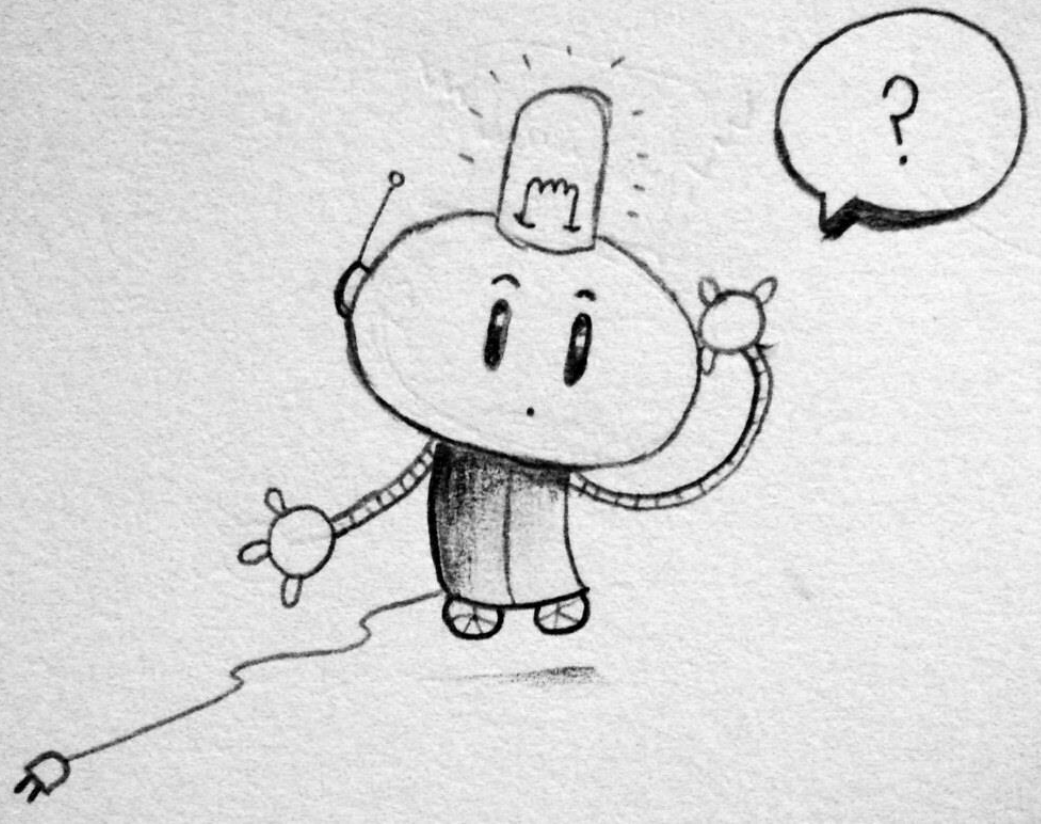
Edwin Howard Armstrong

(1890-1954)

Radio Pioneer

Let’s start with a couple of questions



Edwin H. Armstrong…

A. Developed the Neutrodyne circuit used in 1920's receivers
B. Developed an early method of positioning directional antennas known as the Armstrong Method
C. Developed the regenerative circuit which greatly amplified received signals, making for the first truly practical radio receivers.
D. Developed circuitry that permitted vacuum tubes to act as continuous wave oscillators, CW transmitters.
E. Both C and D are correct
F. Both A and C are correct

