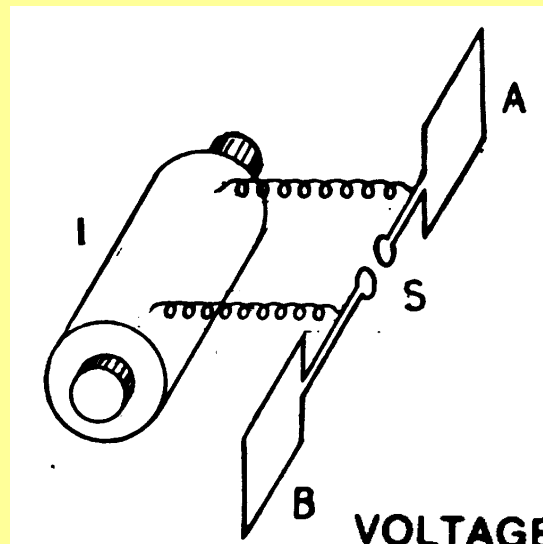
FIG. 5.—Photograph of an oscillatory electric spark.



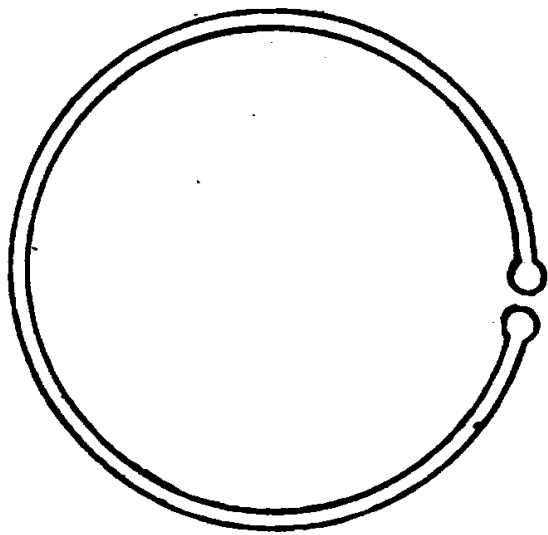
Heinrich Hertz
1857 - 1894

Hertz

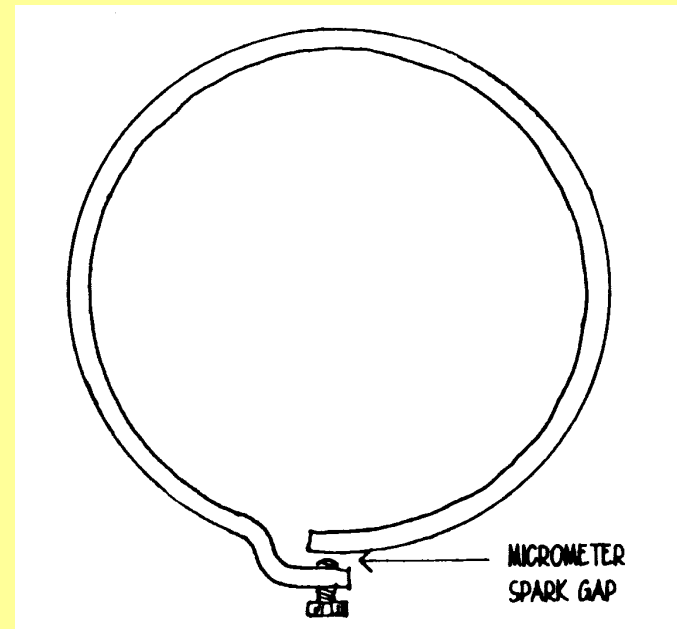
Ca. 1888



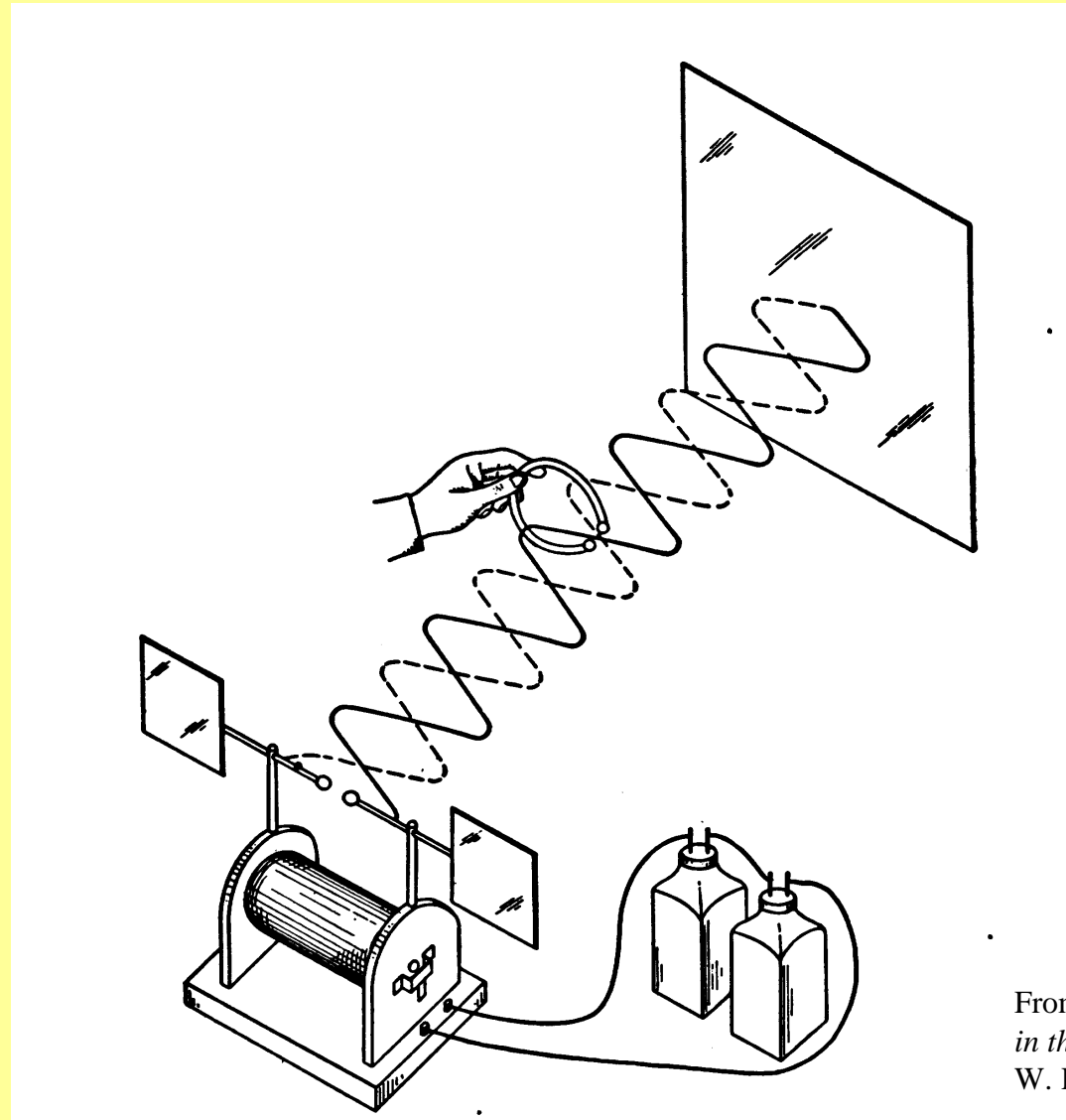
The First Radio Receiver



**FIG. 10.—A Hertzian
ring resonator.**



A Hertzian Experiment



From *Invention & Innovation
in the Radio Industry*,
W. Rupert MacLaurin, 1949

