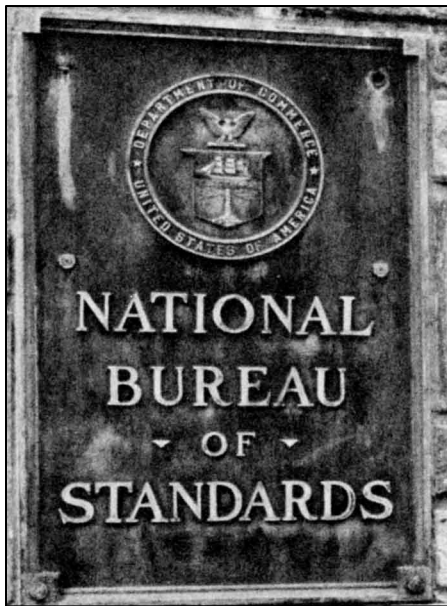


Measurements And Standards For Radio



**NBS Supports
A New Industry**

The Bottom Line First:

Radio had a huge impact
on the 20th Century,
and
NBS made
important contributions
to radio science & technology

Is “Radio” Still Important In The Age of Smart Phones?



YES!

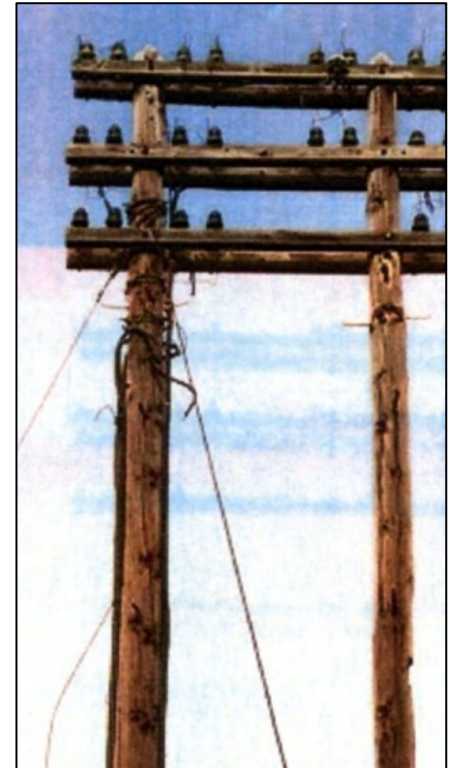
Radio's Spinoffs

- Television
- Microwaves and Radar
- Radio Astronomy
- Computers
- Electron Microscopes
- Radio Control, Navigation and Guidance
- Test Equipment (oscilloscopes, signal generators, volt-ohmmeters, etc.)
- Satellite communications
- Smart Phones and Wi-Fi

Radio Did Not Begin As An Entertainment Medium

It Came About Because People Wanted to Send Telegrams Without Stringing Wires

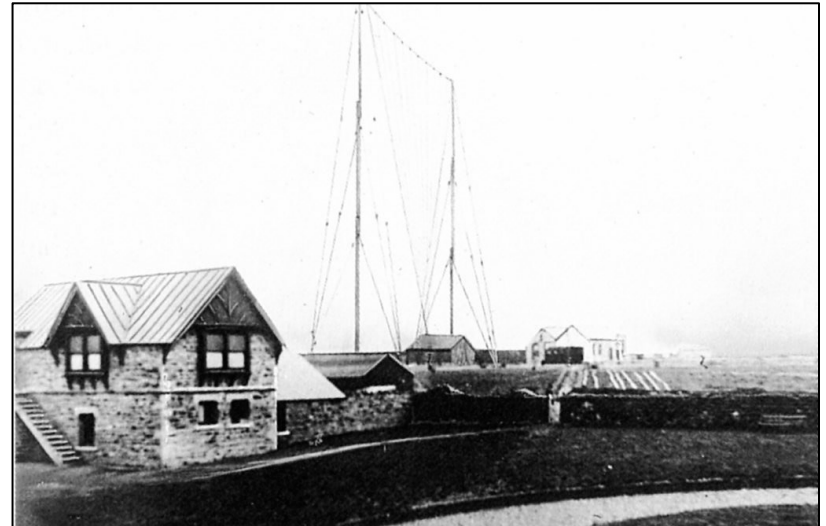
Wireless Telegraphy!



Early Radio

WIRELESS TELEGRAPHY

- Marconi – ship to ship and ship to shore, with Morse code by 1900)
- 1901 - First message across the Atlantic



Early Radio

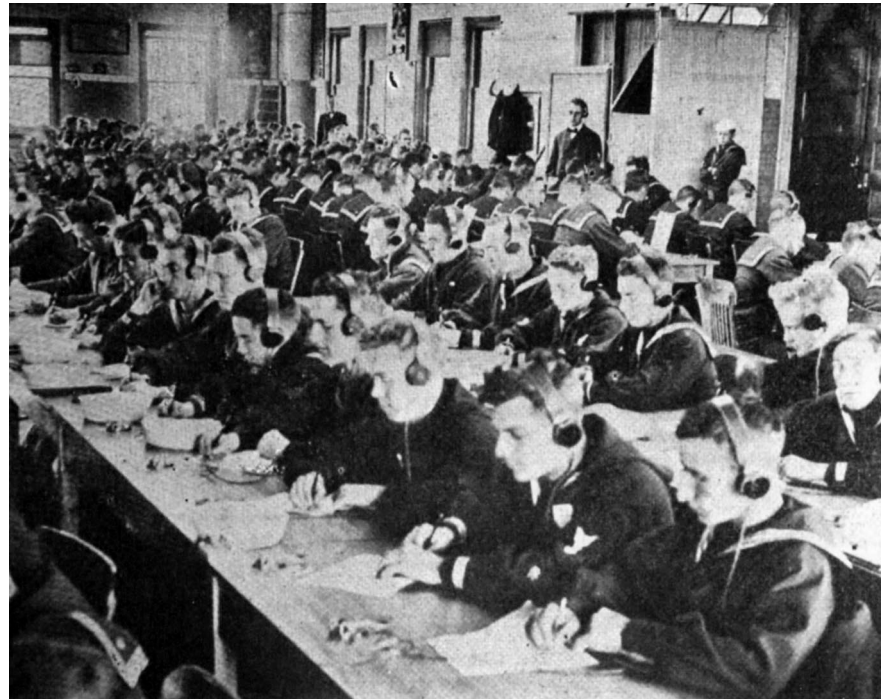
- Wireless telephony (Voice communication ~1906, Brant Rock, Massachusetts)



