

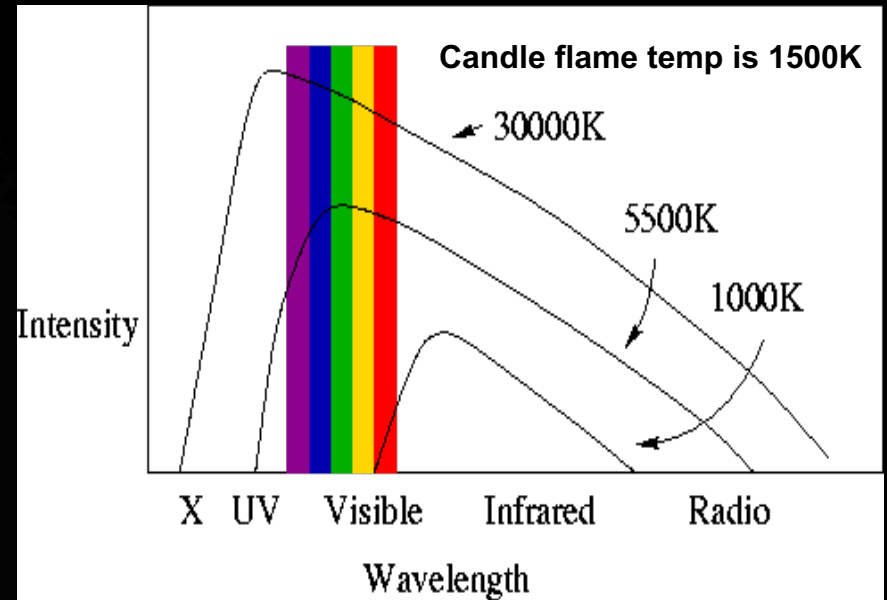
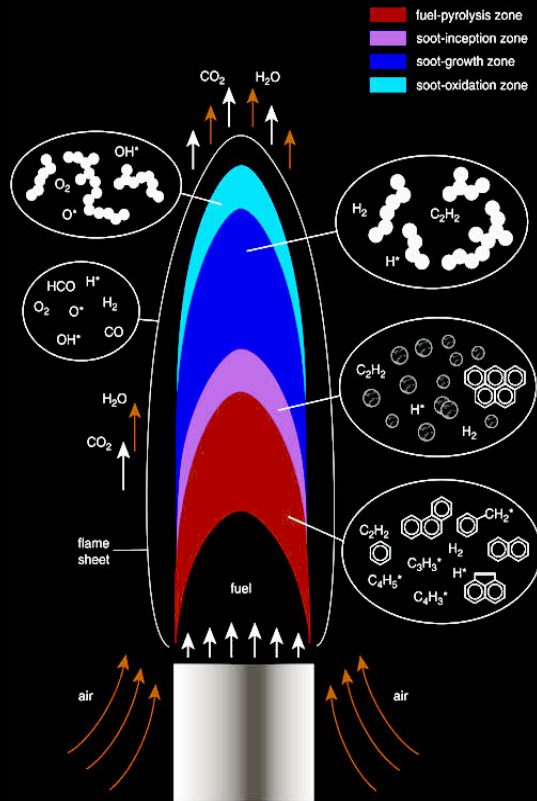
Wireless Telegraphy, Amateur and Broadcast Radio

Global Information Network – National Broadcasting Corporation
Marconi – Sarnoff and Armstrong

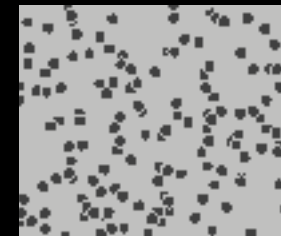
CEE 102: Prof. Michael G. Littman – FCC Call Sign: KD2NFA
Course Administrator: Arianna Sherman ariannas@princeton.edu

Computers for NOTETAKING ONLY
Please - NO Cell Phones, Texting, Internet use

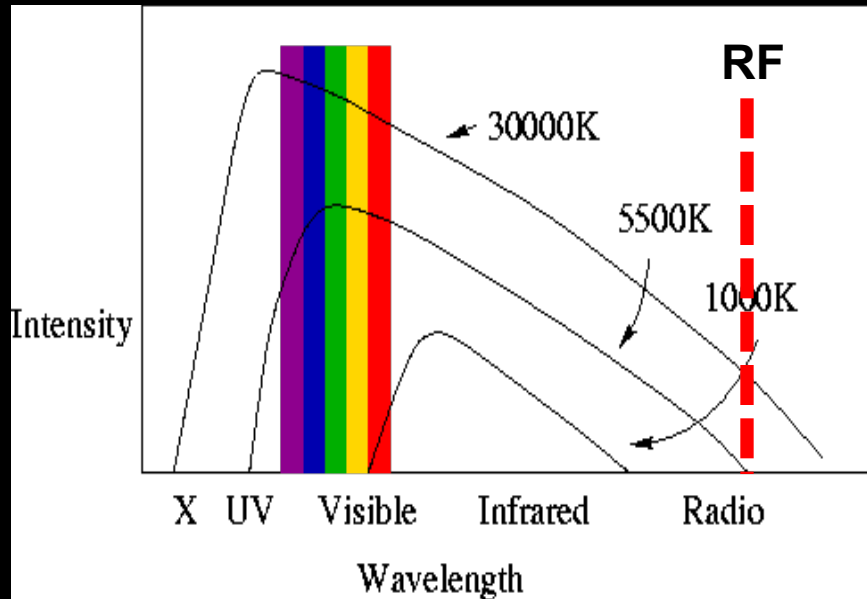
Blackbody Radiation



Electrons in hot carbon (soot) radiate X-rays, UV, visible light, IR, radio (due to random electron motion)

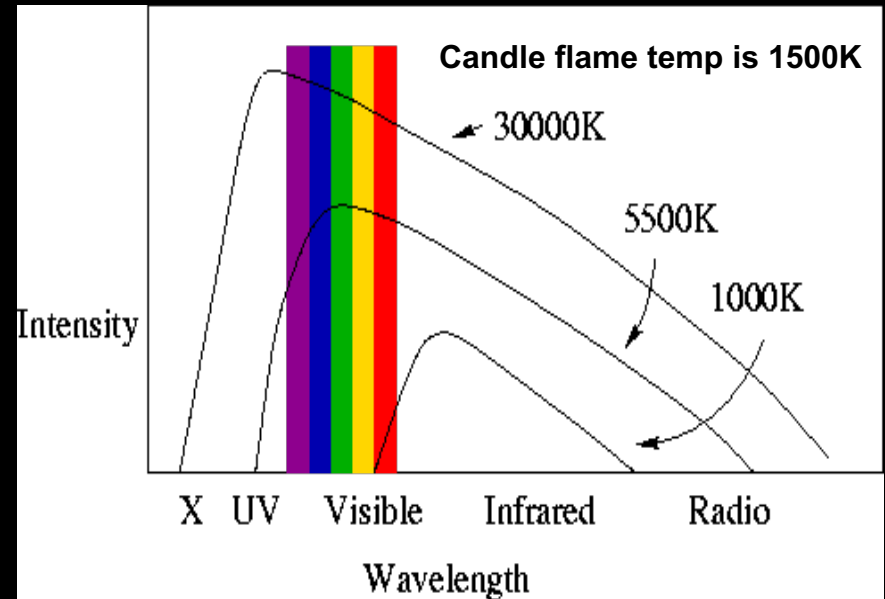


RF Radiation



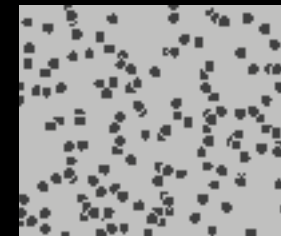
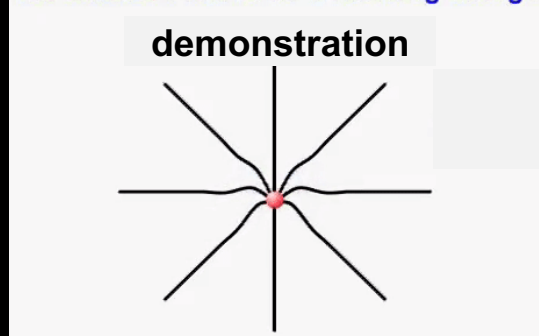
Electrons in antenna radiate waves when forced at single frequency (due to sinusoidal electron motion)

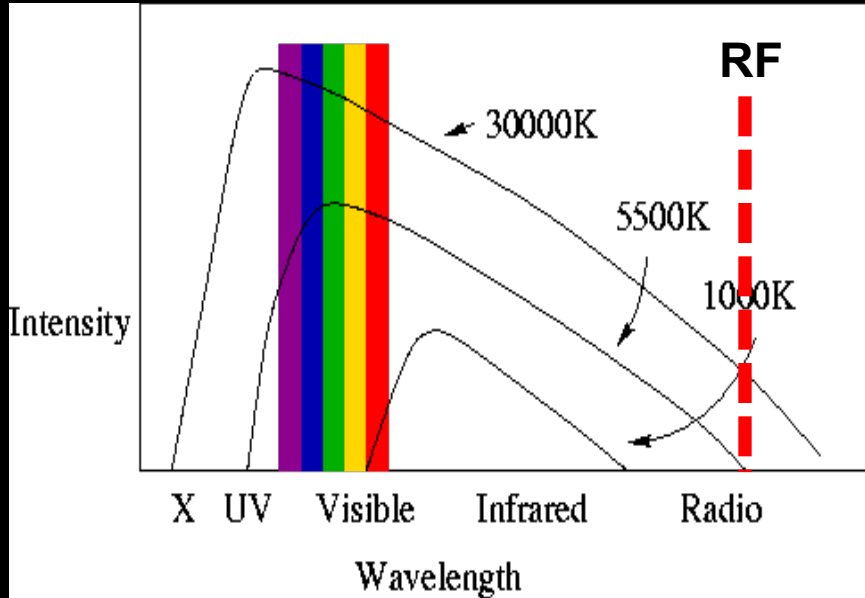
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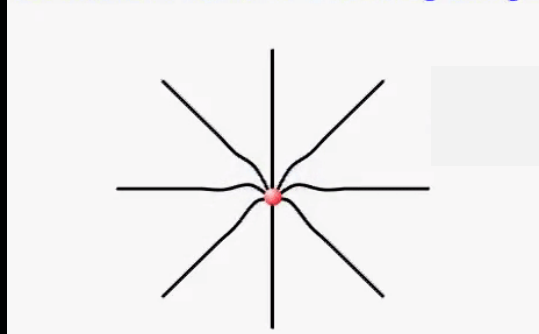
The Electric Field of an Oscillating Charge



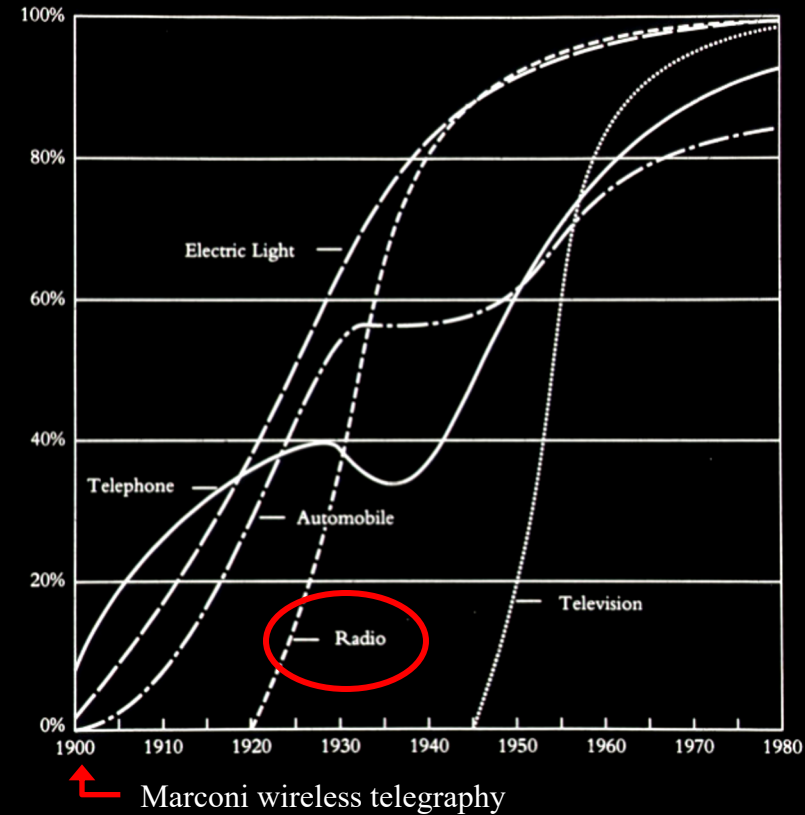


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The Electric Field of an Oscillating Charge