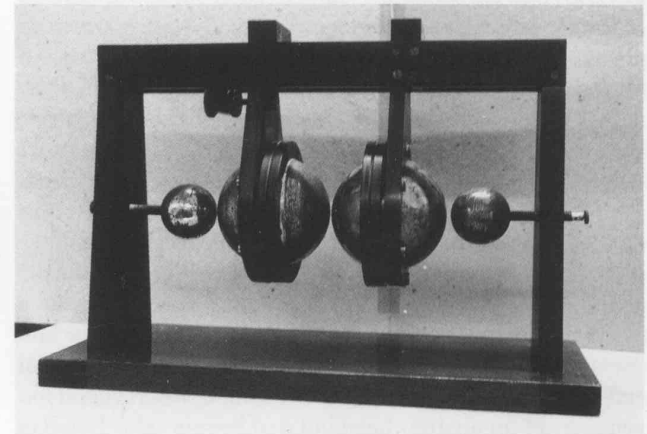
Guglielmo Marconi

- Born 1874
- Wealthy Italian father
- Wealthy Irish mother (Jamison)
- Tech. Institute at Leghorn
included telegraphy
- Inspired by Hertz's Obituary in 1894



Marconi

at Villa Grifone



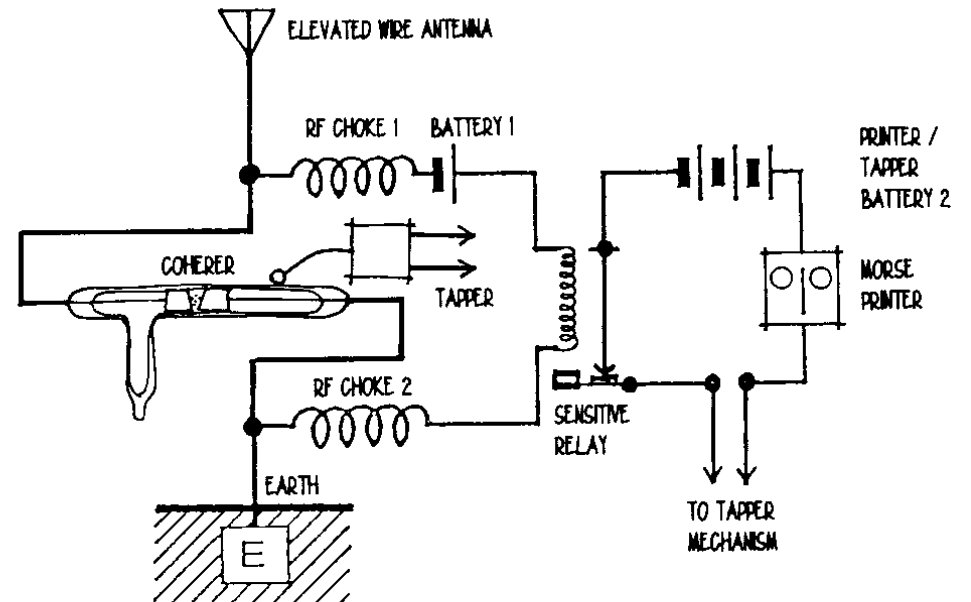
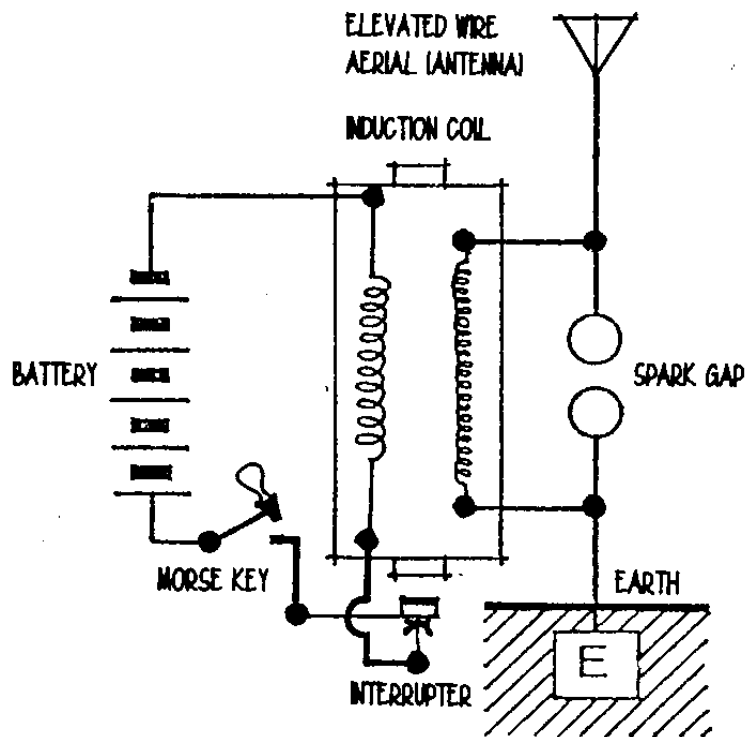
A set of spark balls as used originally by Professor Righi and then by Marconi in 1896.