Reginald Fessenden

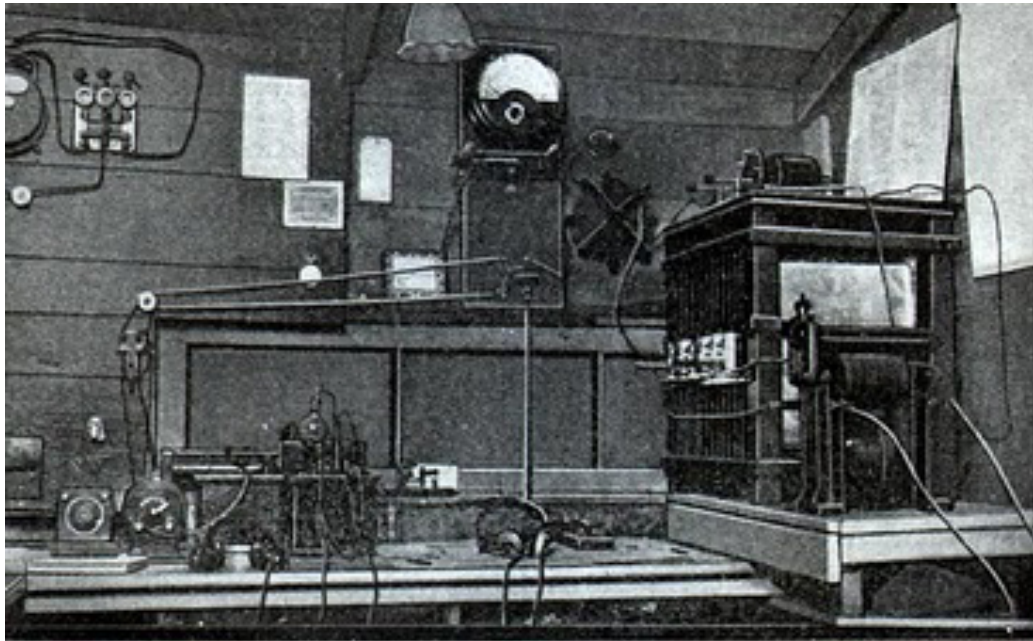
Early Radio

- Military Communications
 - Direction Finding
 - Ships at Sea
 - Air to ground
 - Trench communication
 - Trans-Atlantic

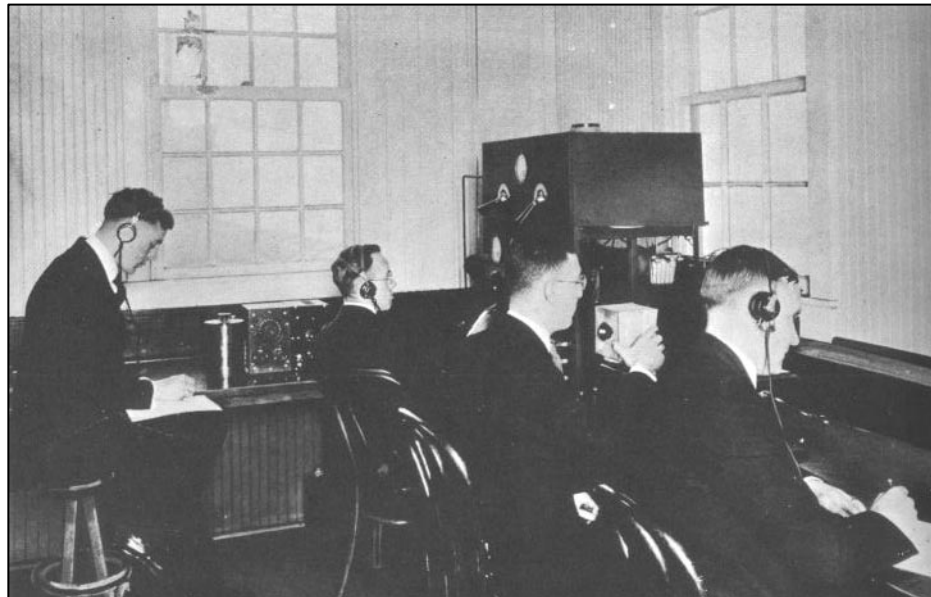


Early Radio

Amateur ("Ham") Radio
began around 1905-06



**NBS began its radio research
almost two decades before
entertainment radio
broadcasting to American
homes became widespread**

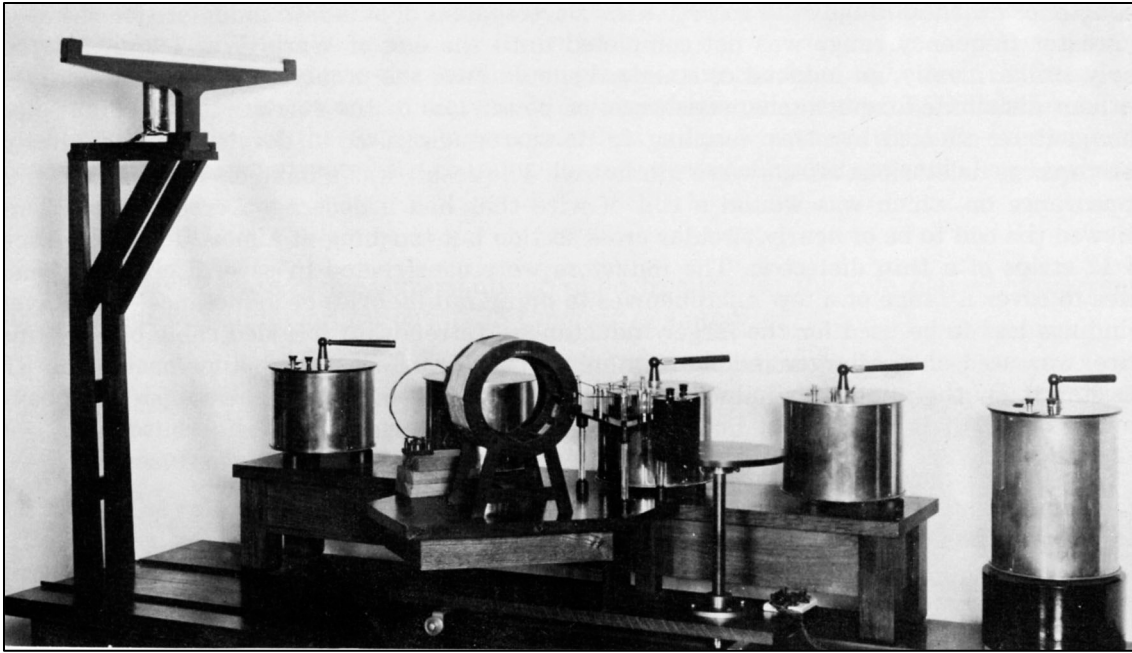


How Did NBS Get Started in Radio?