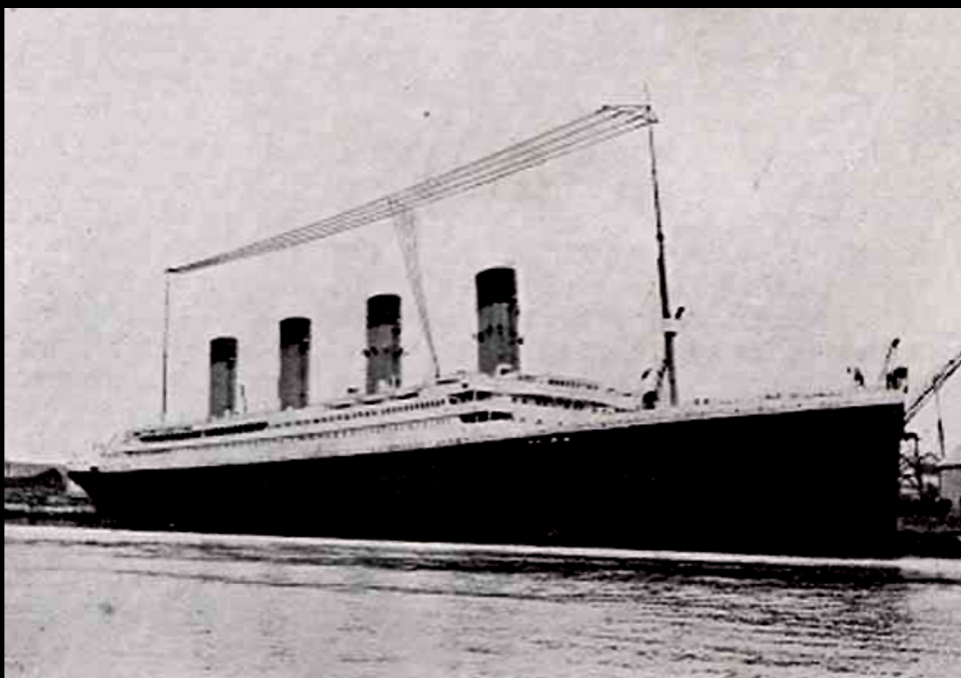
Consumer Goods 1900 - 1980



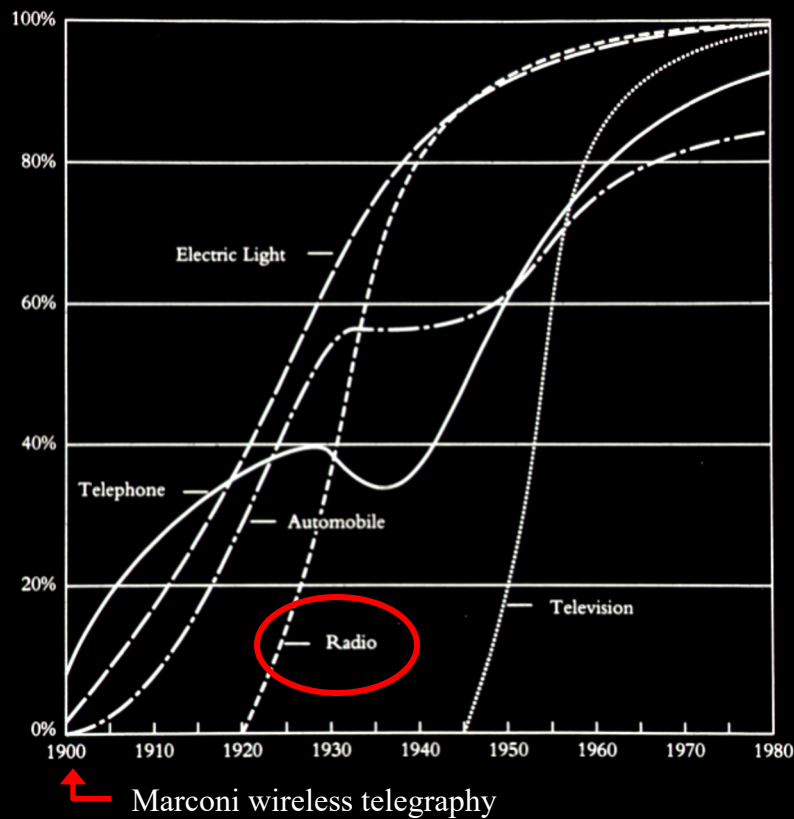
Economics and Politics



Consumer Goods 1900 - 1980

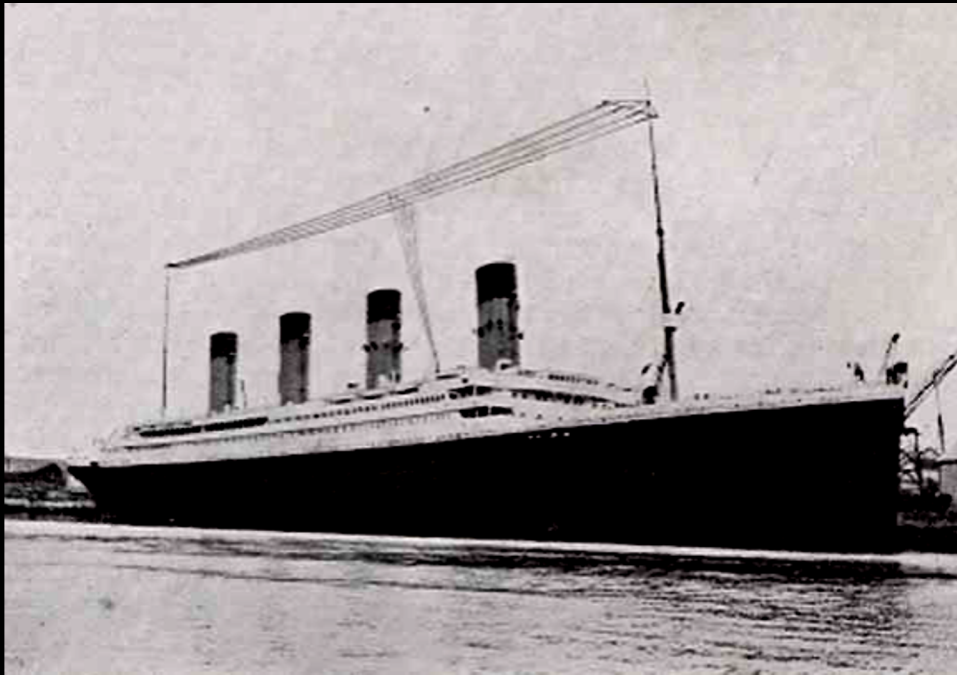


RMS Titanic with Marconi Antenna



Economics and Politics





RMS Titanic with Marconi Antenna

Electricity

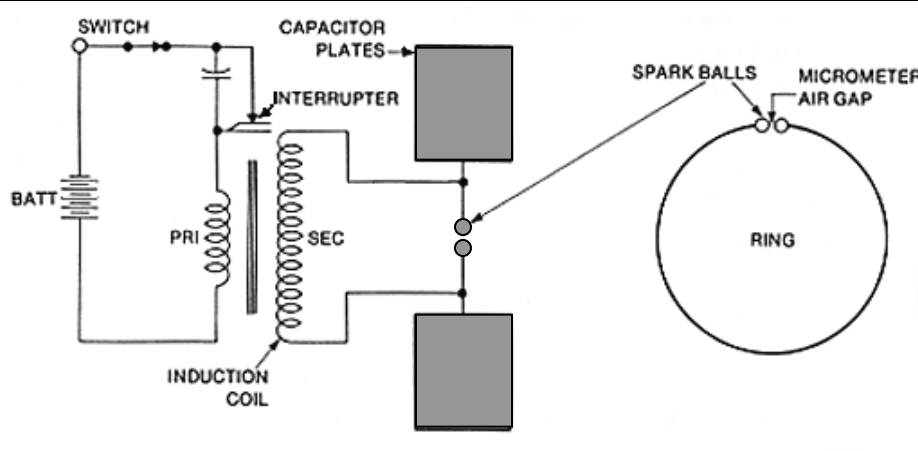
Morse - Intelligence at a distance

Edison - Lighting a city

Westinghouse - Power at a distance

Marconi - Wireless messages at sea

transmitter receiver



Heinrich Hertz's Experiment - 1888

- Spark in transmitter initiates radio burst
- Spark in receiver ring detects radio burst

Electricity

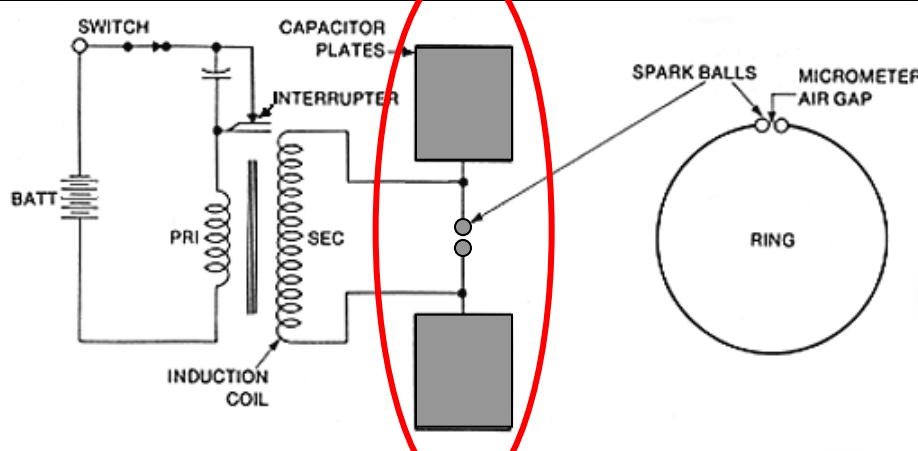
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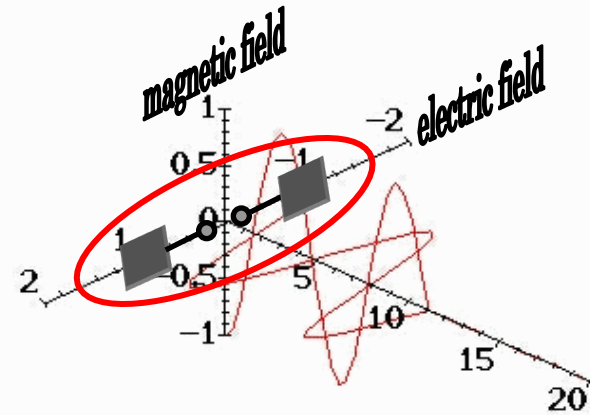
Marconi - Wireless messages at sea

transmitter receiver

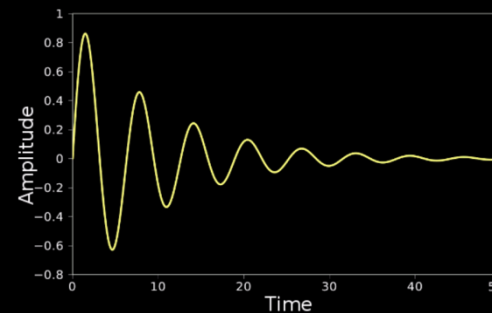


Heinrich Hertz's Experiment - 1888

- Spark in transmitter initiates radio burst
- Spark in receiver ring detects radio burst



- * One-meter long wire legs separated by spark gap
- * Radio waves generated at $\sim 50,000,000$ cycles/second



Roughly 5 cycles of electrical oscillation after each spark

Electromagnetic Wave

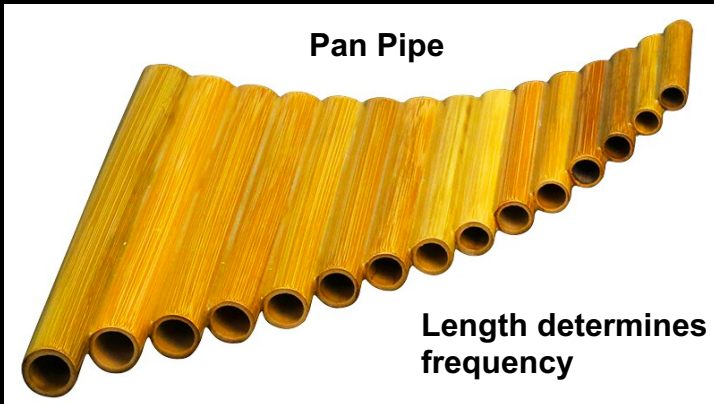
frequency wave-speed

$$\nu \lambda = c$$

wavelength

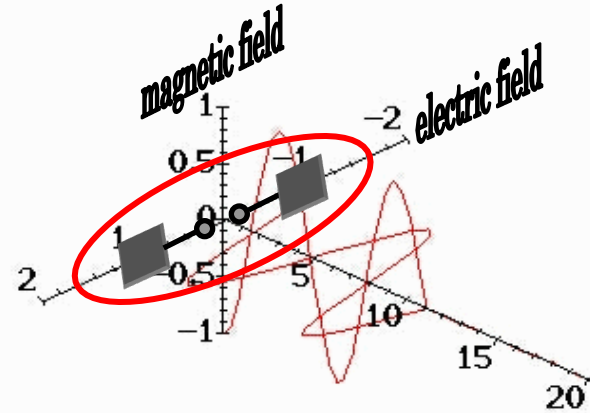


Time or Length

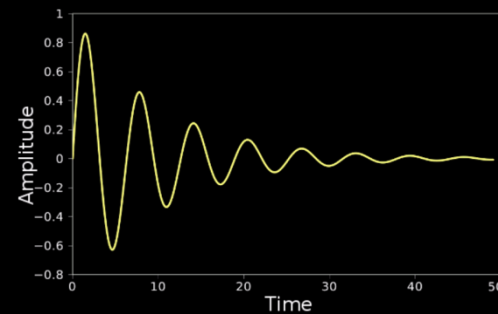


Pan Pipe

Length determines frequency



- * One-meter long wire legs separated by spark gap
- * Radio waves generated at $\sim 50,000,000$ cycles/second