Photos and drawings from *Early Radio*
by Peter R. Jensen

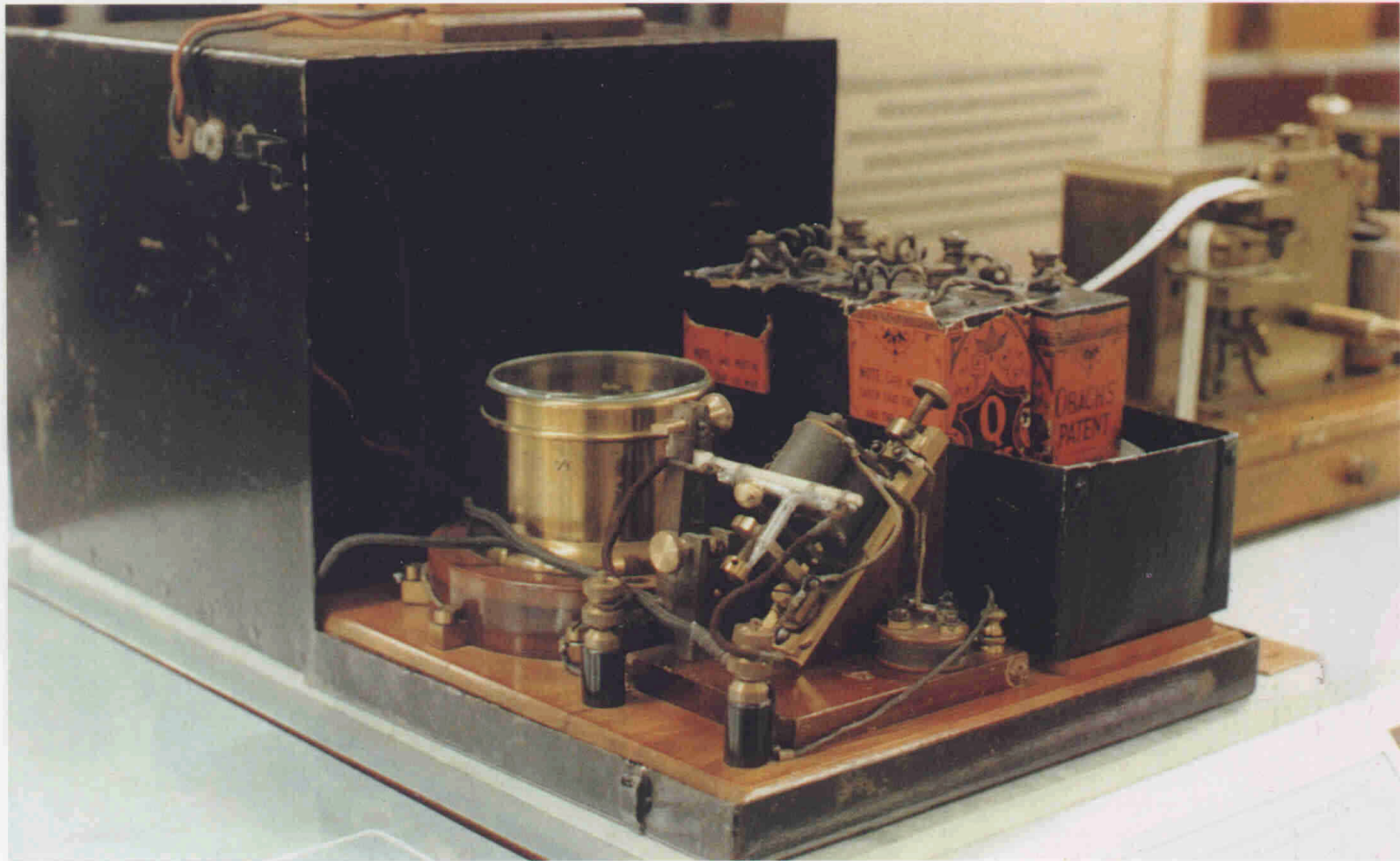
Marconi Developments

- 1896 Moves to Great Britain
- Sept. 1896, 2.8Km, Salisbury Plain
- Mar. '97, 14Km, Bristol Channel
- Late 1898, 29Km, Isle of Wright

Marconi 1896



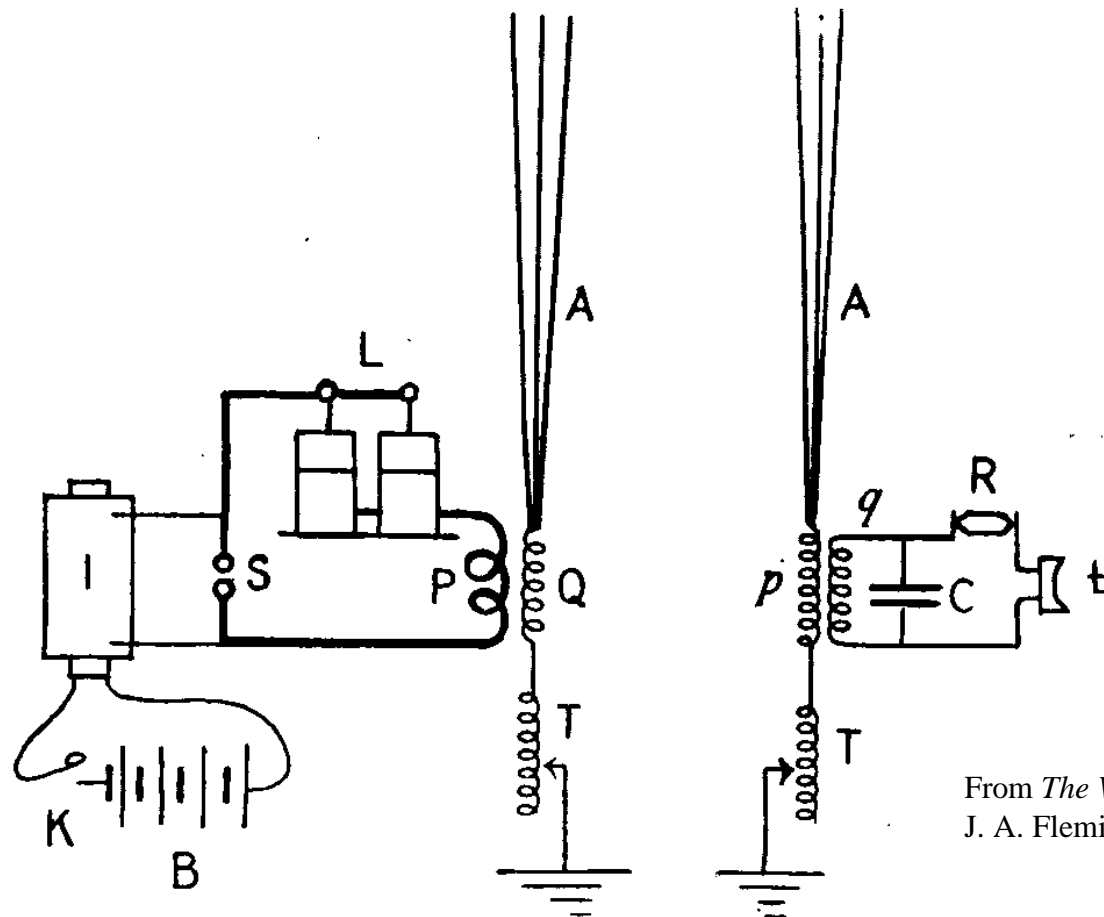
MARCONI RECEIVER



Inside the mysterious 'black box' at the archives, Great Badow.