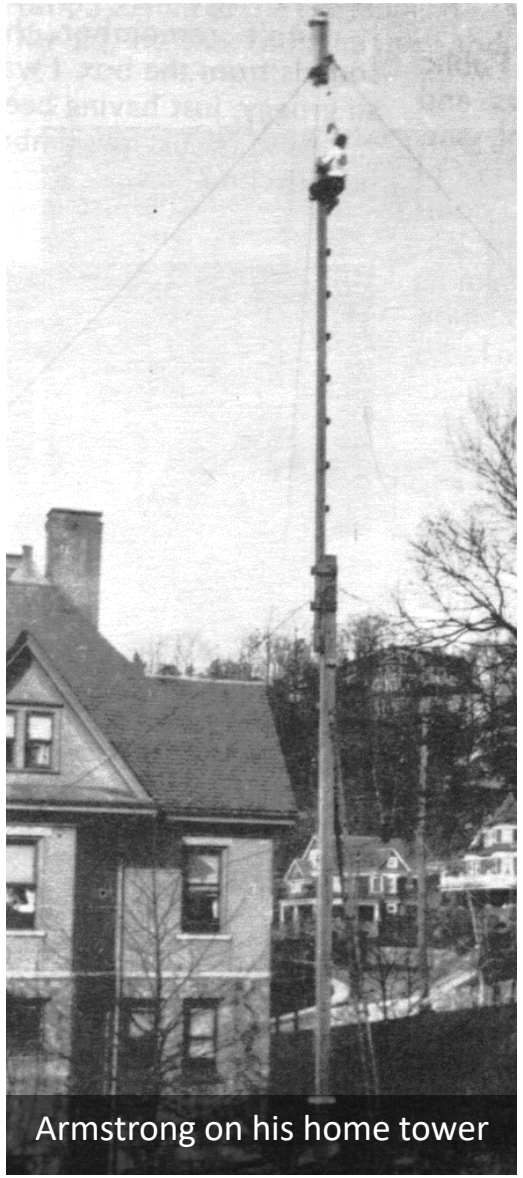
Edwin H Armstrong…

A. Was part of a 1921 team of hams and radio experts that achieved the first transatlantic transmissions on the ham bands.
B. Developed the superheterodyne circuit, a circuit that is still used in modern analog receivers
C. Created the Armstrong Method for launching antennas into trees.
D. Developed a static-free system of radio transmission and reception.
E. Both B and D are correct
F. A, B, and D are correct

That guy did a lot for radio!

Edwin Howard Armstrong
An early amateur

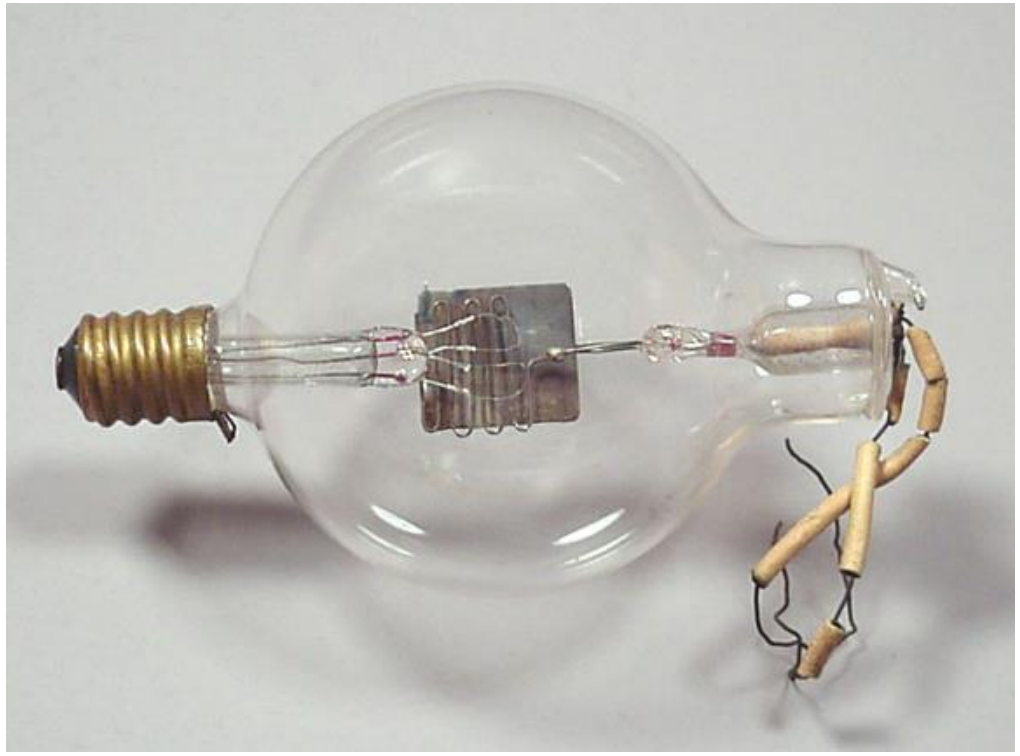
- Born December 18, 1890 in New York City
- By his mid teens, Armstrong was building and using both radio receivers and transmitters.
- In 1910, he built a 125 foot antenna tower to improve his reception.
- He used a boatswain's chair to hoist himself up the tower both during its construction and to later take in the view, he always enjoyed high places.
- Armstrong never held a ham license.