Roughly 5 cycles of electrical oscillation after each spark

Electromagnetic Wave

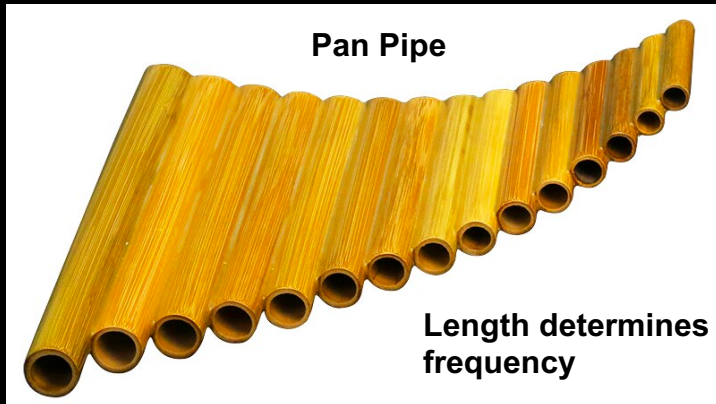
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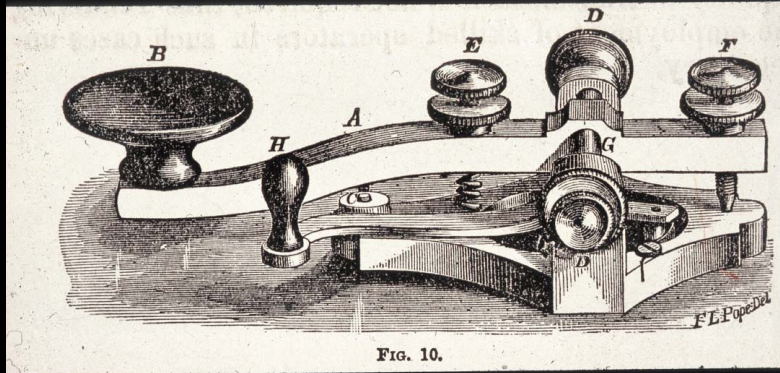
Wireless Telegraph

Hertz Discovery

Marconi Patents

Marconi Demonstrations

Marconi's Wireless Telegraph

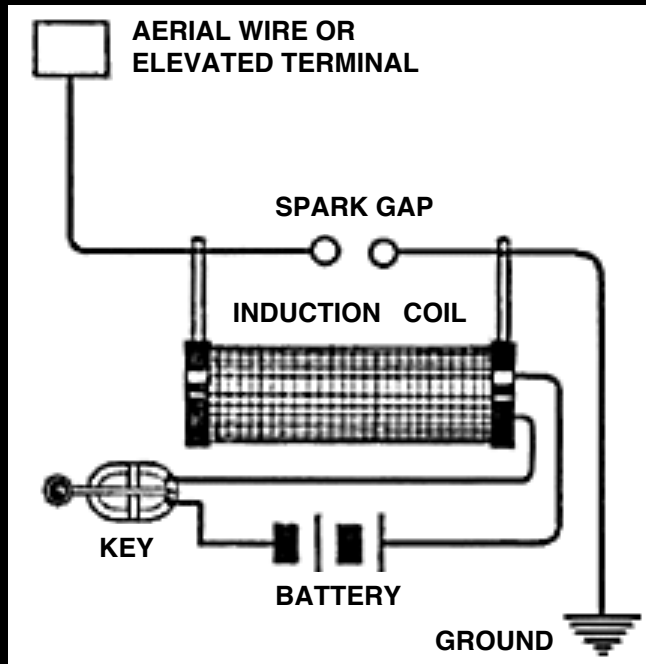


Wireless Telegraph

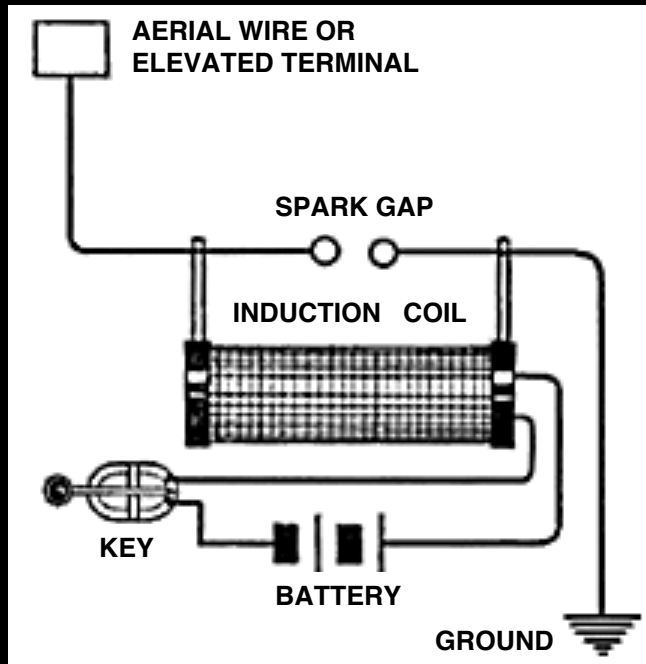
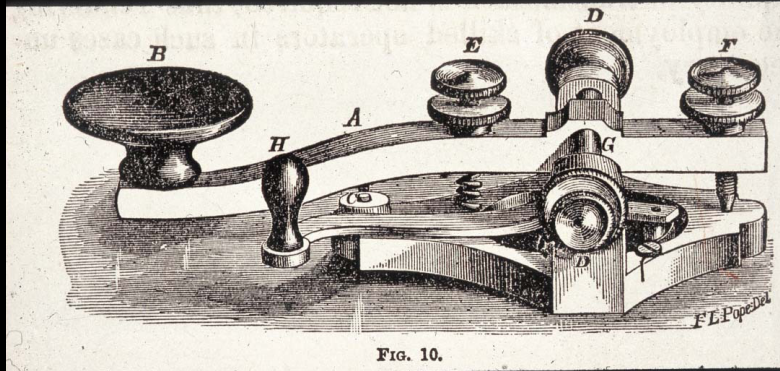
Hertz Discovery

Marconi Patents

Marconi Demonstrations



Marconi's Wireless Telegraph





transmitter

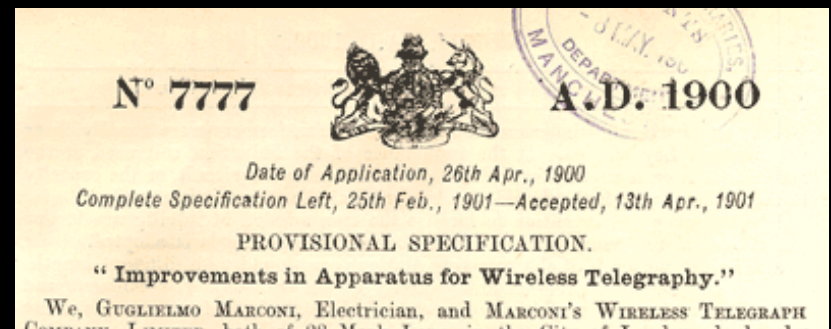
receiver



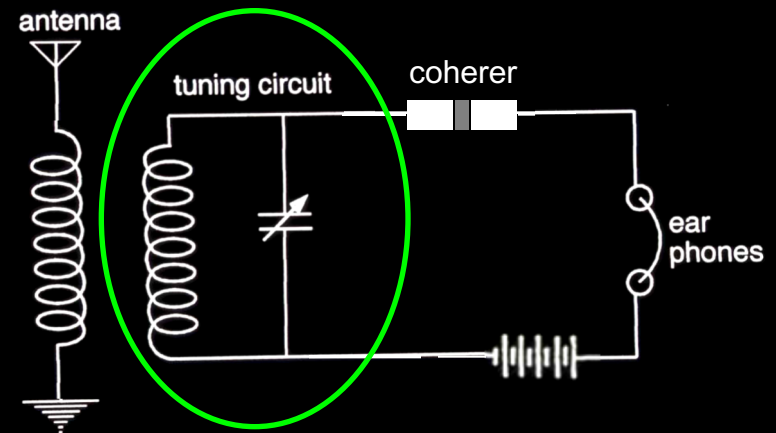


transmitter

receiver

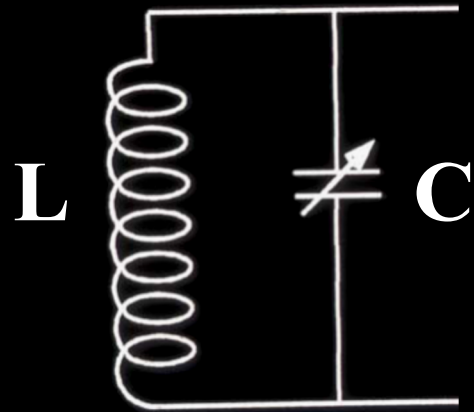


Marconi's 7777 Patent tuning circuits used for transmitter and receiver

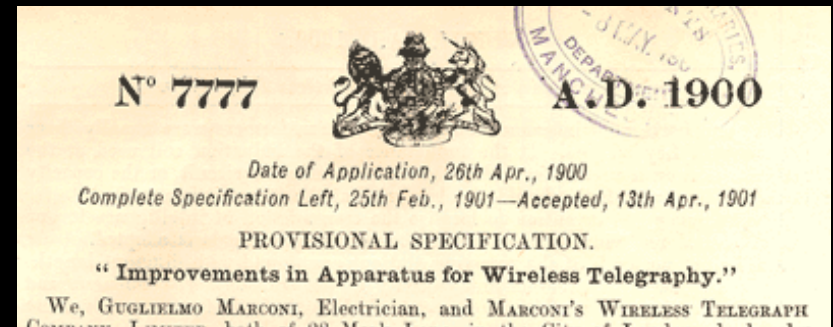
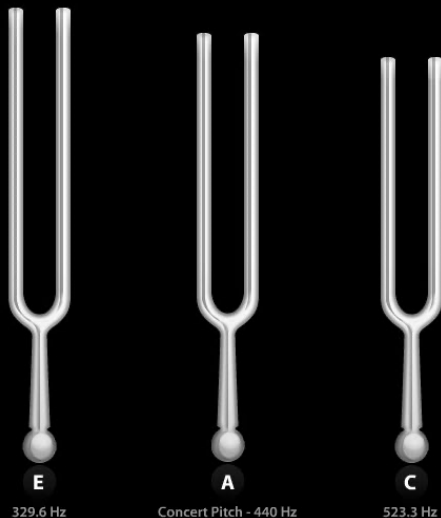


Coherer resistance drops when hit with radio burst – causes click in ear phones – then a tap returns it to high resistance

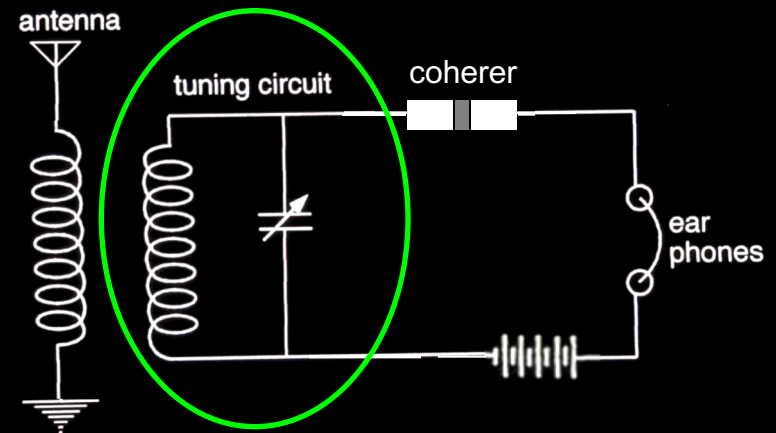
Tuning Circuit (sensitive and selective)



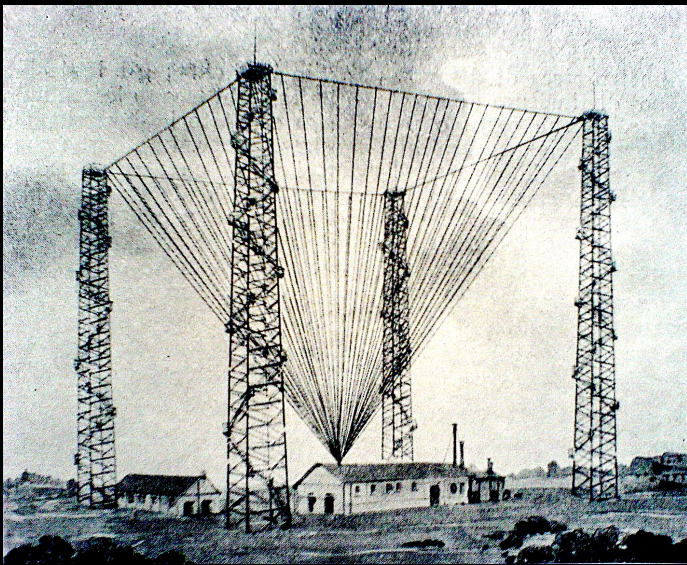
Adjust resonant frequency by changing C



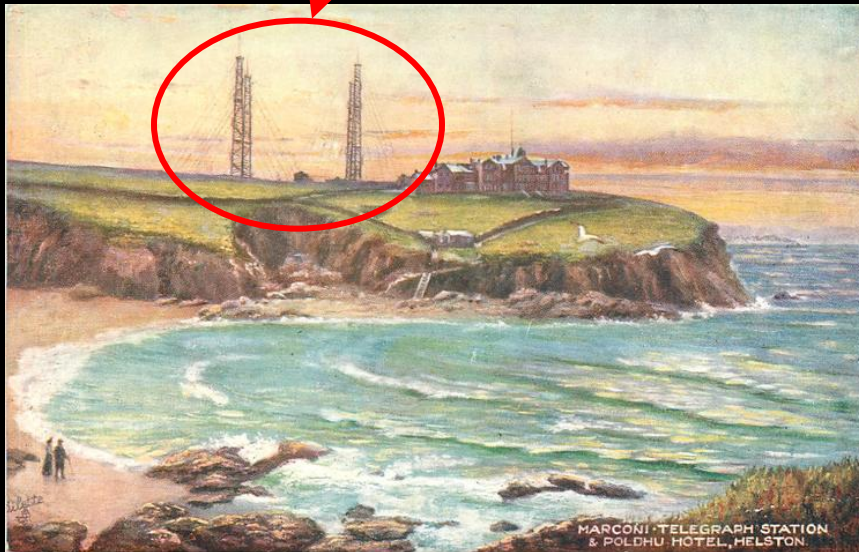
Marconi's 7777 Patent tuning circuits used for transmitter and receiver