Patent 7777

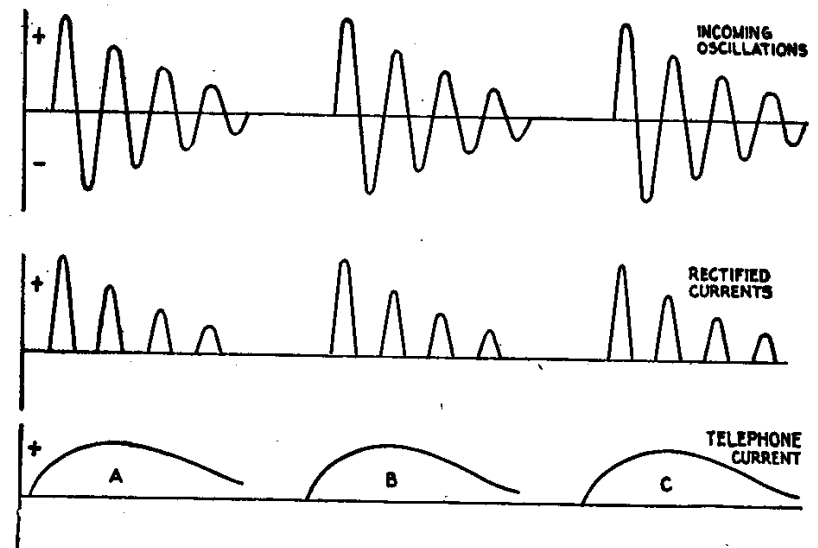
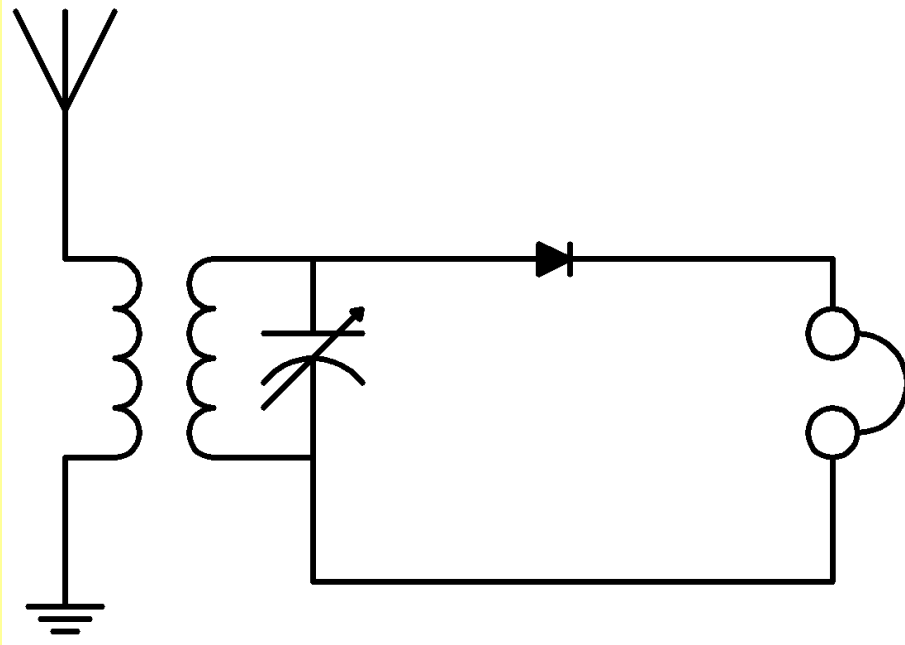
Application filed 12 April 1900



From *The Wonders of Wireless Telegraphy*
J. A. Fleming, London, 1913

FIG. 45.—Marconi syntonic transmitter and receiver.

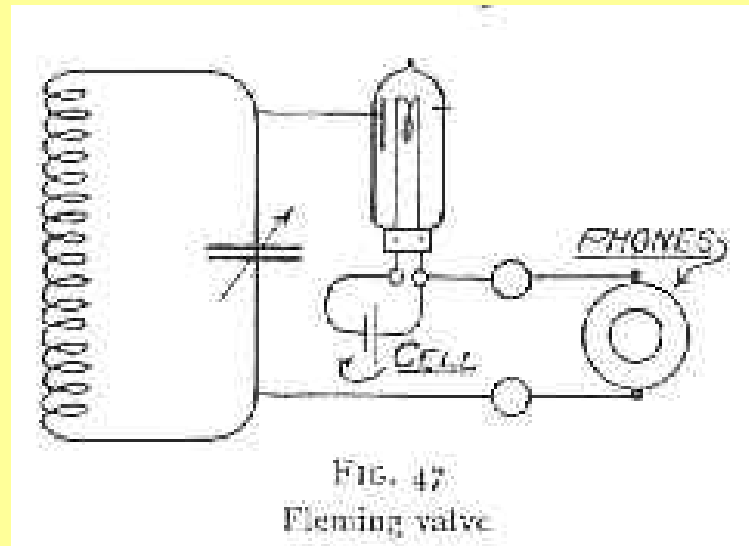
Passive Receivers



The Fleming Valve



John Ambrose
Fleming³
(1849 - 1945)

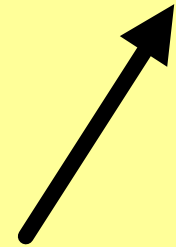


Marconi Timeline

- 1899 - Spans English channel
- 1901 – Trans-Atlantic signals
- 1901 – America's Cup – Twin Lights
- 1903 – First two-way Trans-Atlantic
- 1909 – *Republic / Florida* Collision
- 1909 – Nobel Prize for Physics



Atlantic Highlands



David Sarnoff



Sarnoff / RCA Timeline



- 1906** - Hired as office boy at the Marconi Company
- 1907** – Promoted to Junior Operator, age 16
- 1912** – Titanic – Sarnoff was Marconi op in station in the Wanamaker's Department store in NYC
- 1913** – Chief Inspector Sarnoff meets Armstrong
- 1916** – Proposes “Radio Music Box”
- 1917** – Sarnoff appointed Commercial Manager
- 1919** – RCA established

We need a
reliable
Amplifier!