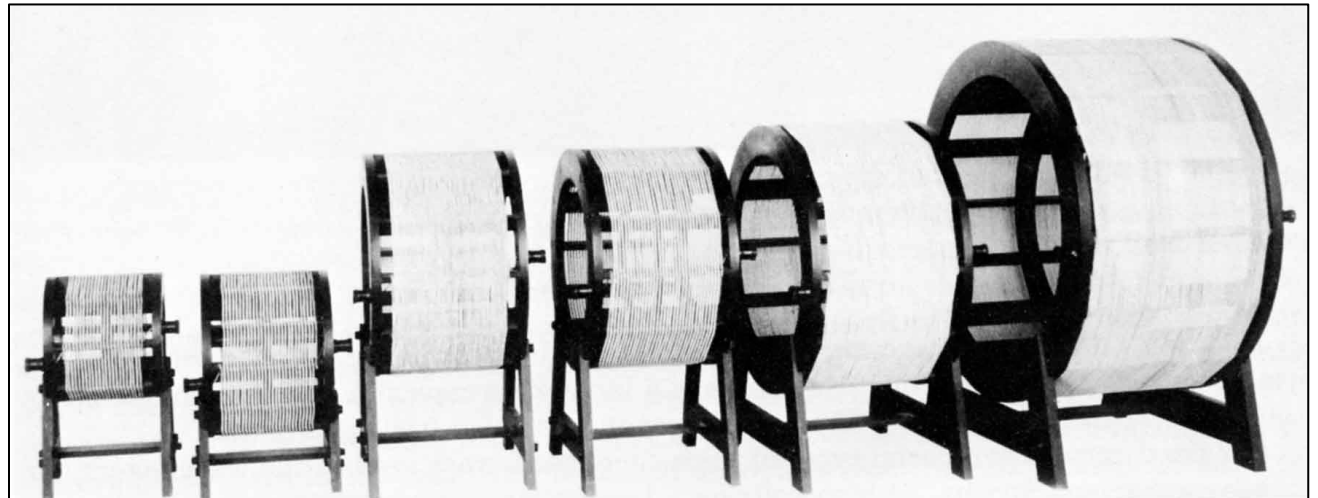
Essential Electrical Measurements:

- Voltage (AC and DC)
- Current (AC and DC)
- Capacitance
- Resistance
- Inductance
- Wavelength/Frequency
- Properties of conductors and insulators

Standard capacitors

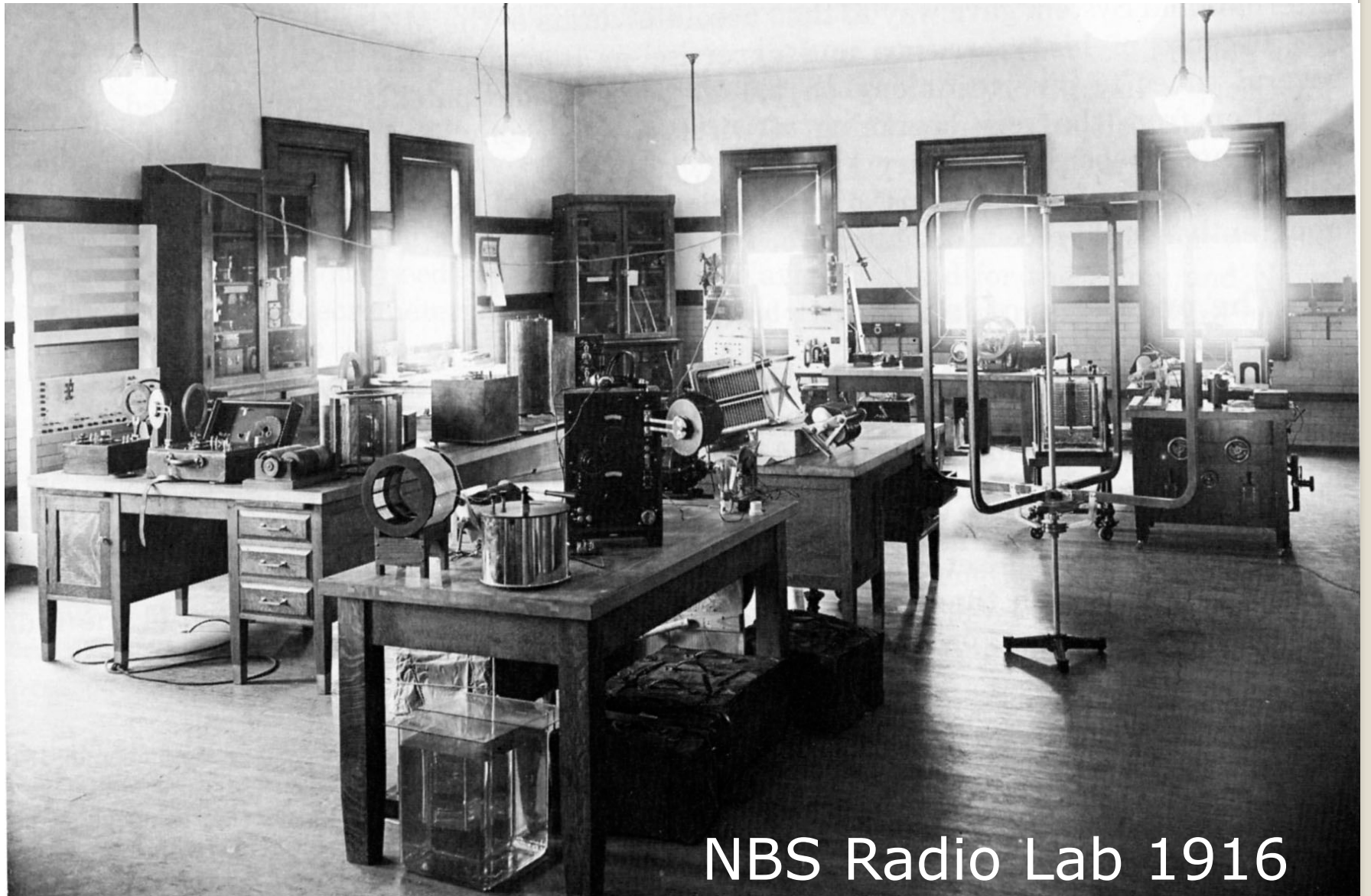


Standard inductors



NBS Gears Up To Support The Radio Industry

- 1904 - First radio researcher – Louis Austin – arrives at NBS (Electrical Division under Edward Rosa)
- 1905 - NBS' first publication on wireless
- 1911 - First regular radio-related calibration service (wavemeters)
- 1913 – Radio Section formed