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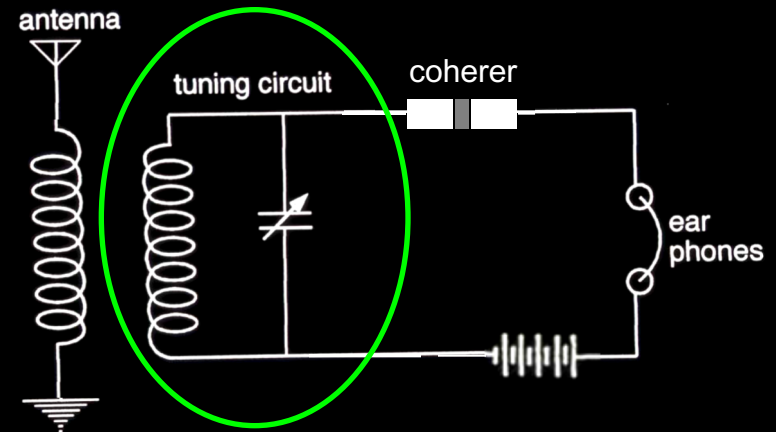
Inverted Pyramid Transmitting Antenna



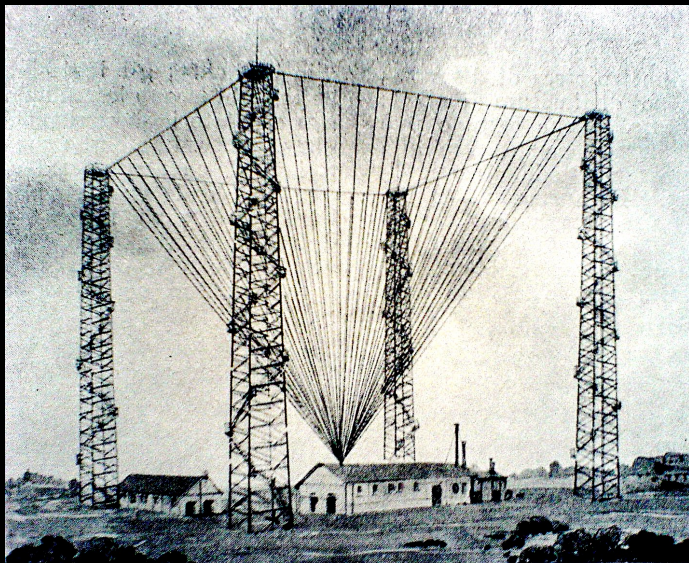
Cornwall (England)



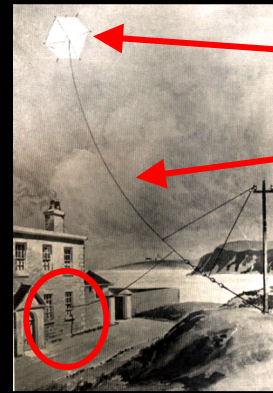
Marconi's 7777 Patent tuning circuits used for transmitter and receiver



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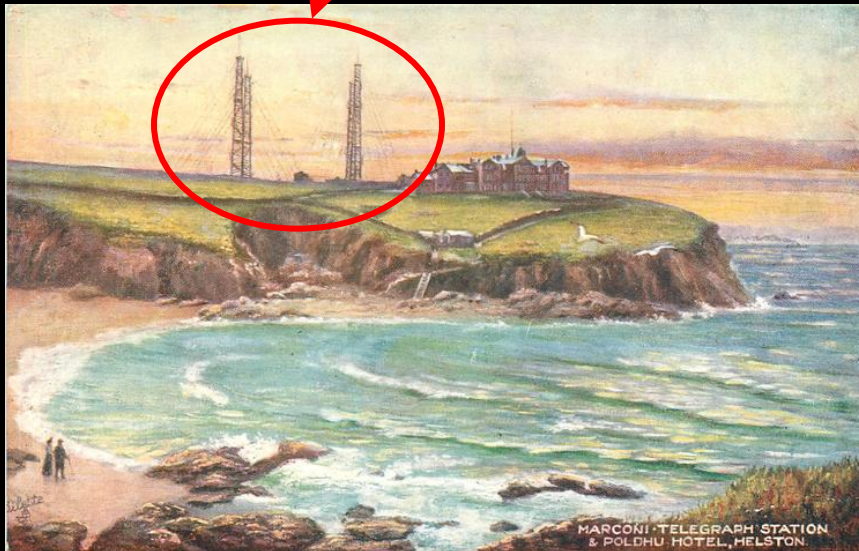
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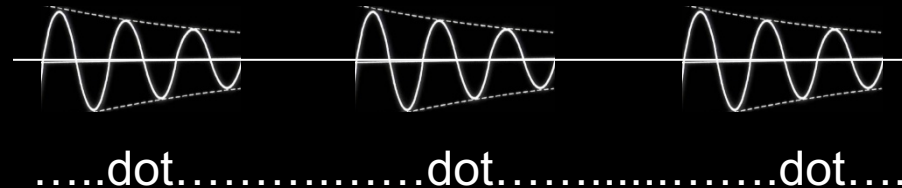
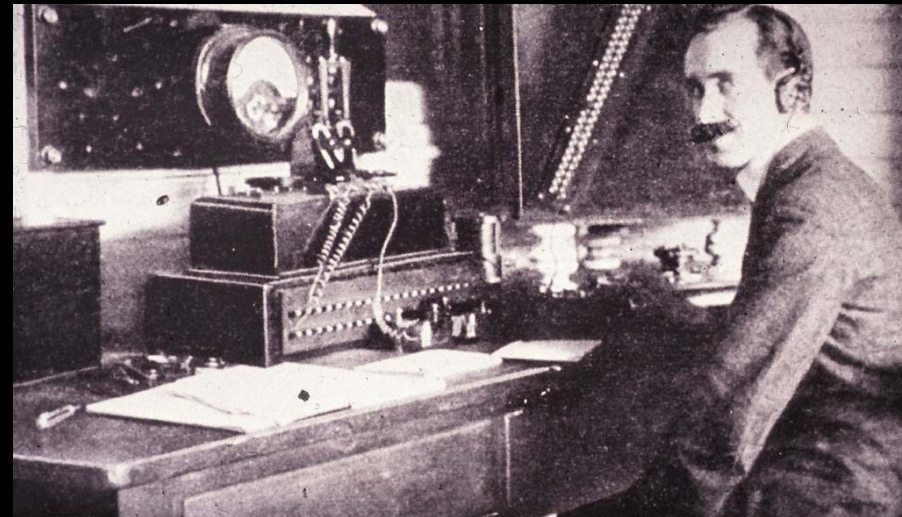
KITE

Receiving antenna

Saint John's (Newfoundland)



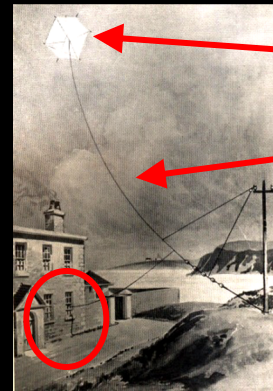
Cornwall (England)



December 12, 1901 17

Crossing the Atlantic

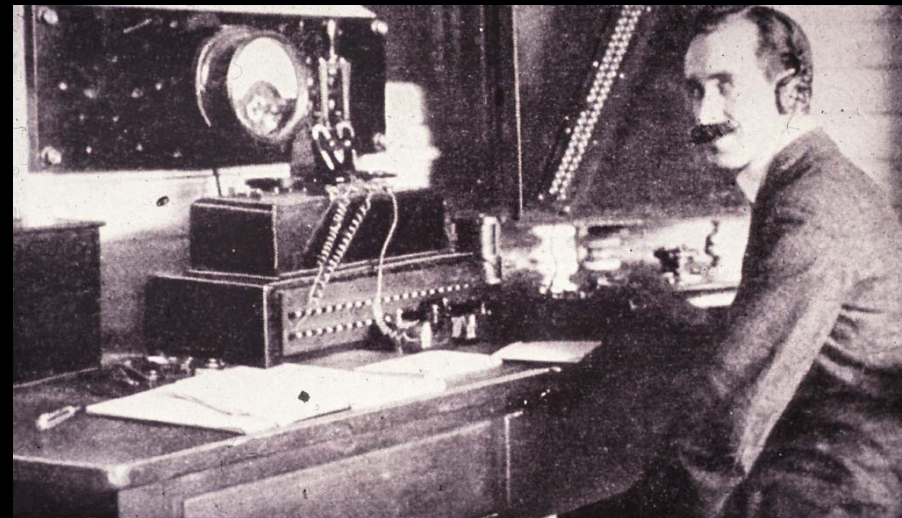
1856	Morse	telegraph
1901	Marconi	wireless
1927	Lindberg	airplane



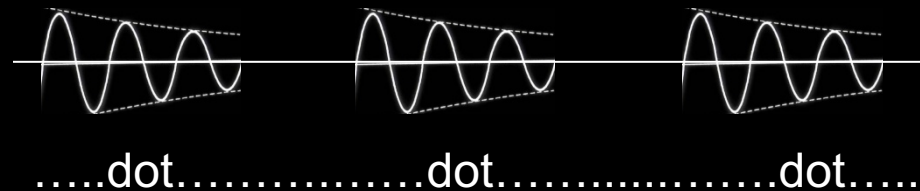
KITE

Receiving antenna

Saint John's (Newfoundland)



Marconi gets Physics Nobel Prize in 1909

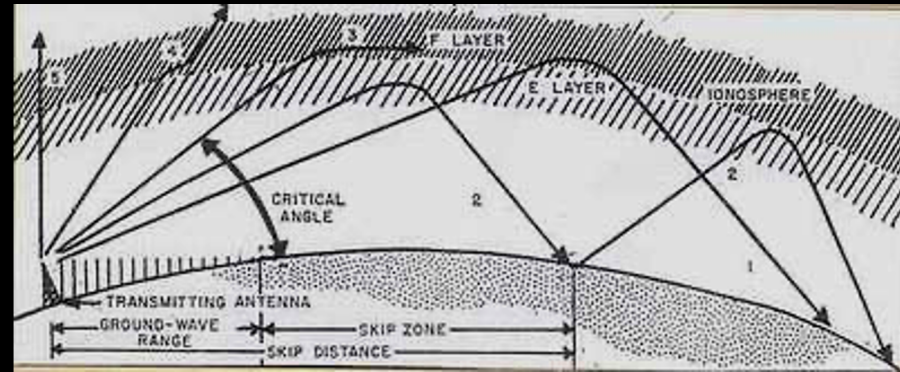
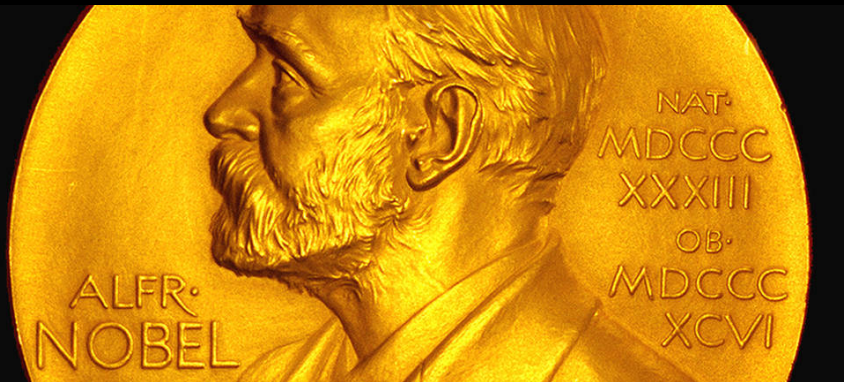