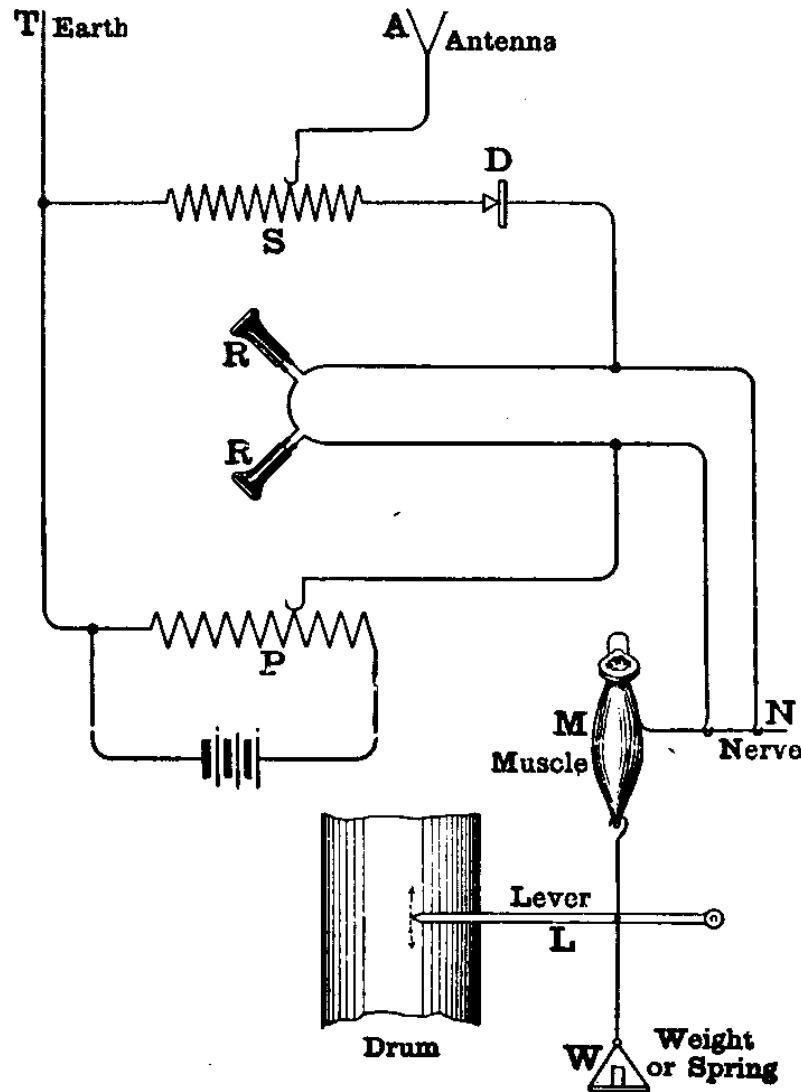


FIG. 39.—A Frog's leg used to receive wireless messages.

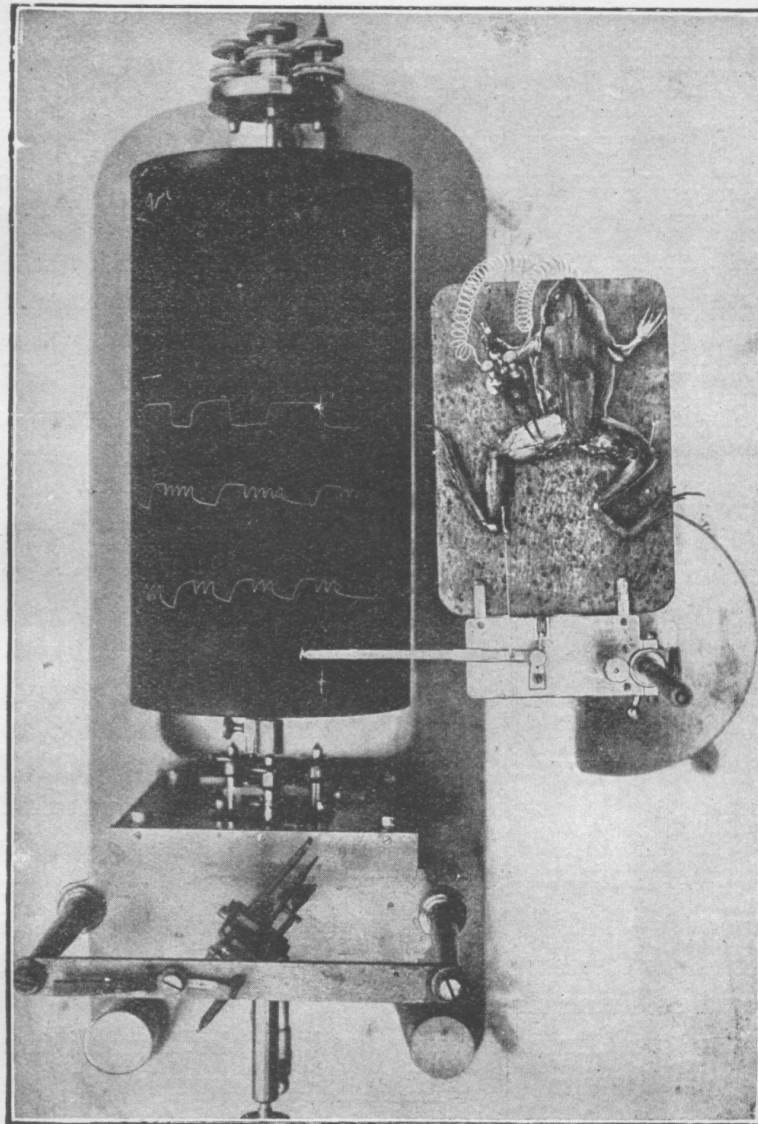


FIG. 40.—Eiffel Tower signals recorded by a frog's leg receiver.