Armstrong on his home tower

The Audion

- The three element audion (triode) vacuum tube was invented by Lee DeForest in late 1906.
- The audio worked OK as an amplifier though, no one including DeFeorst truly knew it's potential.
- By 1912, Armstrong began experimenting with the audion.

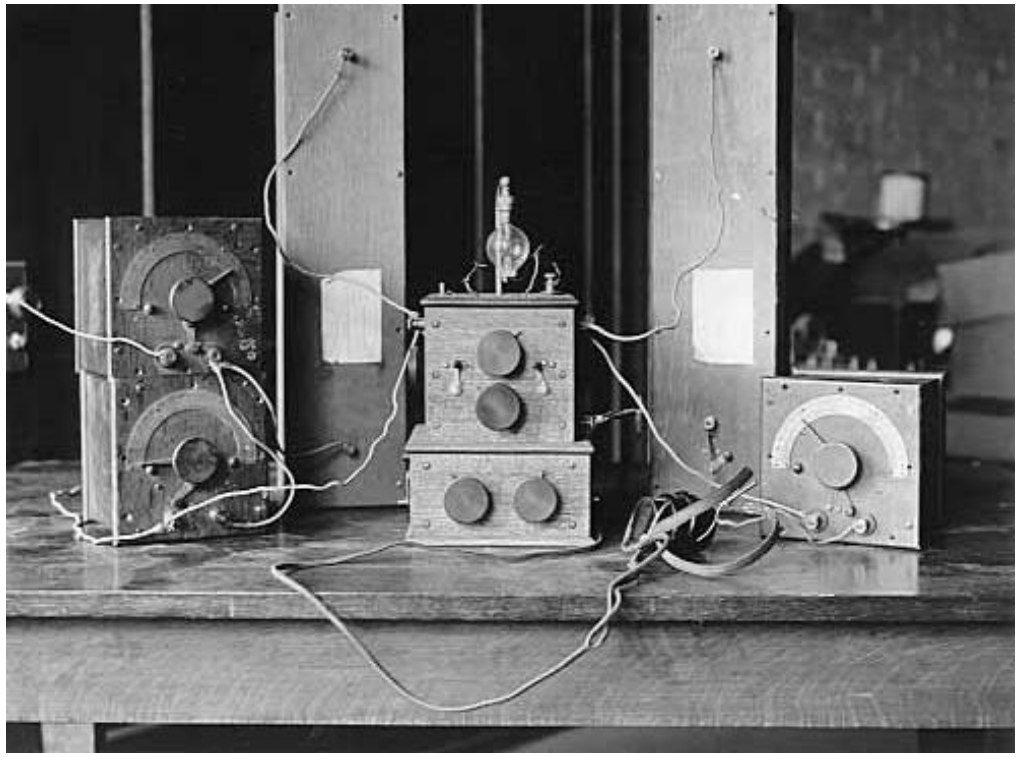


Armstrong discovers regeneration

- A radio signal fed to the grid of a tube effected the flow of electrons from the cathode to the plate, amplifying the incoming signal a few times.
- Armstrong decided to take the signal from the plate and repeatedly fed it back through the system (regeneration) achieving far greater amplification.
- On September 22, 1912 Armstrong was successful. The following year he filed for a patent on his “wireless receiving system”.

A really important discovery.

- Regeneration improved receiver's capability over a thousand-fold.
- Armstrong also found that if he fed the signal back even more, the circuit would oscillate on its own… a CW transmitter.
- Armstrong demonstrated his receiver for the Marconi Company's chief inspector, David Sarnoff in 1914.
- Sarnoff was impressed but the Marconi Company wasn't interested in the receiver.



Armstrong's 1929 Prototype Receiver

E. H. ARMSTRONG
The discoverer of the "feed-back" circuit, in the uniform of a major in the Signal Corps during the war

Later, in 1917…

- Howard Armstrong joins the U.S. Army Signal Corps.
- In 1918, Armstrong used the heterodyne principle (mixing two signals to get a third, different signal) to make his second big discovery, the superheterodyne receiver circuit.
- This is the circuit still used in most analog receivers.