December 12, 1901 ¹⁸

Crossing the Atlantic

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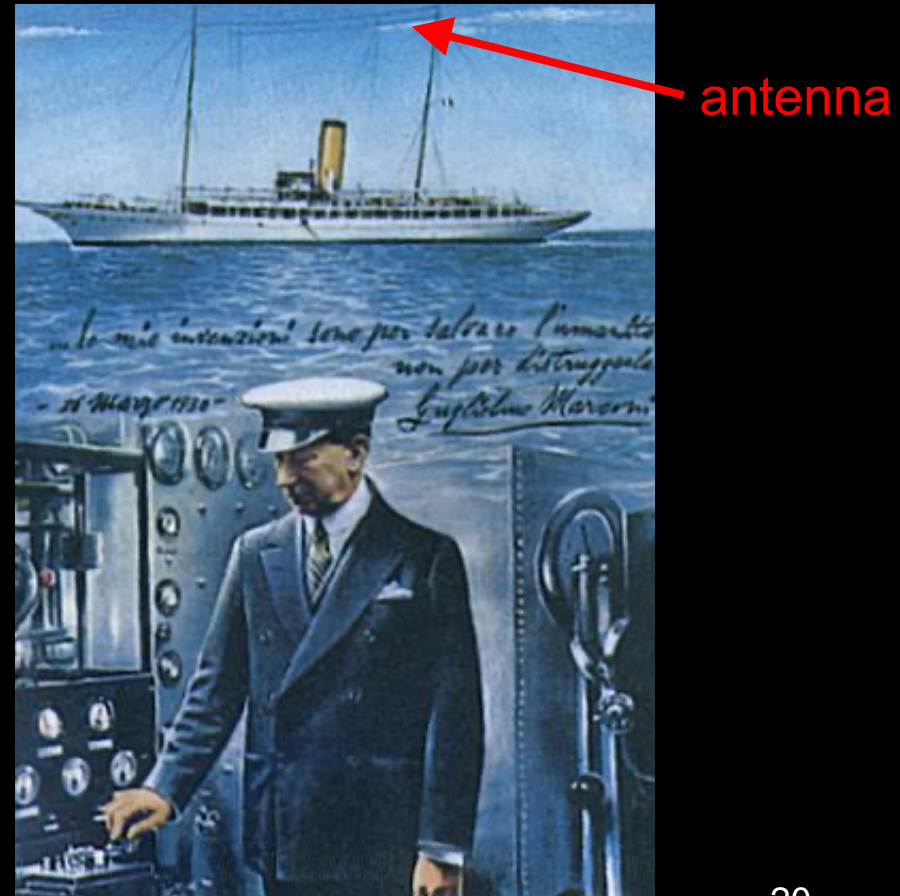
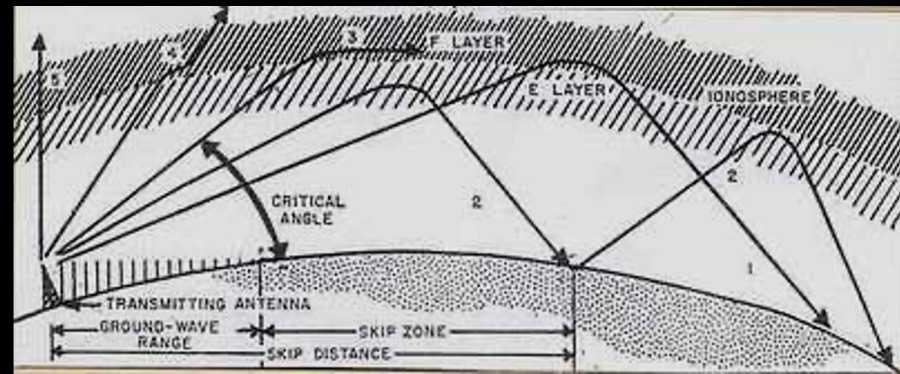
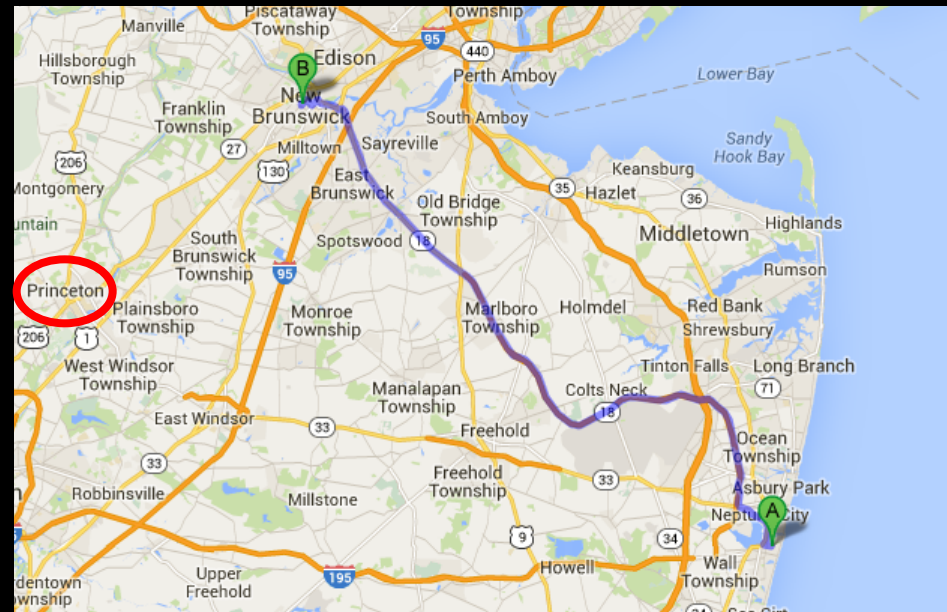


World Wide Wireless Plan in 1912



Each location to be a station pair, ...

Transmitter in New Brunswick NJ
Receiver in Belmar NJ

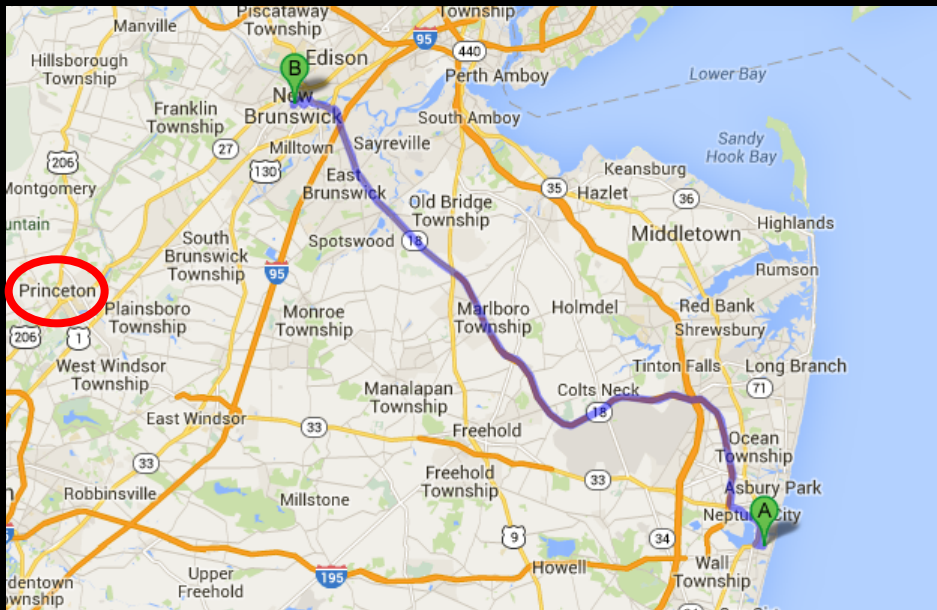


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Marconi Wireless Telegraph Company of America



World Wide Wireless Spanning the Atlantic and Pacific

Public message service is
now in successful operation

AT GREATLY REDUCED RATES BETWEEN
**AMERICA, GREAT BRITAIN
JAPAN, HAWAII, ALASKA**

Universal communication with ships at sea
Commercial office—42 Broad St., New York

Builders of every type of Wireless Apparatus
Works at Aldene, New Jersey

School of Instruction for Operators—
25 Elm St., New York

John W. Griggs, *President*
Edward J. Nally, *Vice-President & General Manager*
George S. DeSousa, *Traffic Manager*

Executive offices
WOOLWORTH BUILDING, NEW YORK



In later years Marconi rejects idea to
send voice by radio

Inflexible Pioneer (with a dark side)

**Marconi
Wireless Telegraph Company
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Theories of Innovation

applied science
social process
individual genius

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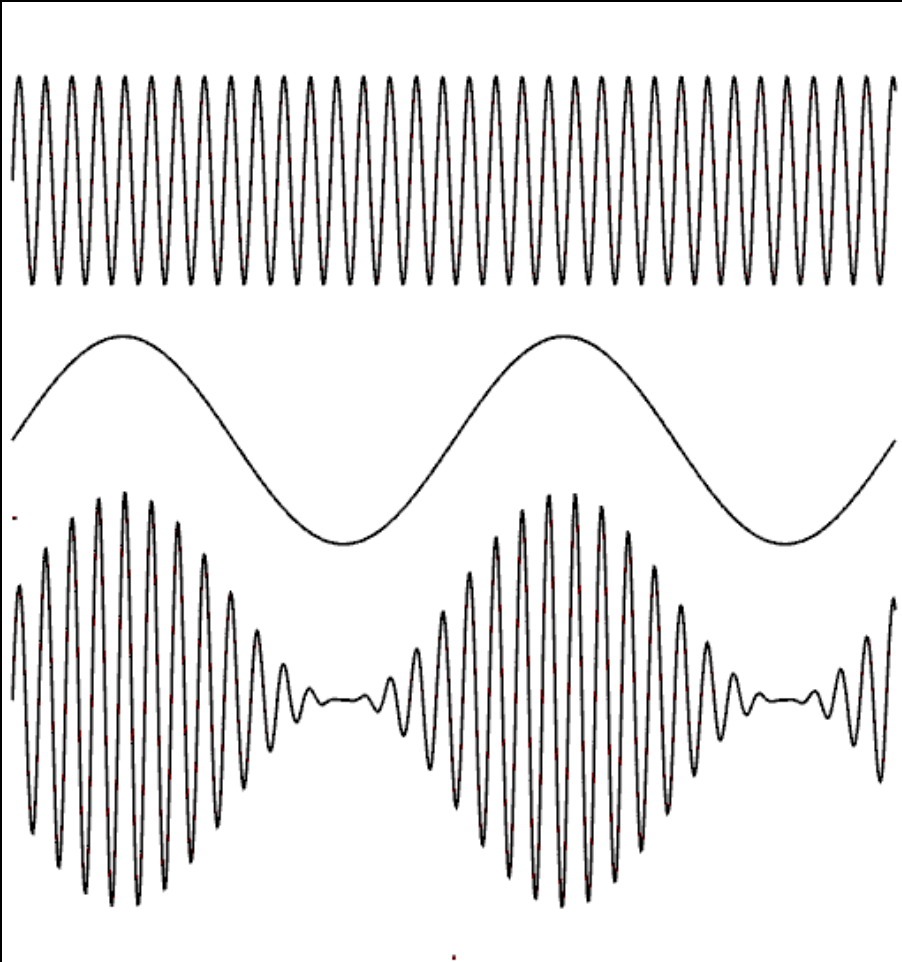
Theories of Innovation

applied science
social process
individual genius



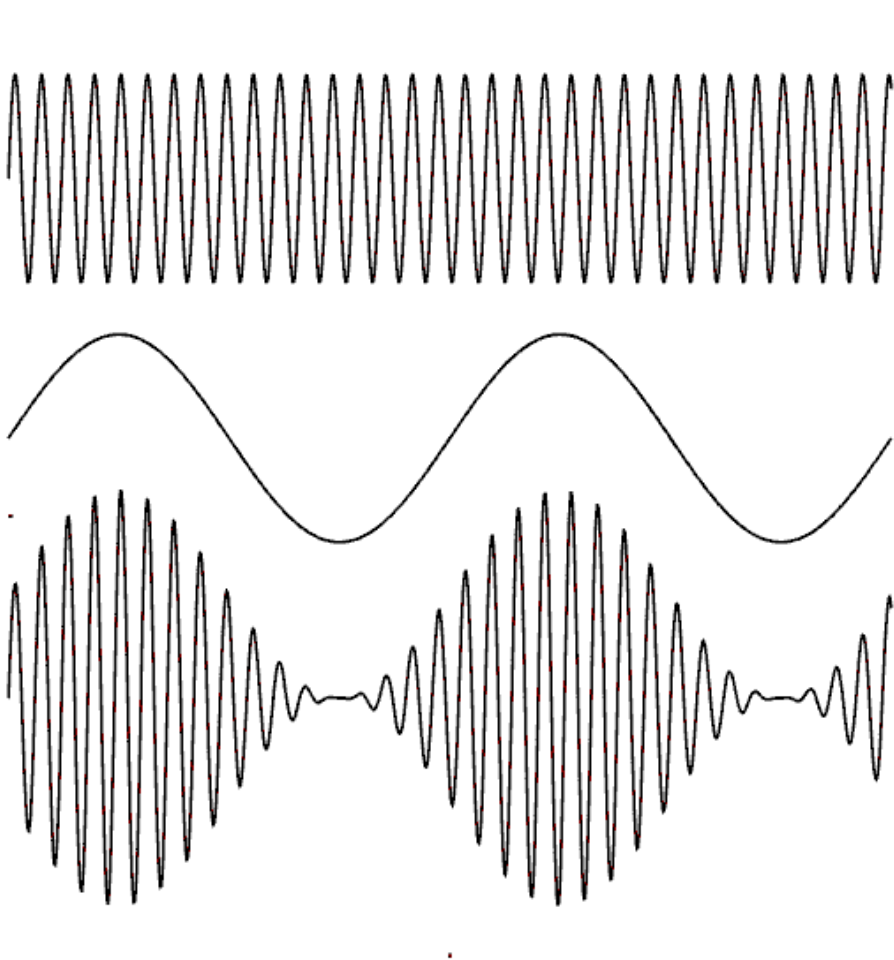
EE Prof. Reginald Fessenden
University of Pittsburgh - 1906