NBS Radio Lab 1916

NBS' Radio Work in WW I

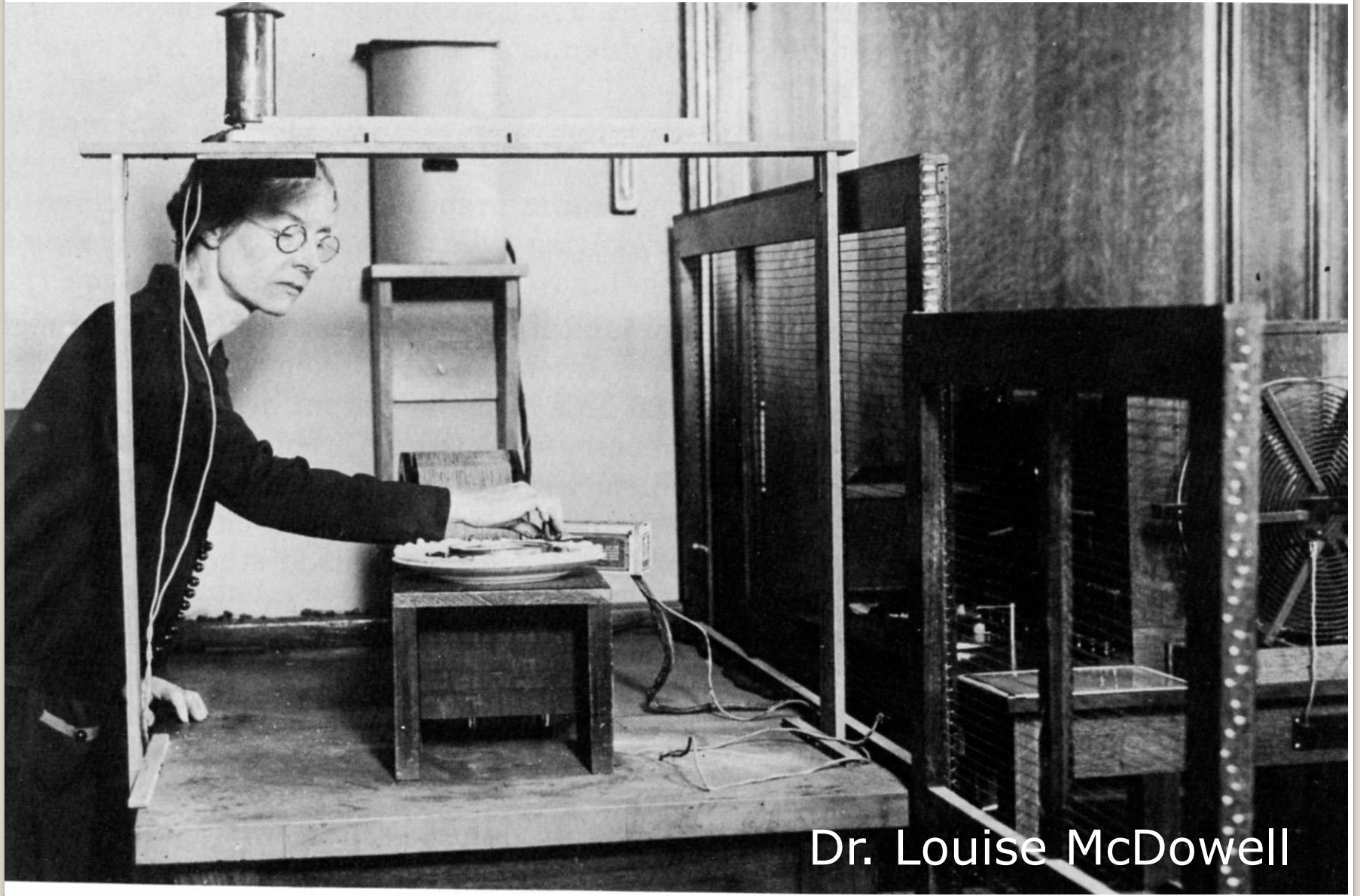
- NBS' Radio Section was dedicated to the War effort
- 7 employees at the beginning of the war, 40 by the end)
- Radio was sufficiently important that it got its own separate building in 1918



NBS Radio Building - 1918

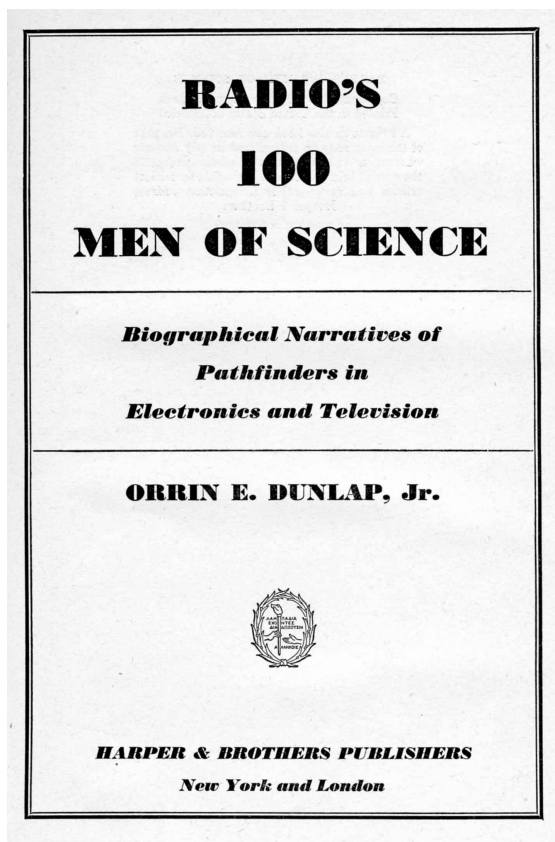
NBS' Radio Section in WW I

- The Army Signal Corps and the Navy both maintained radio laboratories at NBS
- 40 Classified papers, 7 open publication papers
- Research emphasis included:
 - Vacuum tube theory and characterization
 - Submarine antennas
 - Direction finding
 - Dielectric and other materials



Dr. Louise McDowell

Recognition for NBS Radio Scientists and Engineers



This 1944 book honors
four NBS people:

- Louis Austin
- John Dellinger
- Frederick Kolster
- George Southworth

Louis Austin



- Came to NBS in 1904 from PTB, as a guest worker
- Worked on early detectors
- 1908-1923 Headed US Naval Wireless Telegraphic Lab at NBS
- 1923: Lab for Special Radio Transmission Research (OA funds)
- IRE President and Medal of Honor winner
- Developed Austin-Cohen equation

$$\epsilon = 377 \frac{hI}{\lambda d} \sqrt{\frac{\theta}{\sin \theta}} e^{\frac{-0.0014d}{\lambda^{0.6}}} \times 10^3$$

John Dellinger



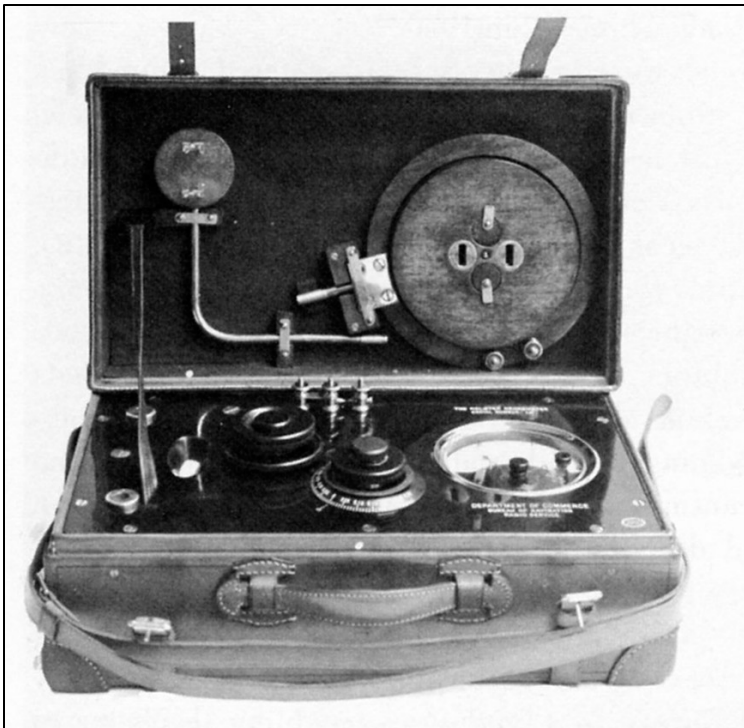
- Came to NBS in 1907
- 1919 Chief of Radio Section
- Worked on instruments, ionospheric propagation (Dellinger Effect), radio beacons, aircraft landing systems
- IRE President and Medal of Honor
- Officer of International Scientific Radio Union
- Write numerous papers and books, e.g., *Circular 60: Electrical Units and Standards* (1920)
- Retired in 1948, CRPL Chief

Frederic Kolster



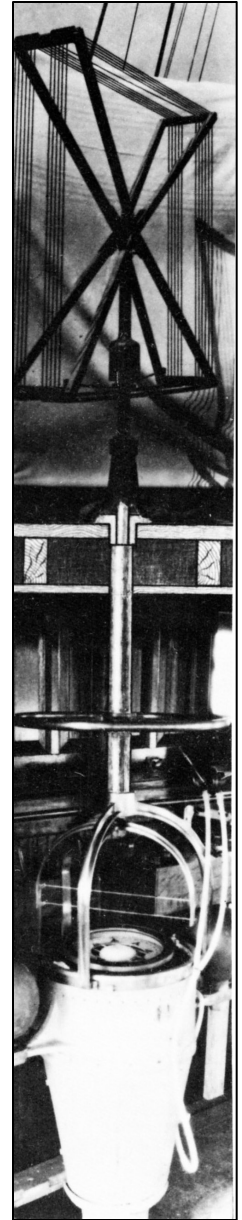
- 1913-1921 Chief of Radio Section
- Invented the Kolster decimeter
- Developed the Kolster radio compass and radio beacons for navigation
- Consultant to US Navy on direction finding technology

Kolster's Work



Decremeter/wavemeter

Direction
Finding
Antenna

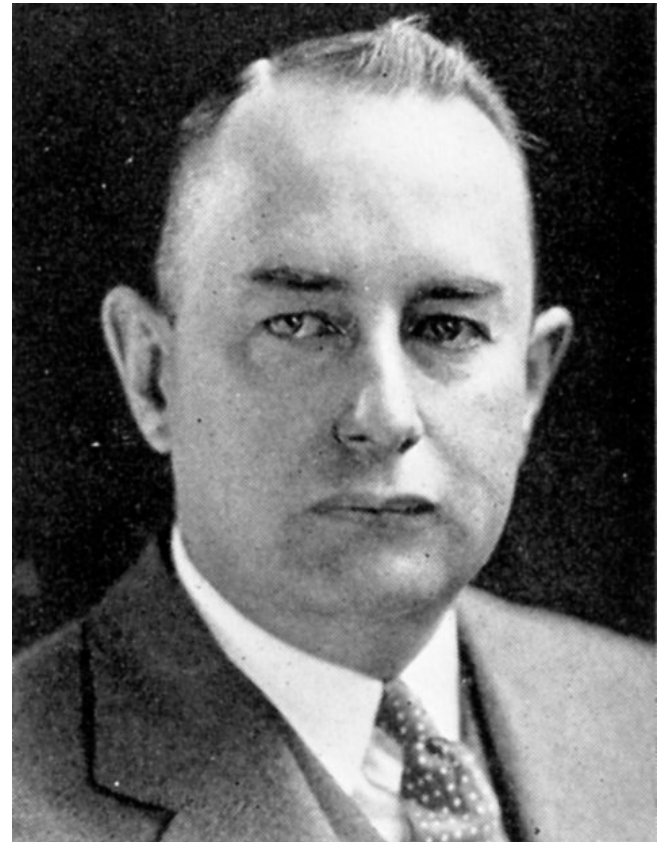




Kolster Model 6D, 1926 (\$85)

George C. Southworth

- 1917-18 at NBS
- Went to Bell Labs and became famous for his work on waveguide theory



Another NBSer With A Successful Career In Industry

- Asst. Chief, NBS' Radio Section, 1922 to 1930
- Chief Engineer, Federal Radio Commission 1930-35
- RCA Board of Directors, Chief Scientist and VP, until retired in 1964



Charles B. Jolliffe

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

**RADIO
INSTRUMENTS AND
MEASUREMENTS**

CIRCULAR C74

1924

**The Principles Underlying
Radio Communication**

(SECOND EDITION)