Developing the superheterodyne receiver

- The idea of applying the heterodyne principle was not new to radio.
- It had been first used by Reginald Fessenden in 1901.
- Fessenden's approach was geared towards making an audible tone when CW was received.
- This is the principle behind the beat frequency oscillators or BFOs on older shortwave receivers.
- Armstrong used heterodyning to change the incoming signal to a more manageable (amplifiable) frequency.

Reginald who????

Time for a question

Reginal Fessenden (1866-1932)

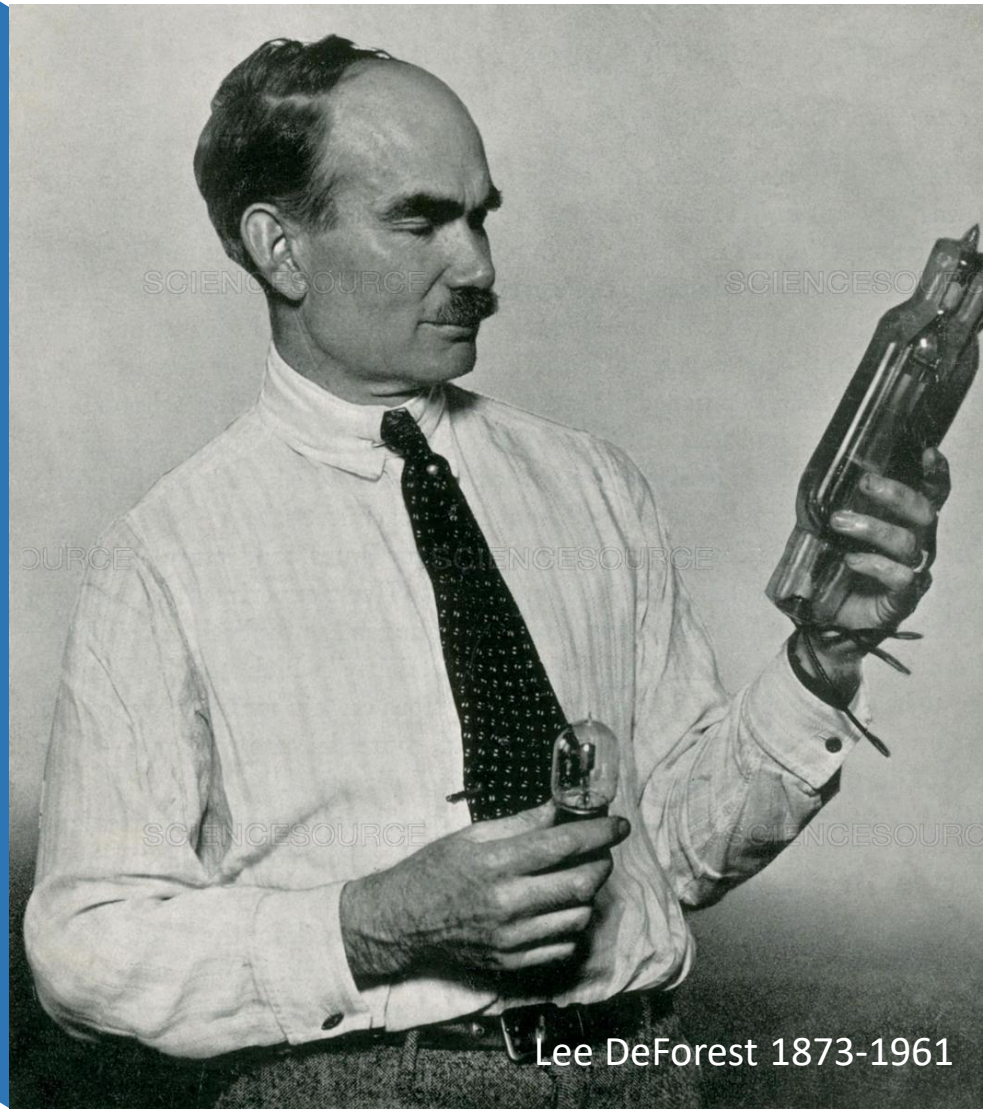
A. Conducted the first two-way transatlantic radio transmissions in 1906.
B. Won a $2,000,000 lawsuit against Edwin Howard Armstrong in 1925 for using the heterodyne principle in the superheterodyne receiver.
C. Made the first audio transmission by radio over a distance of about one mile in 1900.
D. Both A and C are correct.
E. All are correct.