Amplitude Modulated (AM) Carrier Wave



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Amplitude Modulated (AM) Carrier Wave

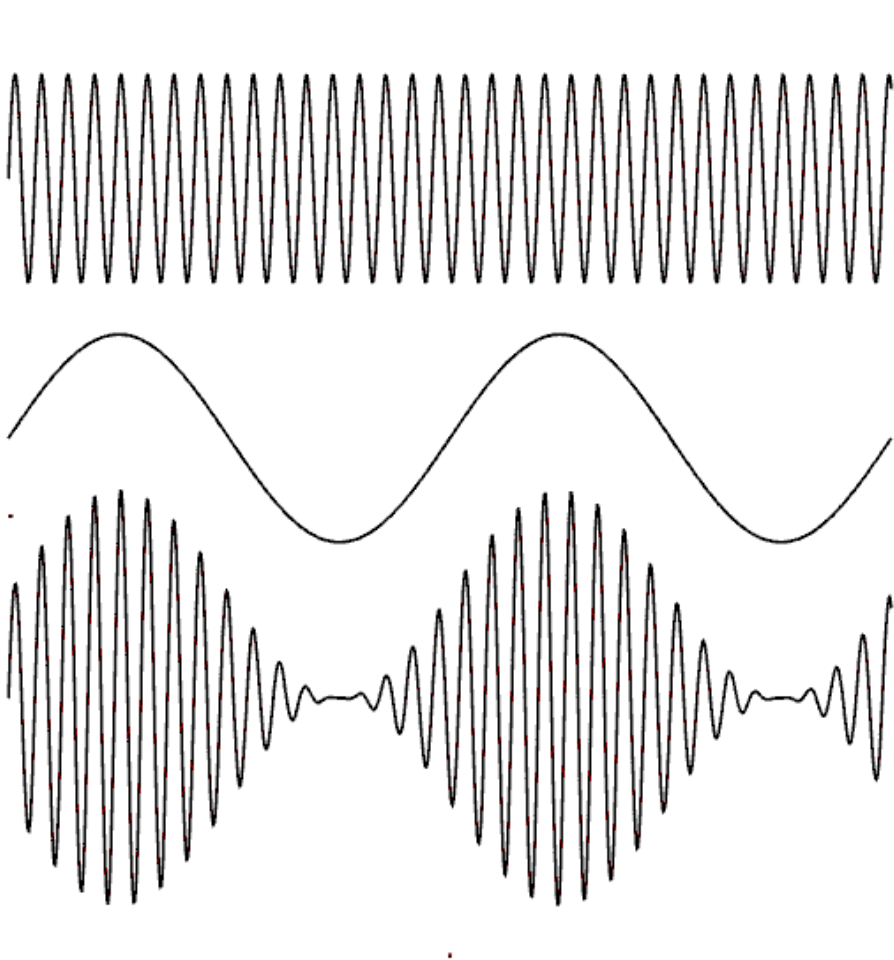


← 550 – 1600 KHz (Carrier Freq.)
example – 1010 KHz (WINS)

← 20 – 10,000 Hz (Audio Freq.)
example – 440 Hz (musical note A₄)

← Combined Wave

Amplitude Modulated (AM) Carrier Wave



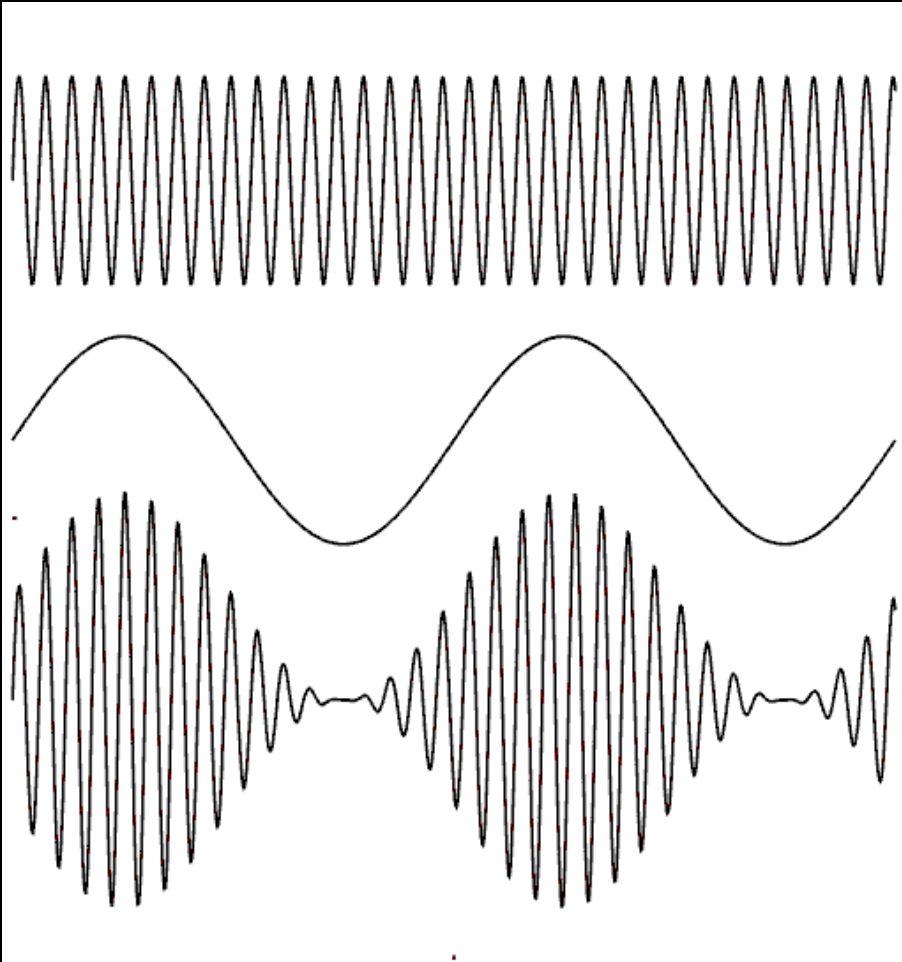
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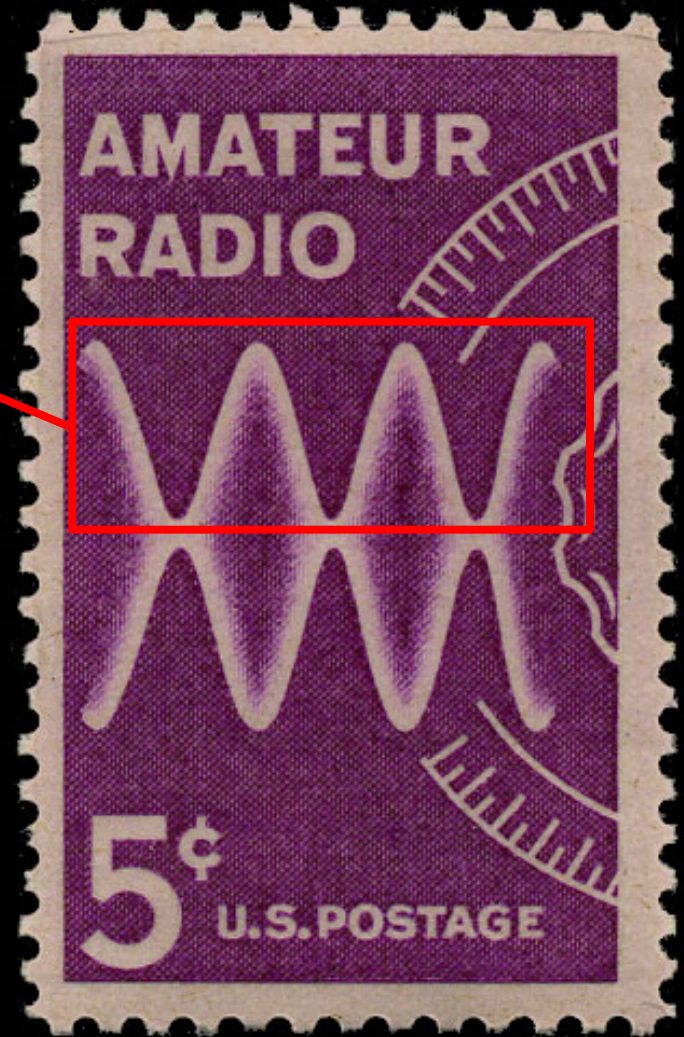
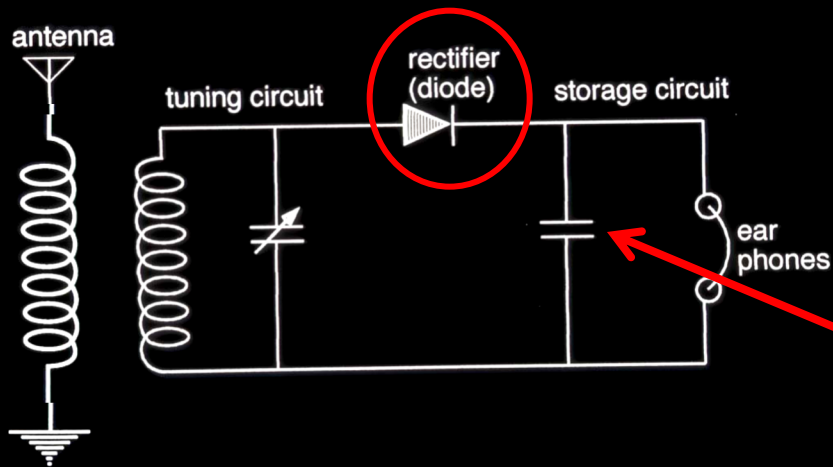
← Combined Wave