receiver, it will be of advantage to the reader if we describe

From *The Wonders of Wireless
Telegraphy*

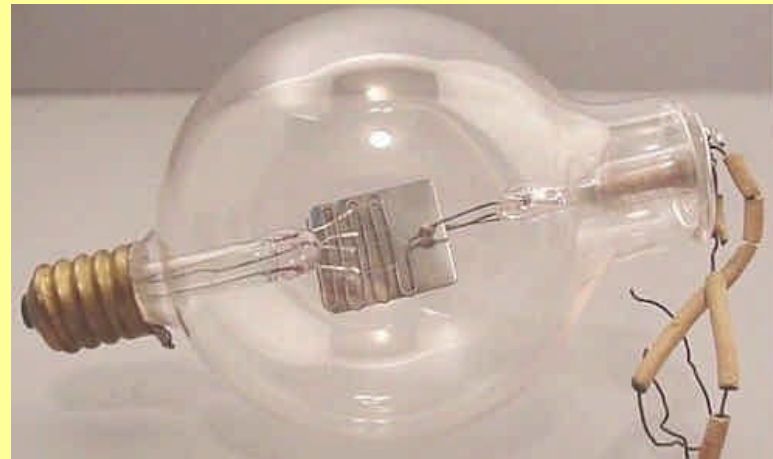
J. A. Fleming, London, 1913

The Audion

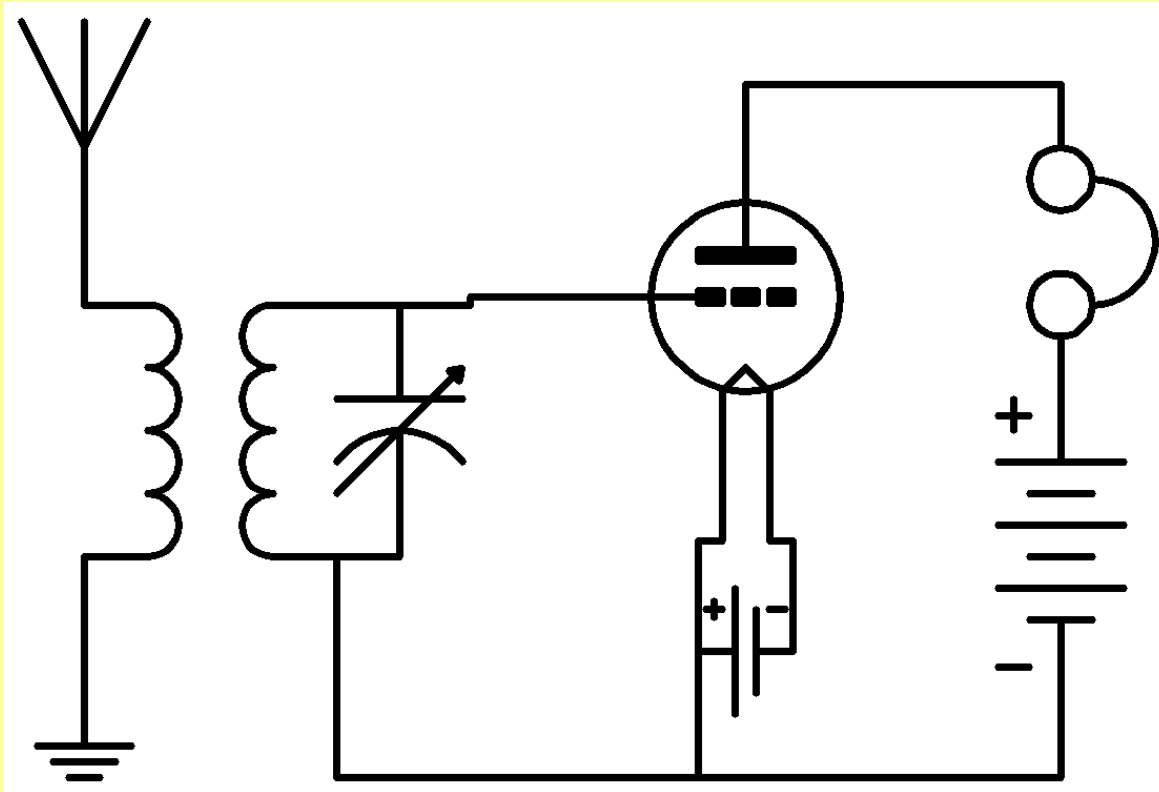


Lee DeForest

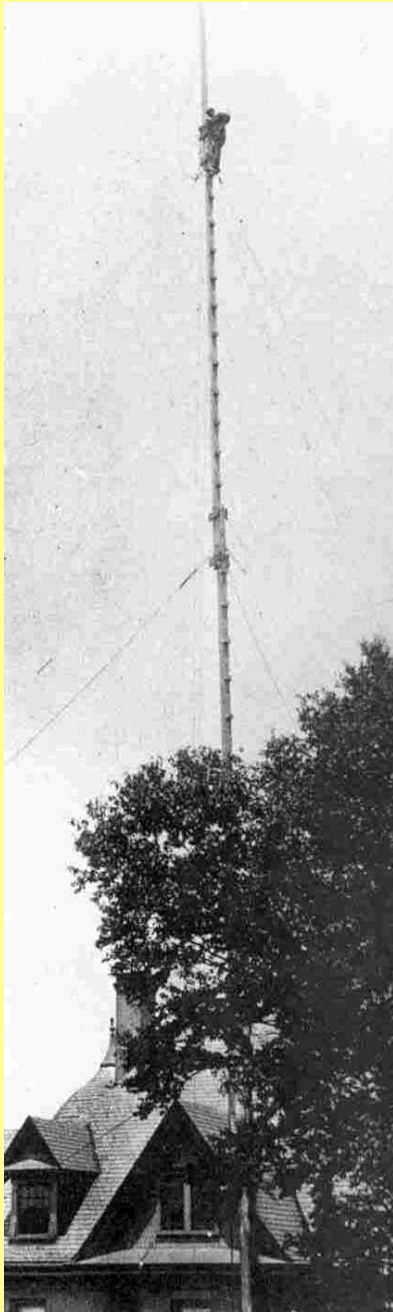