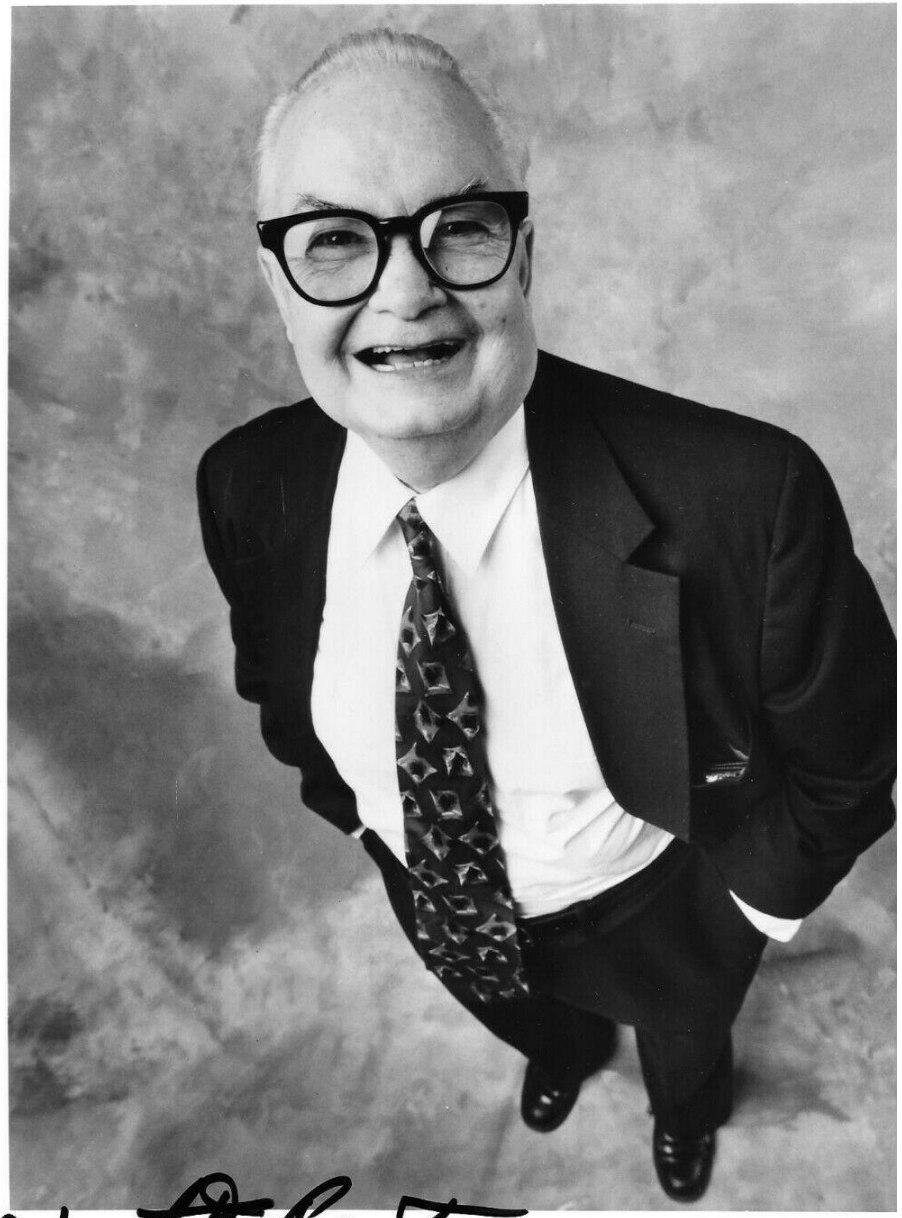
Armstrong's legal battles

1919 – 1954 and beyond

The battle over regeneration

- Though not completely understanding the operation of the audion, it's inventor Lee DeForest claimed that he had discovered regeneration prior to Armstrong.
- DeForest (and others) began using regeneration without permission or licensing by Armstrong.
- In 1919, Armstrong filed patent infringement charges against Deforest starting the longest running patent lawsuit in history at that time.


Lee DeForest 1873-1961



Lee DeForest had a well known younger second cousin.
Do you know who it was?