Demonstration
Amplitude Modulation and Detection

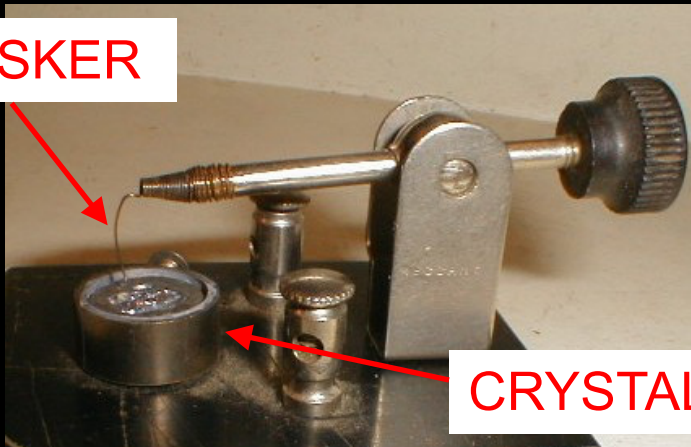
Amplitude Modulated (AM) Carrier Wave



Cat's Whisker Crystal Radio



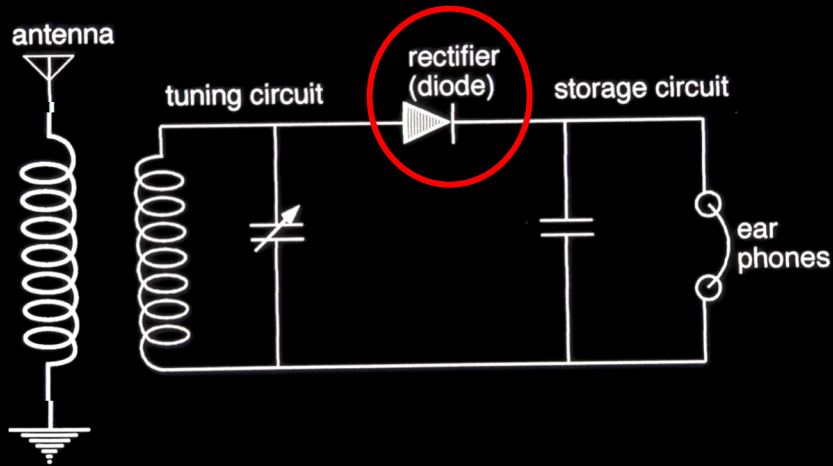
WHISKER



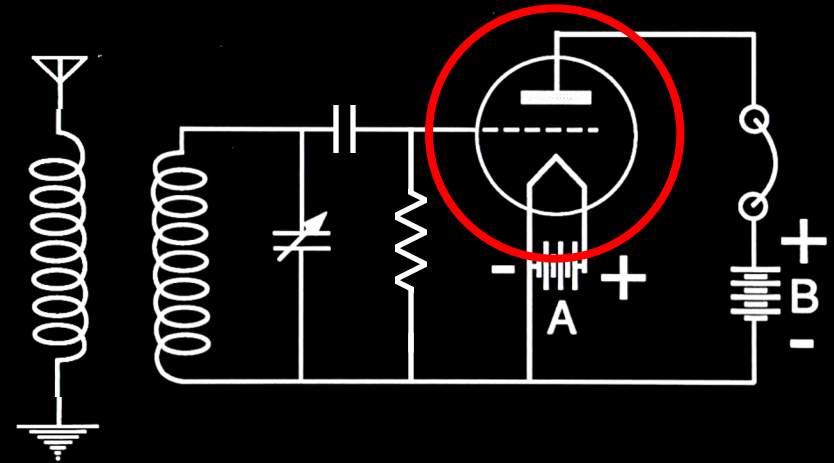
CRYSTAL

Crystal Diode as
One-Way Valve

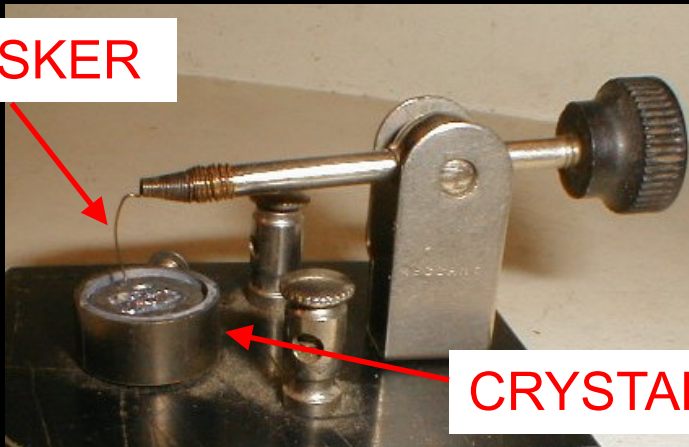
Cat's Whisker Crystal Radio



Vacuum Tube Radio



WHISKER



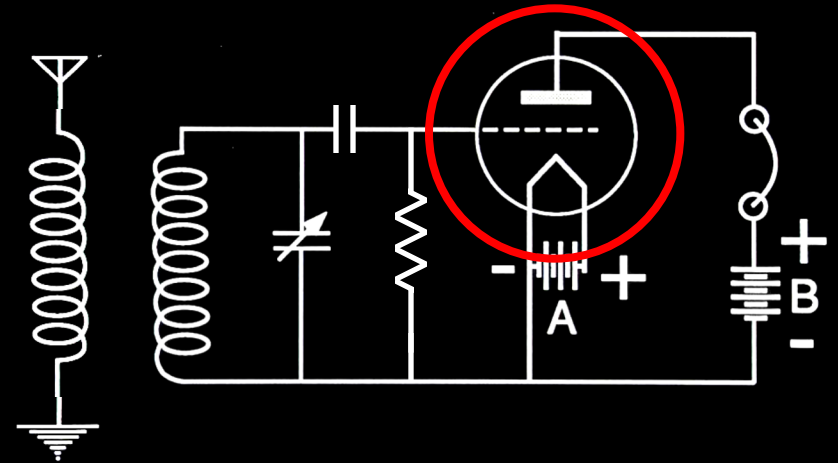
Crystal Diode as
One-Way Valve



Light Bulb Triode as both
One-Way Valve and Amplifier



Vacuum Tube Radio



Light Bulb Triode as both
One-Way Valve and Amplifier



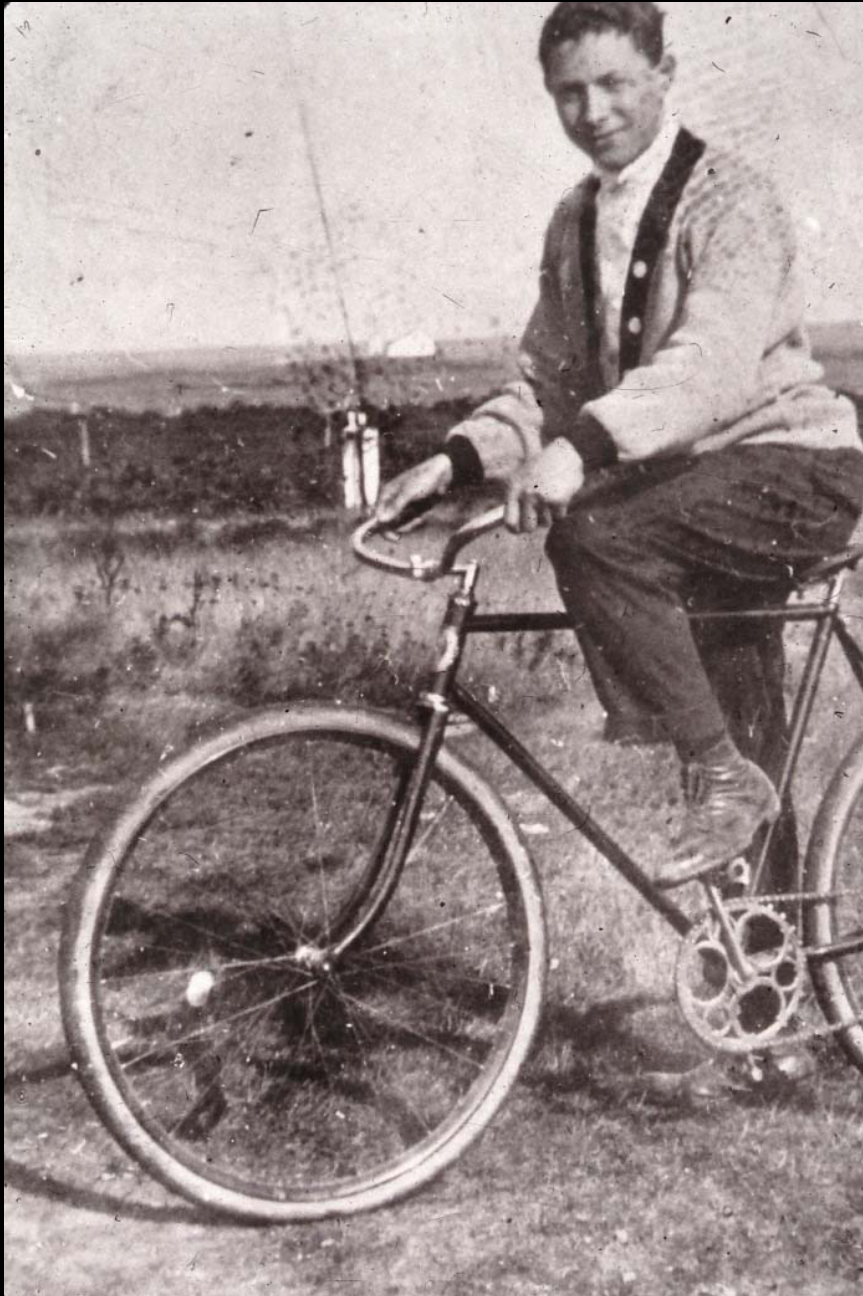
David Sarnoff

early (before WWI)

Telegrapher and office boy
American Marconi Company

Meets Columbia Univ. Student
Edwin Armstrong

Commercial Manager of
American Marconi Company



David Sarnoff

early (before WWI)

Telegrapher and office boy
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“I have in mind a plan of development which would make radio a ‘household utility’ in the same sense as the piano or phonograph. The idea is to bring music into the house by wireless.”

- Sarnoff in 1915

"The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?"

- Sarnoff's associates in response to his urgings for investment in the radio in the 1920s

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Edwin Howard Armstrong

Regeneration Circuit

First IRE Medal of Honor

SUPERHET Circuit

FM Radio Circuit



Edwin Howard Armstrong

Regeneration Circuit

First IRE Medal of Honor

SUPERHET Circuit

FM Radio Circuit







After WWI ...

Radio Corporation of America

RCA founded out of American Marconi with GE executive as CEO

RCA buys AT&T's patents

RCA buys Westinghouse's patents

... and then dominates American Radio

After WWI ...



Listening to KDKA (Pittsburgh) - 1921

Radio Corporation of America

RCA founded out of American Marconi
with GE executive as CEO

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After WWI ...

Sarnoff

Einstein



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New Brunswick NJ – 1921

After WWI ...

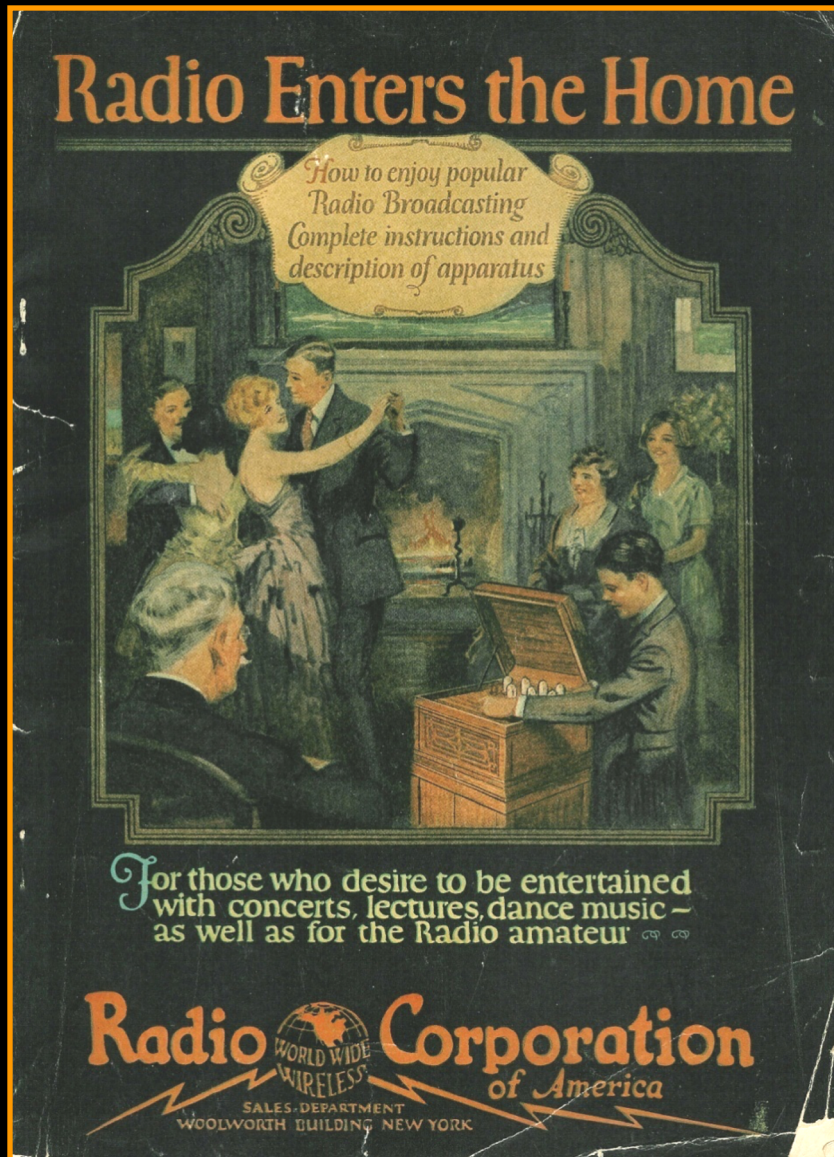
Radio Corporation of America

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RCA Catalog of Products - 1922

Radio Enters the Home

How to enjoy popular
Radio Broadcasting
Complete instructions and
description of apparatus



For those who desire to be entertained
with concerts, lectures, dance music -
as well as for the Radio amateur