Radio Communication Pamphlet No. 40

Prepared by the Bureau of Standards

Revised to May 24, 1921

Signal Corps, U. S. Army

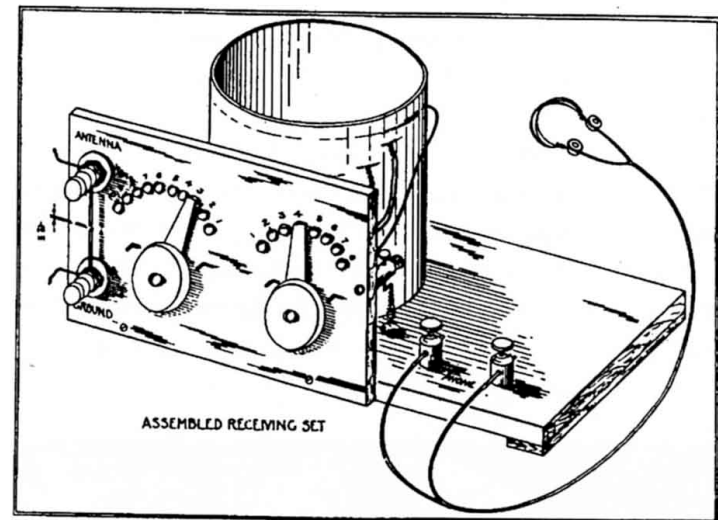


Washington : Government Printing Office : 1922

NIST Centennial Publication (SP 958)

"Construction and Operation of a Simple Homemade Radio Receiving Outfit" (1922 Circular # 120)

- Published in response to public demand for information
- Sold for 5 cents, reprinted in newspapers and magazines
- Many other radio LCs published

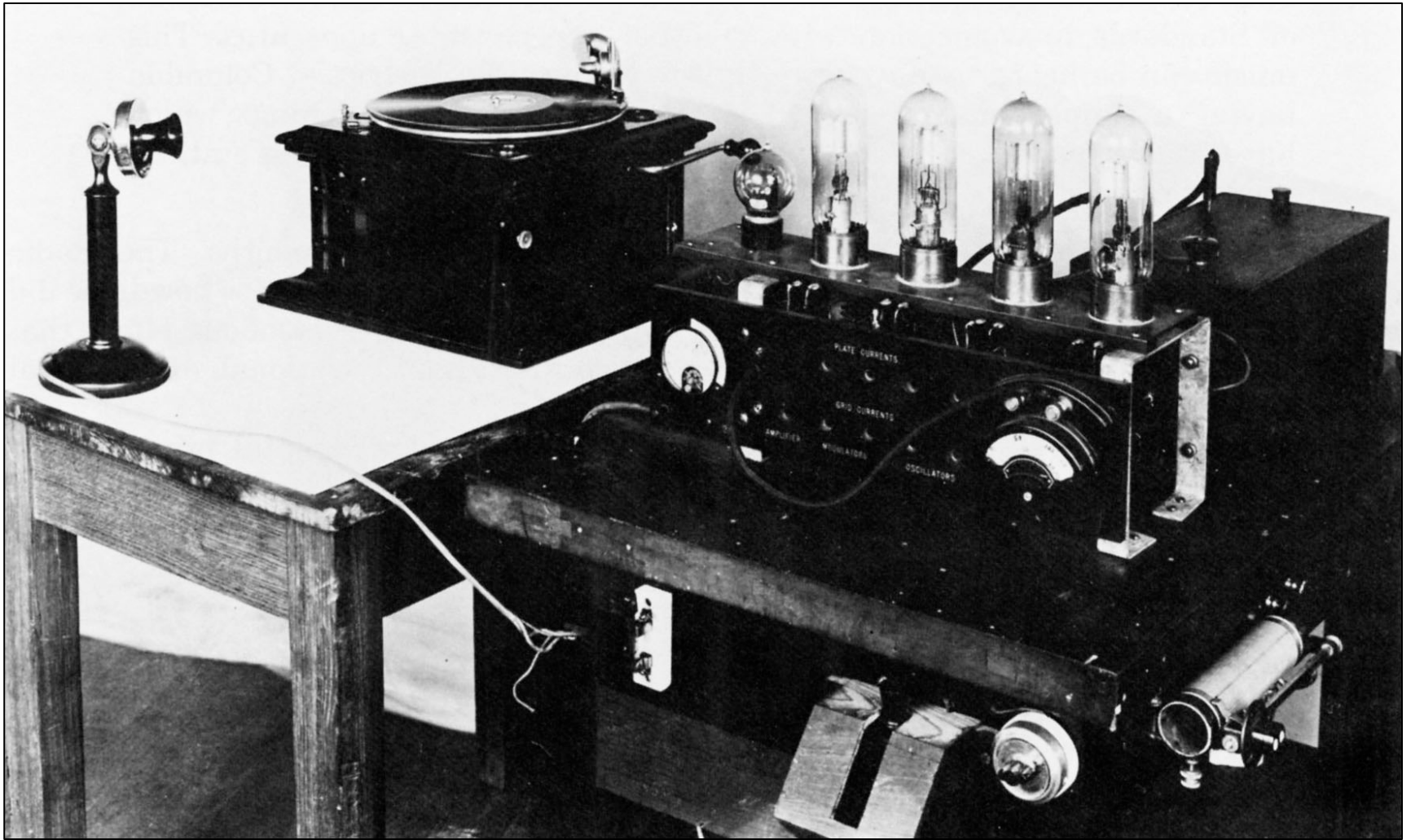


NBS' Radio Stations (WWV, WWVH, WWVL)

Check out John Lowe's colloquium:

nist.gov/news-events/video-gallery/search?combine=WWV

- WWV celebrated 100 years of service this year
- 1919-23: broadcasting music & market reports
- 1923 Broadcasting standard frequencies
- Other antenna sites in area: Kensington, Brookville Road, Beltsville
- Expanded frequencies used as time went on