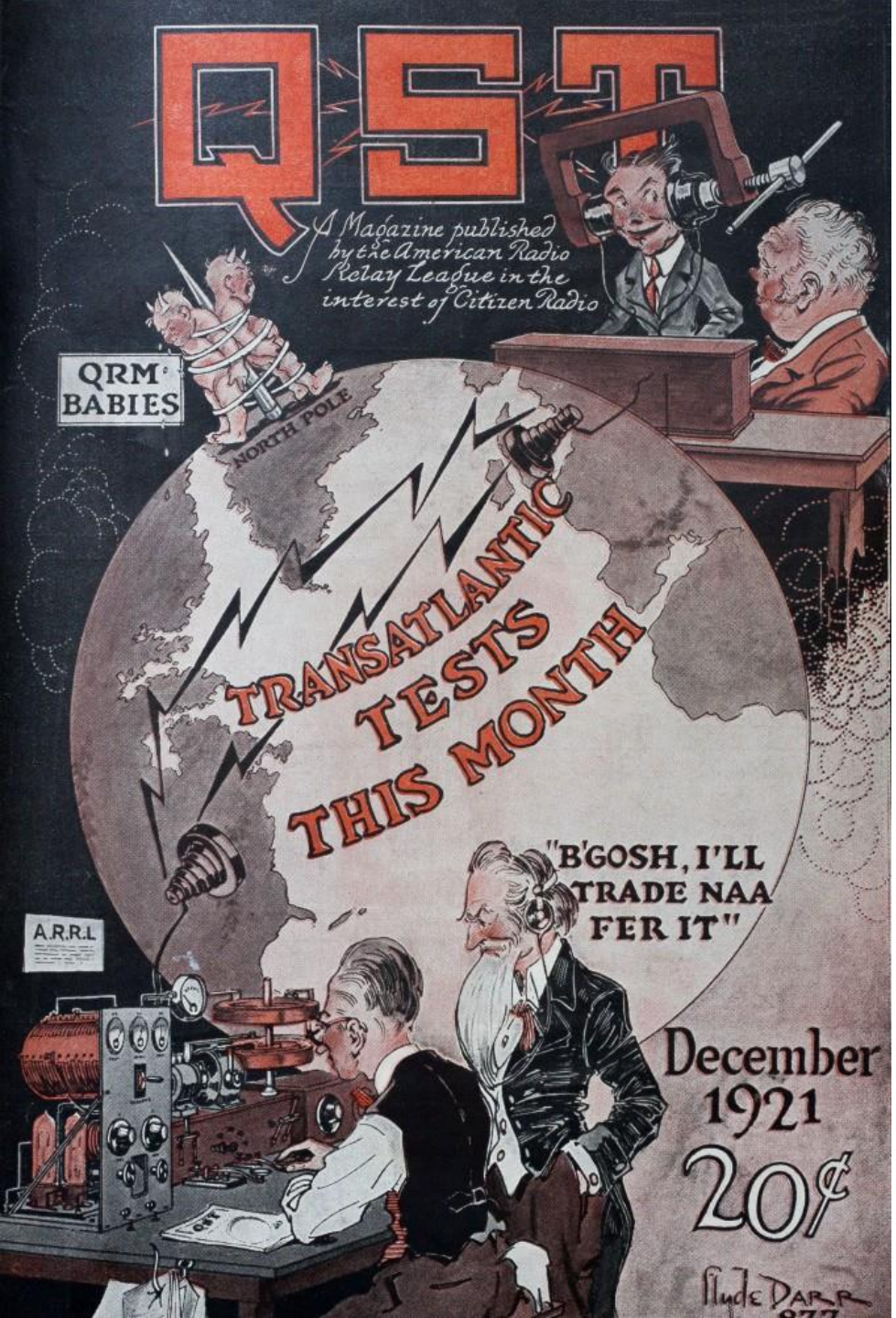
- This person is probably best known to those who watched late night TV in the 1980s and early 90s.
- It's:

Calvert DeForest aka Larry "Bud" Melmam

He was a recurring character on Late Night with David Letterman and later did commercials and a few films.

Back to Howard Armstrong…

- In 1920, Armstrong sold the commercial rights to both his regeneration and superheterodyne circuits to Westinghouse for $335,000 over 10 years.
- That's $4.3 million in today's dollars!
- Armstrong would receive an added $200,000 should he win his suit against DeForest.
- In 1921, the Radio Corporation of America obtained all of Westinghouse's patent rights.
- Armstrong retained the experimental and amateur rights to his patents which netted him an extra $10,000 a month.