1906



An Audion Radio Receiver

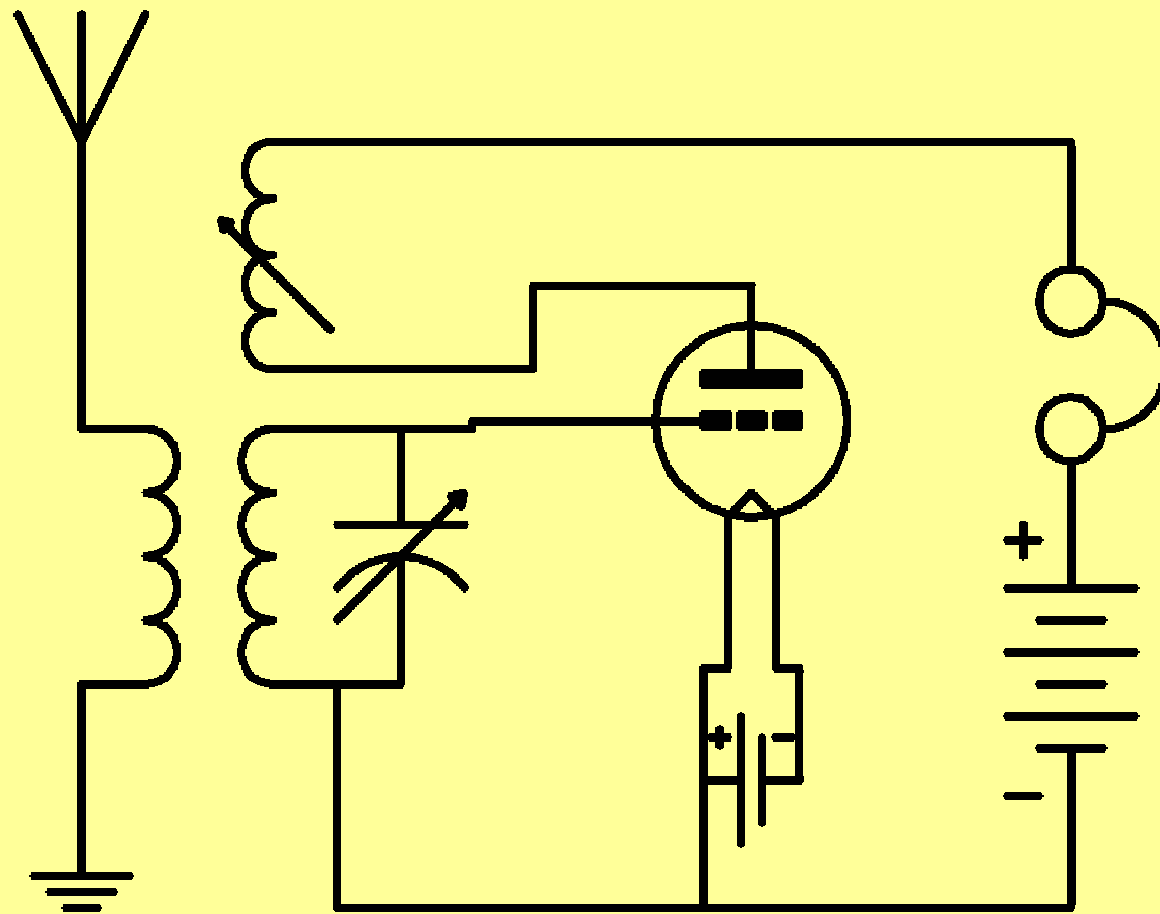


Armstrong



Edwin Howard Armstrong

The Regenerative Circuit

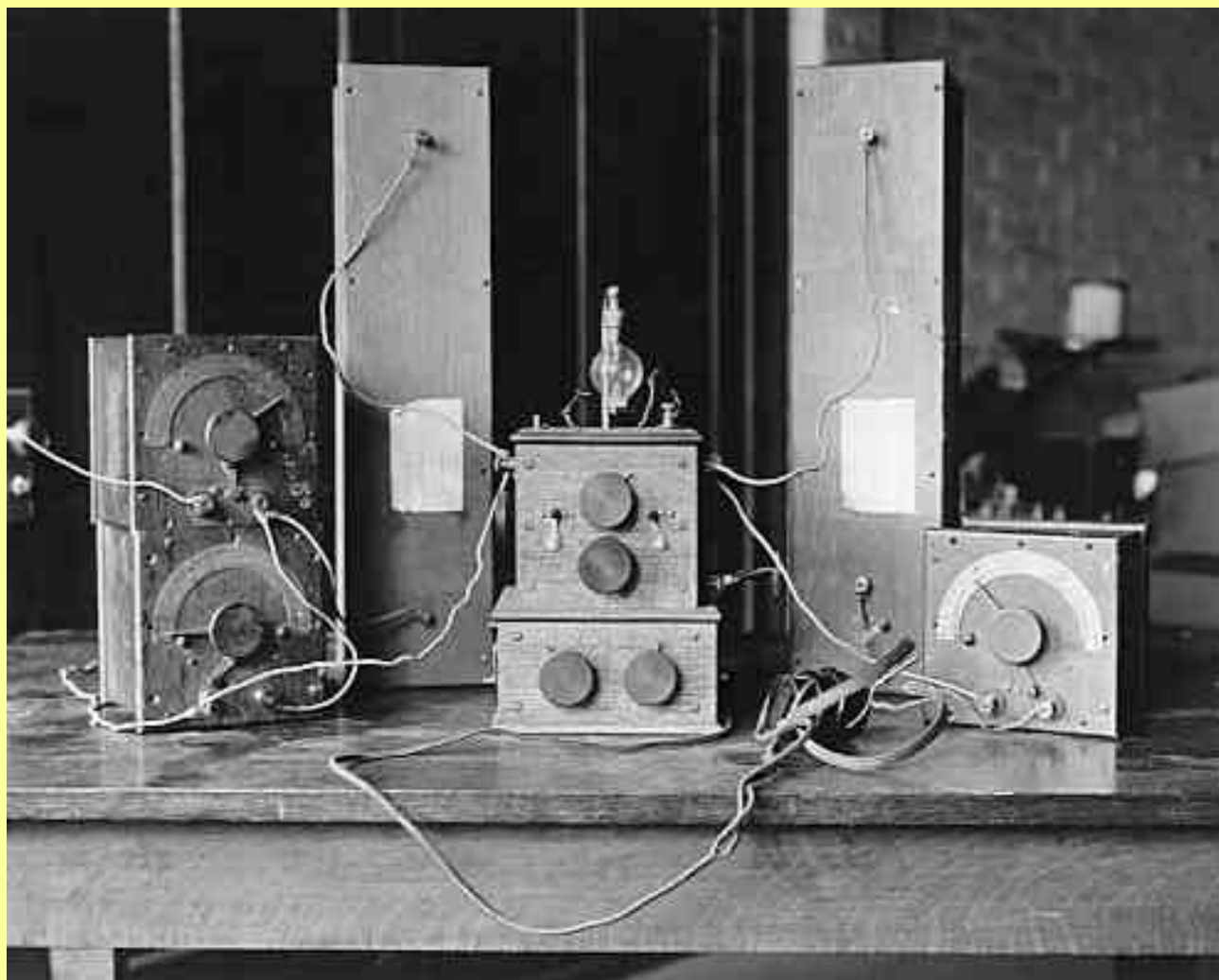


**“Great amplification
obtained at once!”**

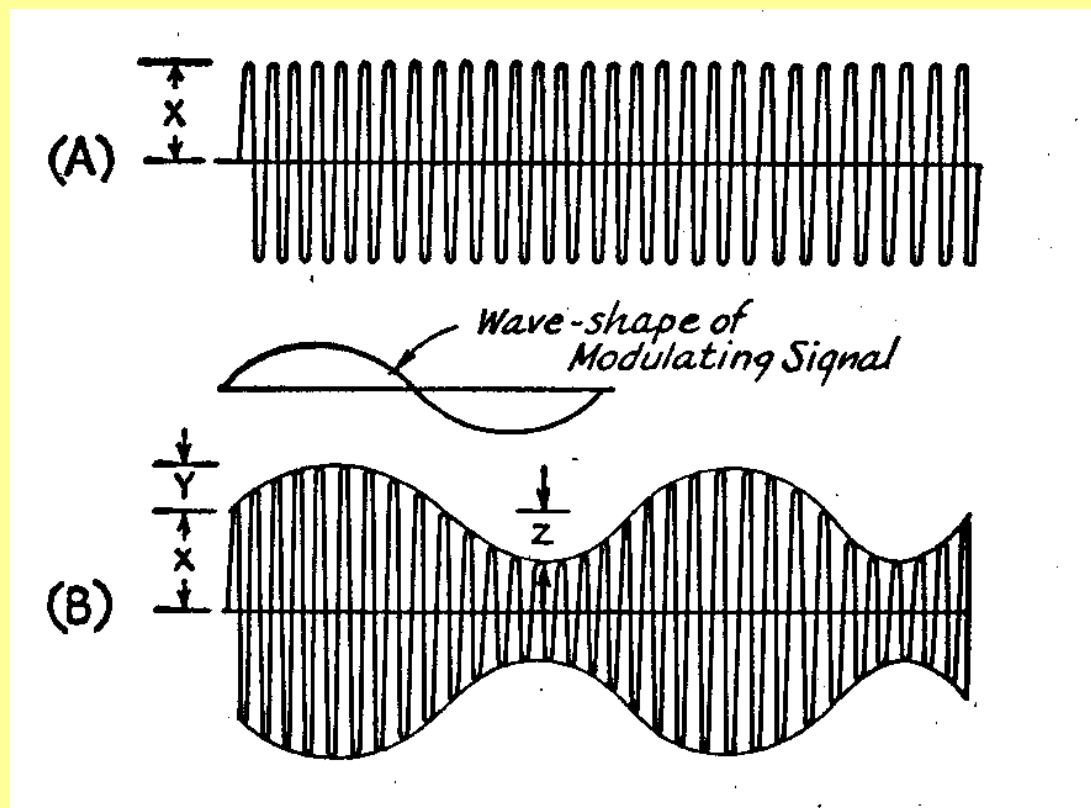