Radio Corporation
of America
SALES DEPARTMENT
WOOLWORTH BUILDING NEW YORK



Newlyweds - Edwin and Marion Armstrong
in December 1922



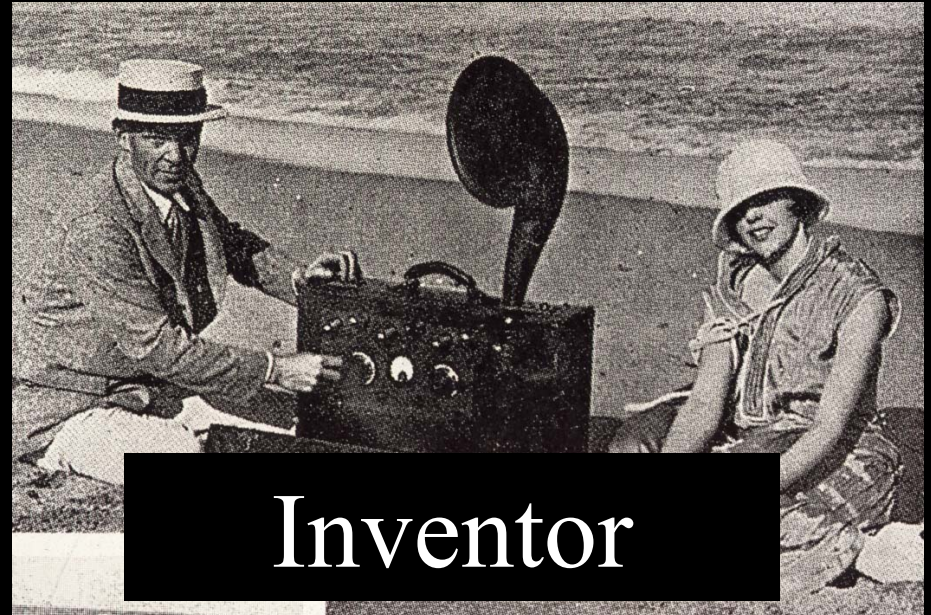
First Broadcasting Network - 1926



Newlyweds - Edwin and Marion Armstrong
in December 1922



First Broadcasting Network - 1926



Newlyweds - Edwin and Marion Armstrong
in December 1922



Entrepreneur

First Broadcasting Network - 1926



David Sarnoff
President of RCA in 1929



Presidential Fireside Chats with
US Citizens 1933 - 1944



David Sarnoff
President of RCA in 1929



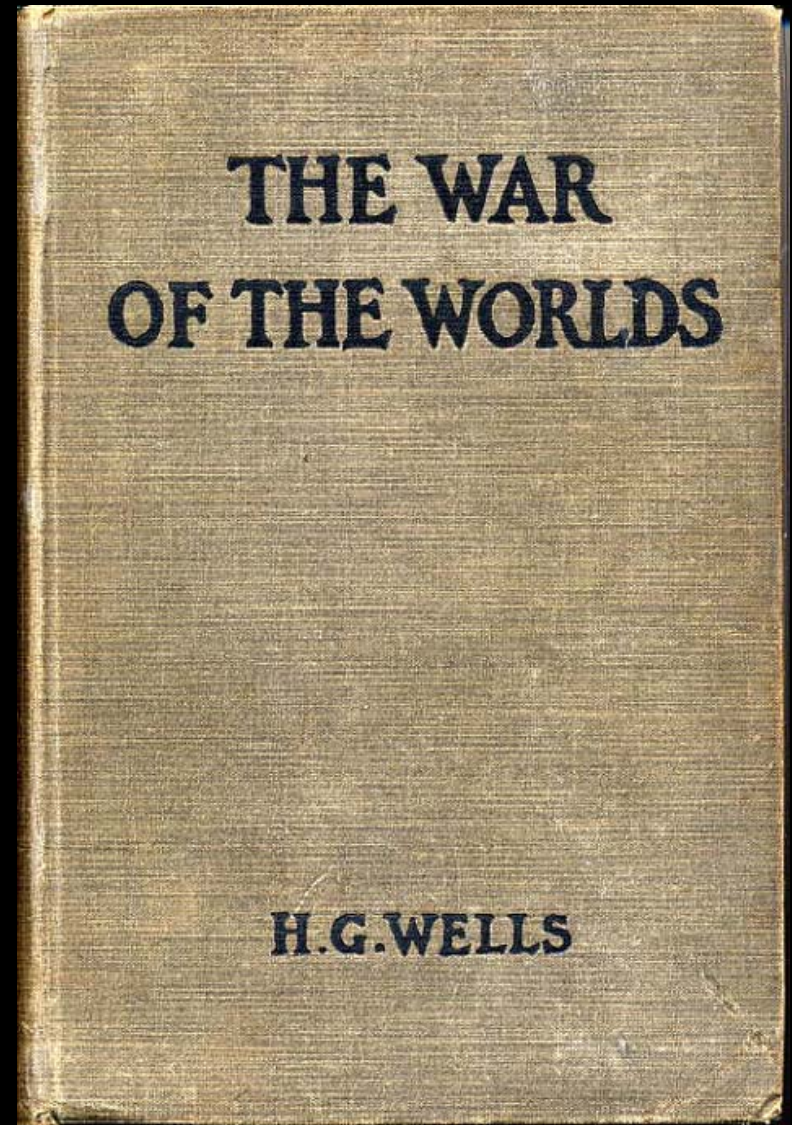
Radio Drama: Mercury Theatre
on the Air with Orson Wells



David Sarnoff
President of RCA in 1929



Radio Drama: Mercury Theatre
on the Air with Orson Wells



3:34 into radio broadcast



Radio Drama: Mercury Theatre
on the Air with Orson Wells

Ladies and gentlemen, we interrupt our program of dance music to bring you a special bulletin from the Intercontinental Radio News.

At twenty minutes before eight, central time, Professor Farrell of the Mount Jennings Observatory, Chicago, Illinois, reports observing several explosions of incandescent gas, occurring at regular intervals on the planet Mars. The spectroscope indicates the gas to be hydrogen and moving towards the earth with enormous velocity.

Professor Pierson of the Observatory at Princeton confirms Farrell's observation, and describes the phenomenon as, quote, "like a jet of blue flame shot from a gun," unquote.

We now return you to the music of Ramón Raquello, playing for you in the Meridian Room of the Park Plaza Hotel, situated in downtown New York.

The New York Times.

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NEW YORK, MONDAY, OCTOBER 31, 1938.

FP

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MEAD STANDS PAT AS A NEW DEALER IN BID FOR SENATE

Democratic Candidate Opposes
Any Except Minor Changes in
Labor and Security Laws

UPHOLDS THEORY OF TVA

Radio Listeners in Panic, Taking War Drama as Fact

Many Flee Homes to Escape 'Gas Raid From
Mars'—Phone Calls Swamp Police at
Broadcast of Wells Fantasy

A wave of mass hysteria seized thousands of radio listeners throughout the nation between 8:30 and 9:30 o'clock last night when a broadcast of a dramatization of H. G. Wells's fantasy, "The War of the Worlds," first broadcast in the air over station WJZ, and

OUSTED JEWS FIND REFUGE IN POLAND AFTER BORDER STAY

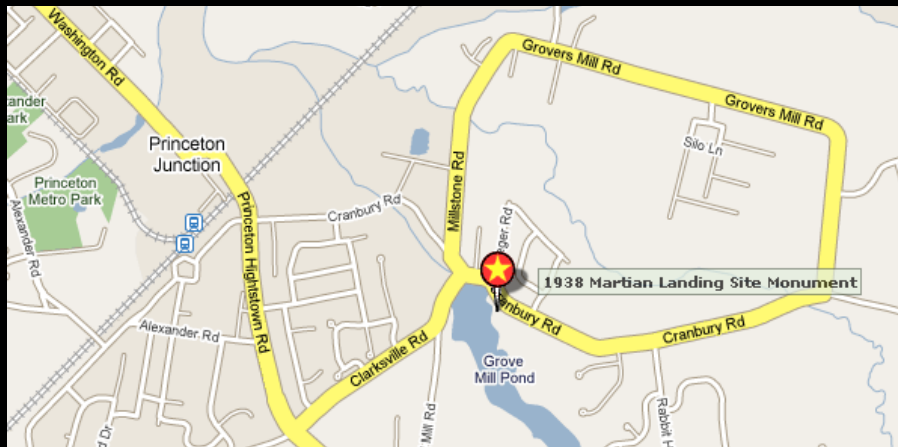
Exiles Go to Relatives' Homes
or to Camps Maintained by
Distribution Committee

REVEAL CRUELTY OF TRIP

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Halloween Prank in 1938



Grover's Mill, West Windsor NJ

3:34 into radio broadcast

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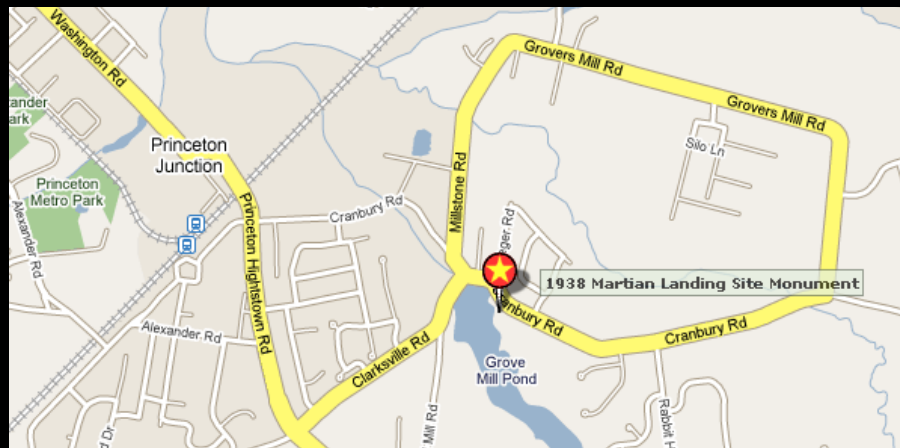
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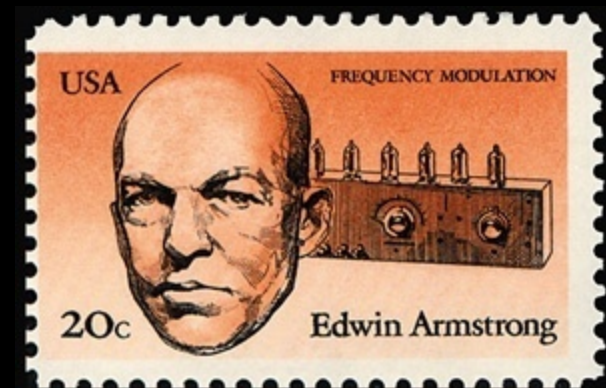
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Halloween Prank in 1938



Grover's Mill, West Windsor NJ



W2XMN & W2XEA

Maj. Armstrong Leaps to Death; FM Inventor; 63



Maj. EDWIN ARMSTRONG.

Note Blames Estrangement

Maj. Edwin Howard Armstrong, 63, the electronics genius who invented FM radio, leaped to his death today from his 13th-floor apartment at River House, 435 E. 52nd St.

A note found by the police in the empty Armstrong apartment indicated that Maj. Armstrong had sought death because of a recent estrangement from his wife, Mrs. Esther Marion Armstrong, now visiting a sister in Granby, Conn.

Maj. Armstrong, professor of electrical engineering at Columbia University, who won the Medal of Merit and a Presidential citation for his contribution to military communications by radio, was recognized as having done more than any other man toward improving radio in the past 30 years. His newest development was a system for multiplexing FM radio so that more than one program could be sent out simultaneously on the same wavelength.

Body Found on Roof.

Maj. Armstrong's body, fully clothed, was found on the roof

Maj. Armstrong, Genius Of Radio, Dies in Plunge

(Continued From Page One.)

E. A. Laurence, of 101 E. 89th St., told reporters that the major had no "immediate illness" when he examined him recently.

The police learned that Mrs. Armstrong left for New York immediately upon hearing of her husband's death. A friend made arrangements to have the body taken to Campbell's Funeral Home at 81st St. and Madison Ave.

No Motive Learned.

Associates at Columbia could not ascribe any motive for suicide. So far as they know, they said, Maj. Armstrong had not complained of illness and had shown no indications of mental depression. He had been at the Marcellus Hartley Laboratories, of which he had charge, within the last few days.

Major Armstrong was credited with having made the four most important contributions to radio. First, he devised the regenerative circuit which took radio out of the crystal detector stage and made possible the loudspeaker. Second came the superheterodyne circuit, which ever since its invention has been the basis of radio reception. Third came the super-regenerative circuit, and finally, in 1935, FM (frequency modulation) radio, which permits reception without static interference of any kind. The audio reception accompanying television is frequency-modulated.

Served in Two Wars.

Maj. Armstrong served in the Army Signal Corps in World

he might have access to the laboratories. He became a full professor at the university in 1934.

Worked Atop Palisades.

Major Armstrong conducted most of his radio experimentation from a small red brick building shielded by tall trees and a high wire fence off Route 9W at Alpine, N. J., atop the Palisades. Most persons would not have known of the existence of a radio outfit there but for the 400-foot transmitter tower that rose above it.

Radio engineers the world over, however, knew of its existence and they and thousands of listeners knew it only as FM Station W2XMN and W2XEA operating on 44.1 and 92.1 megacycles. Few, however, knew that it was an experimental station, or that it was the granddaddy of all FM radio stations. For the most part its programs, devoted largely to dance music, gave no hint of experimentation.

Won Many Citations.

Over the years, Maj. Armstrong won many honors. On Jan. 28, 1947, President Harry S. Truman presented him with the Army Medal of Merit and a citation stating that "Maj. Armstrong contributed greatly to the improvement of military communication by his inventions in the field of radio and by his unselfish, patriotic service to the signal corps." Other honors included:

Medal of Honor of Institute of Radio Engineers, 1917; Radio



February 1, 1954

W2XMN & W2XEA

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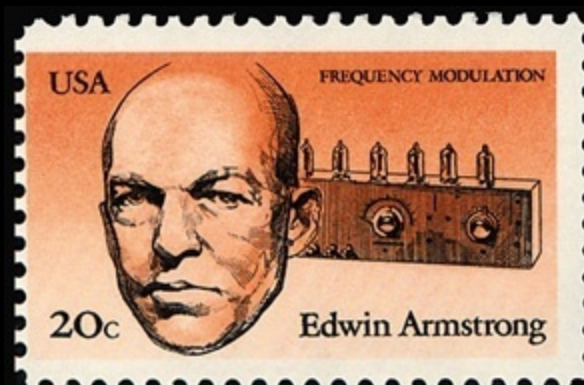
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TIME

THE WEEKLY NEWSMAGAZINE



RCA'S SARNOFF
"Who would dare predict the future?"



February 1, 1954

W2XMN & W2XEA

Ham Radio Operators become Electronics Industry Pioneers



David Packard
9DRV

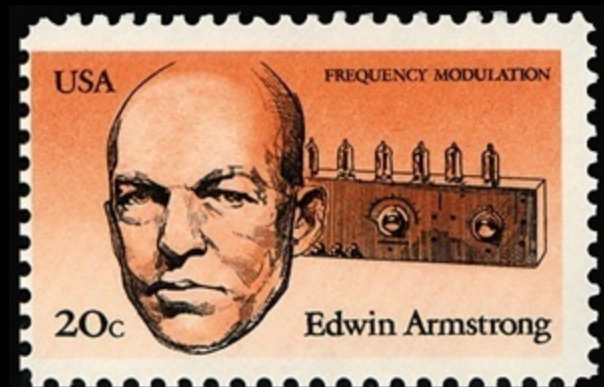


Frederick Terman
6AE

Jack St. Clair Kilby
W9GTY



Steve Wozniak
6A6BND



W2XMN & W2XEA

Ham Radio Operators become Electronics Industry Pioneers



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9DRV



Frederick Terman
6AE

Jack St. Clair Kilby
W9GTY



Steve Wozniak
6A6BND

Key Ideas

Scientific:

Marconi's Tuning Circuit
Armstrong's Many Circuits

Social:

Sarnoff's Broadcast System
Federal Control of Airwaves

Symbolic:

FDR speaks to the Nation