The Transatlantic Tests of 1921

- With the reemergence of ham radio after WWI in 1919, hams began experimenting with radio in the no-man's land of the shorter wavelengths.
- In December 1921, hams organized to try (for a second time) to send signals across the Atlantic.
- Paul Godley, 2ZE, was sent by the ARRL to Scotland with American made equipment to listen for the participating U.S. stations in the tests.

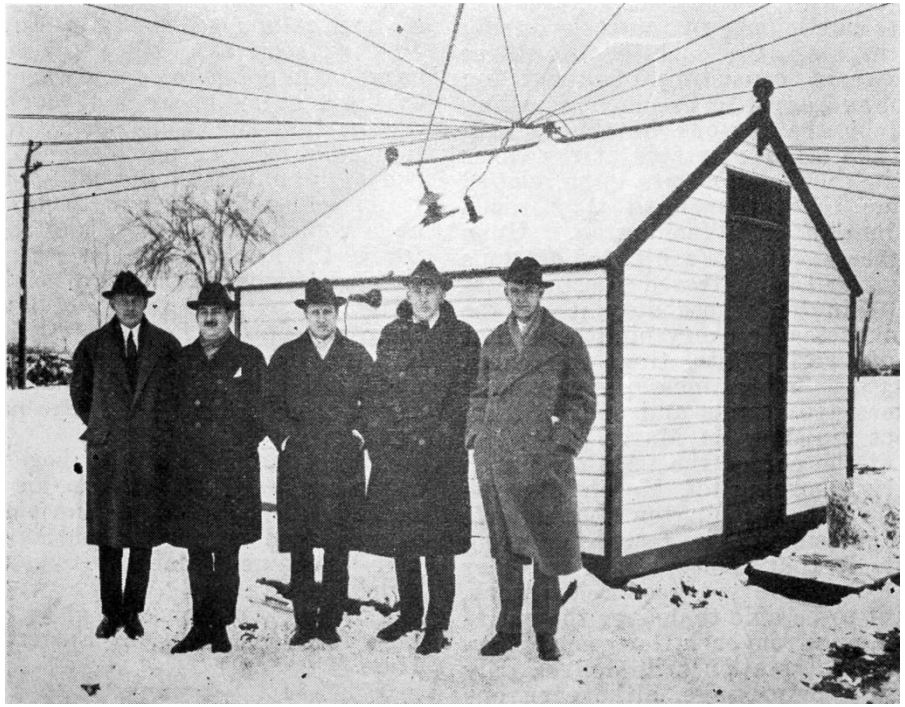
The test was successful!