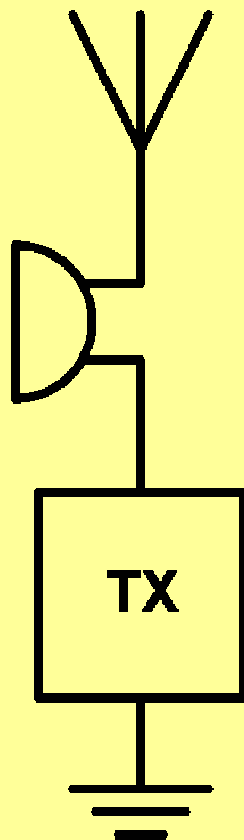
Regen Prototype



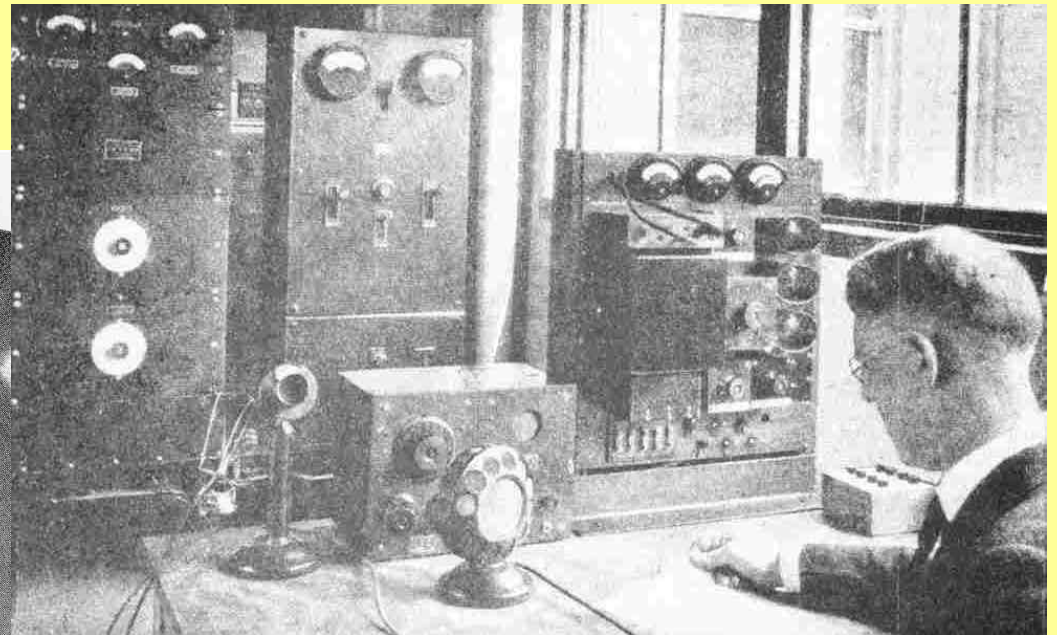
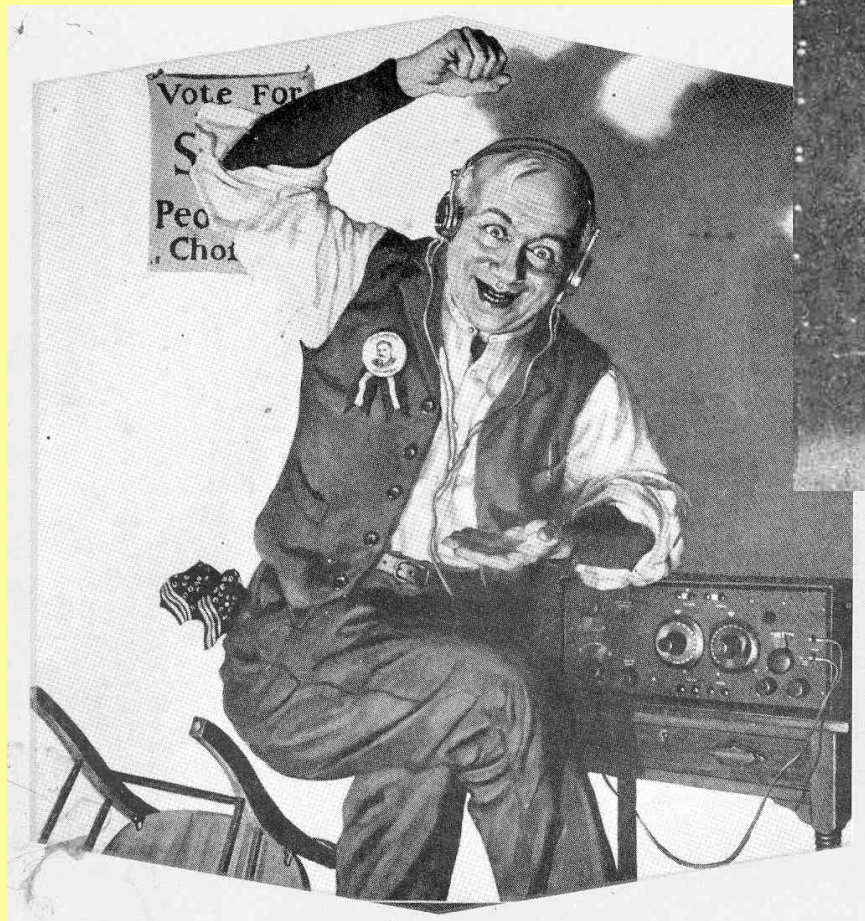
Demonstrated to
Sarnoff at the
Marconi station at
Belmar



Radiotelephone



The Birth of Broadcasting



Timeline