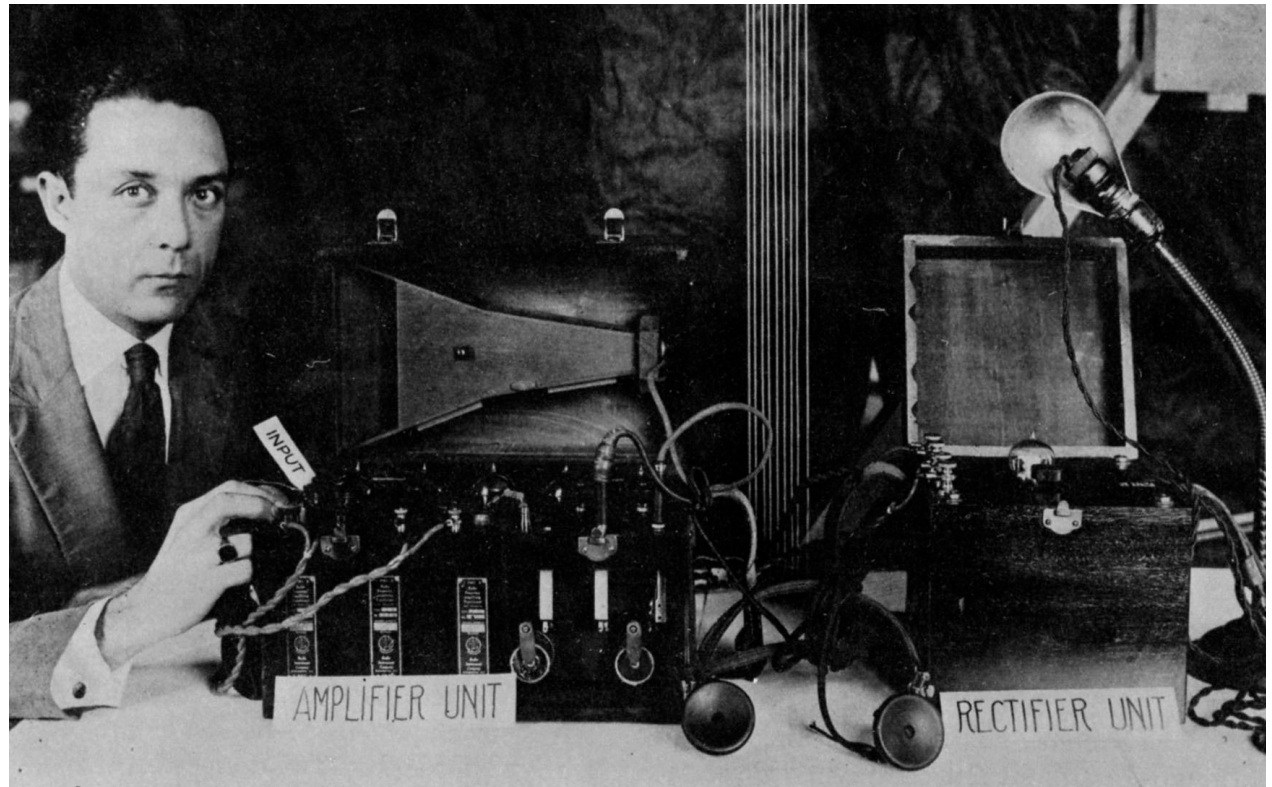


Early WWV transmitter

The First AC-Operated Radio An NBS Innovation

~1921 Percival Lowell and Francis Dunmore created the first AC-operated radio

P. D. Lowell
with his
AC-operated
receiver



First AC Operated Radio

Exclusive rights to Lowell-Dunmore patent purchased by Dubilier Condenser and Radio Corp.

Others (RCA etc.) paid royalties to Dubilier

The Dynergy receiver (1924) - the first commercially marketed AC receiver

*Plugs in
Your Light
Socket*

DYNERGY RADIO RECEIVER *Needs No Batteries!*

Dynergy—revolutionizes radio—no mere cumbersome A, B or C Batteries—no more recharging or replacing Batteries!

Dynergy is a complete 5 tube radio set, simple to tune—extremely sensitive, clear toned and a good distance getter that takes its power from any light socket. Dynergy can never wear out and costs only ¼ to ½ cent per hour to operate—either D. C. or A. C. current. EXPERTS have called it, "The Marvel of the Age."

*On demonstration at all leading musical and radio stores.
Send for descriptive literature.*

DYNAMOTIVE RADIO CORP.

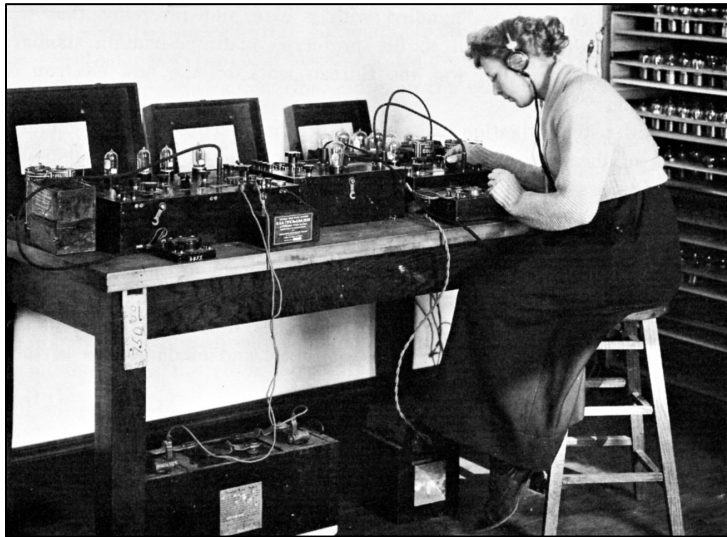
47 Ninth Ave., New York City

Tel. Chelsea 5953



Vacuum Tube Research

- 1919 - Dr. John Miller: “Miller Effect” explained (inter-electrode capacitance in triode vacuum tubes causes oscillation)
- Vacuum tube test methods developed for the Army and Navy



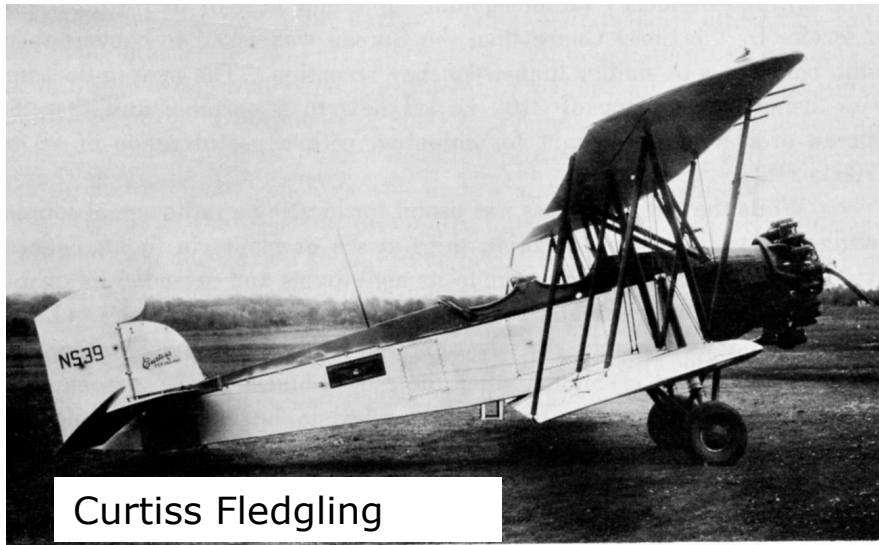
NBS built an
oscilloscope
in 1918

The 1920s and 1930s

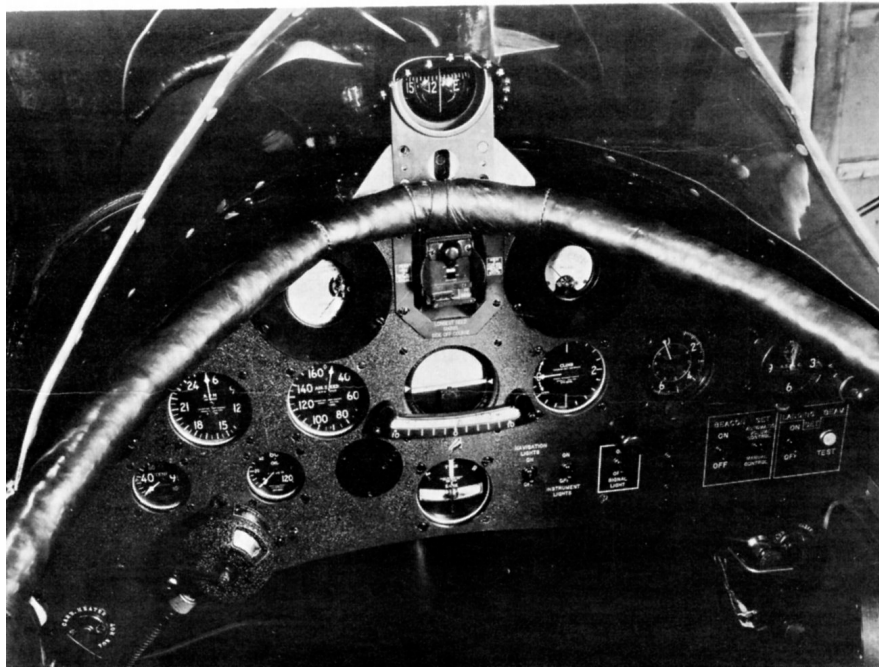
- 1922 National Radio Conference – Chaired by Dr. Stratton
- Radio test methods (sensitivity, distortion, frequency stability of crystal oscillators, etc.)
- Vacuum tube research
- Special projects for the military
- *Dewey Decimal System* (Circular 148)
- *Sources of Elementary Radio Information* (Circular 122)

The 1920s and 1930s (Continued)

- Ionospheric propagation and fading (Dellinger Effect)
- Reference data (dielectric constants, conductivity of materials, etc.)
- Technical articles in *Proceedings of the IRE*
- Proliferation of popular articles in newspapers, *Radio News*, *Radio Broadcast*, etc.



Curtiss Fledgling



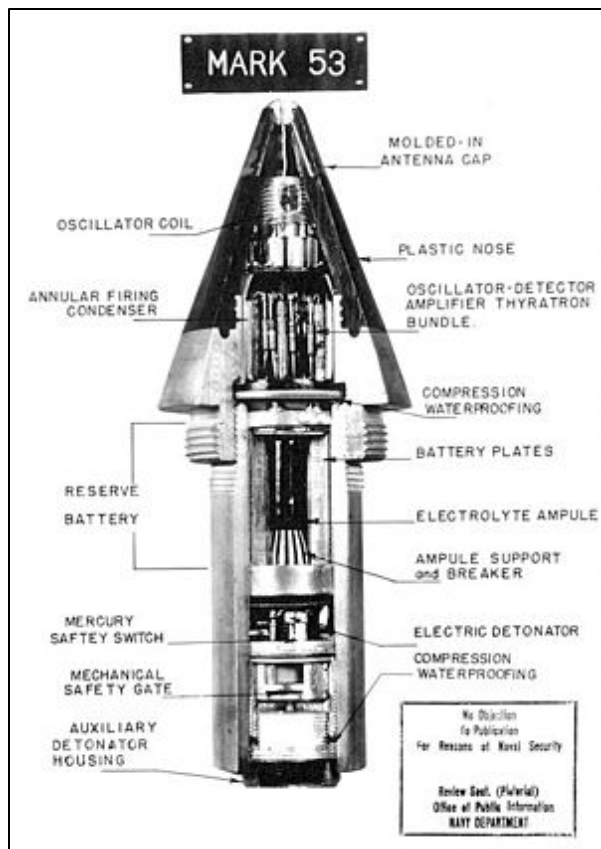
First Blind Landing System

- Tests at College Park Airport
- Harry Diamond, Frances Dunmore, and John Dellinger contributed
- Adopted by the CAA in the 1930s

World War II Radio Work

- Direction finding
- Guided missiles
- Interservice Radio Propagation Laboratory (IRPL)
- Quartz crystals for frequency control
- Proximity Fuse

Proximity Fuses: NBS' Contribution to Winning WW II



The US War Department described the proximity fuse as:

"one of the outstanding scientific developments of WW II – second only to the atomic bomb in military importance."

Harry Diamond



- 1927 Hired by NBS
- Became Chief of Electronics Section
- Worked on radio beacons & aircraft landing systems
- 1940 – Led Ordnance Development Division at NBS, proximity fuses for WW II
- 1953 transferred to Army & became Diamond Ordnance Fuse Laboratories.
- Now part of Army Research Laboratory

Take-Aways:

- Between 1904 and WW II NBS was:
 - A “midwife” for the birth of the electronics industry
 - Recognized and respected as a center of radio science and technology excellence
- NIST’s important work today supporting the communications and semiconductor industries traces back to the pioneering work described in this talk

**Do learn about NBS/NIST’s history
You will be proud to have worked here!**

**And Now,
A Brief Message From**

**The National Capital
Radio & Television
Museum . . .**



National Capital

Radio &
Television
Museum



2608 Mitchellville Road, Bowie, MD

ncrtv.org

1931 Mechanical Scanning Disc TV Sets



1939 Philco Model 39-116



1939 Crosley Reado



1940 RCA-Victor Model TRK-120



1921 Westinghouse Model RC



1954 Regency Model TR-1



National Capital

Radio &
Television
Museum



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