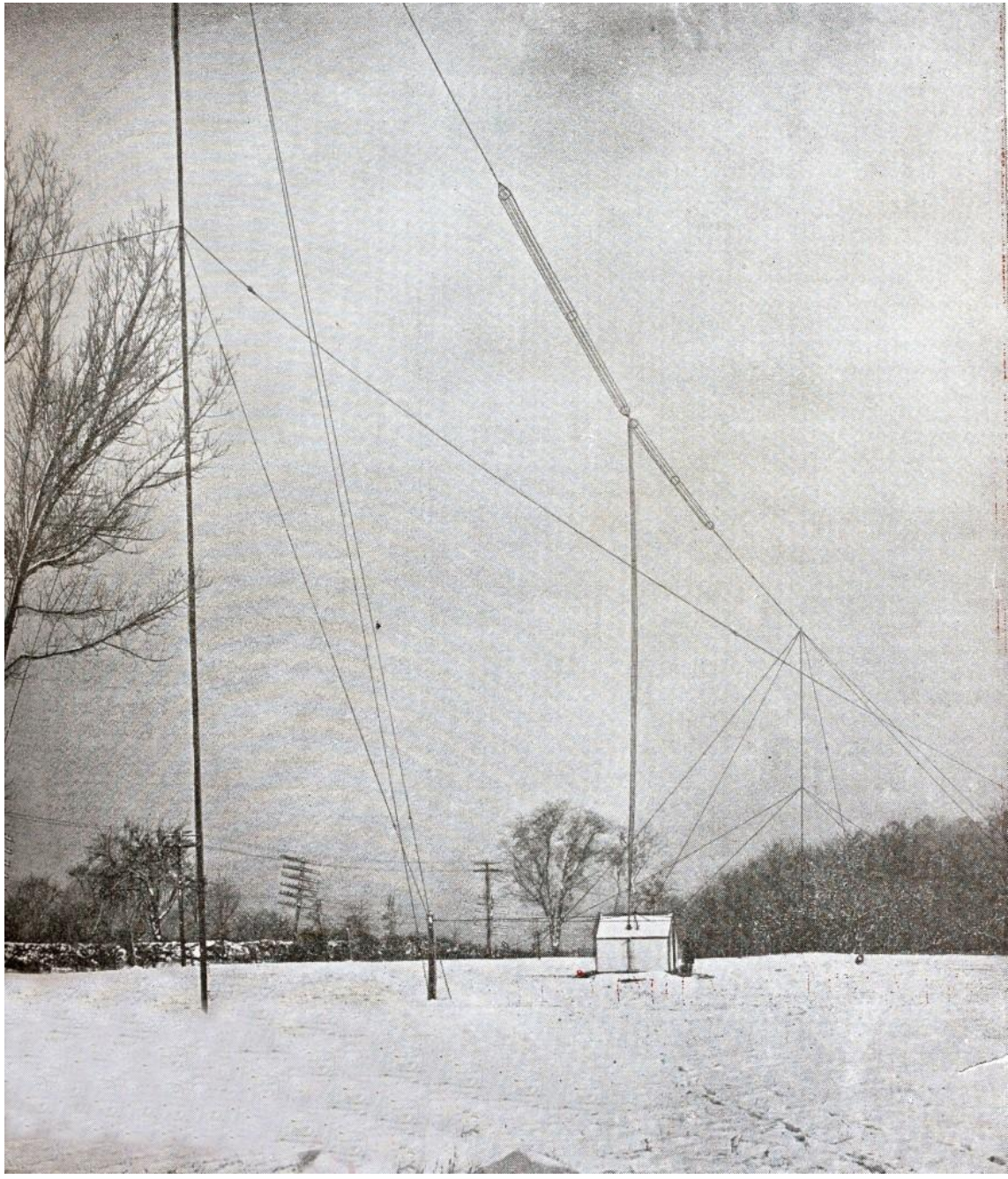
- A number if U.S. stations were heard… this was a one-way test.
- The first station heard on December 10, 1921, was 1BCG in Greenwich, CT
- The station at 1BCG was especially built for the test by members of the Radio Club of America*.
- Howard Armstrong was one a member of the team built this station.

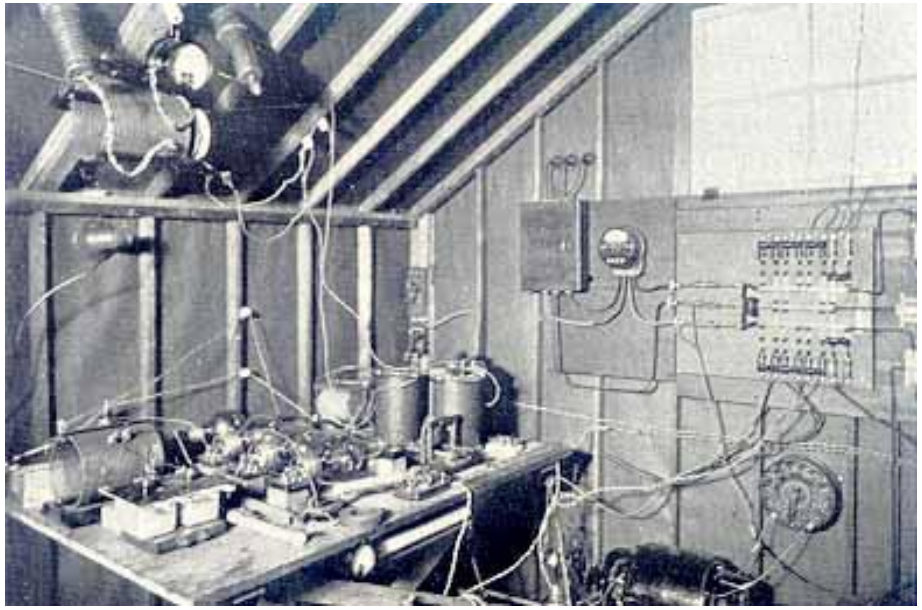
*Founded in 1909, the oldest group of wireless enthusiasts (now mostly professionals) in the country.

1BCG

Armstrong is 4th on right



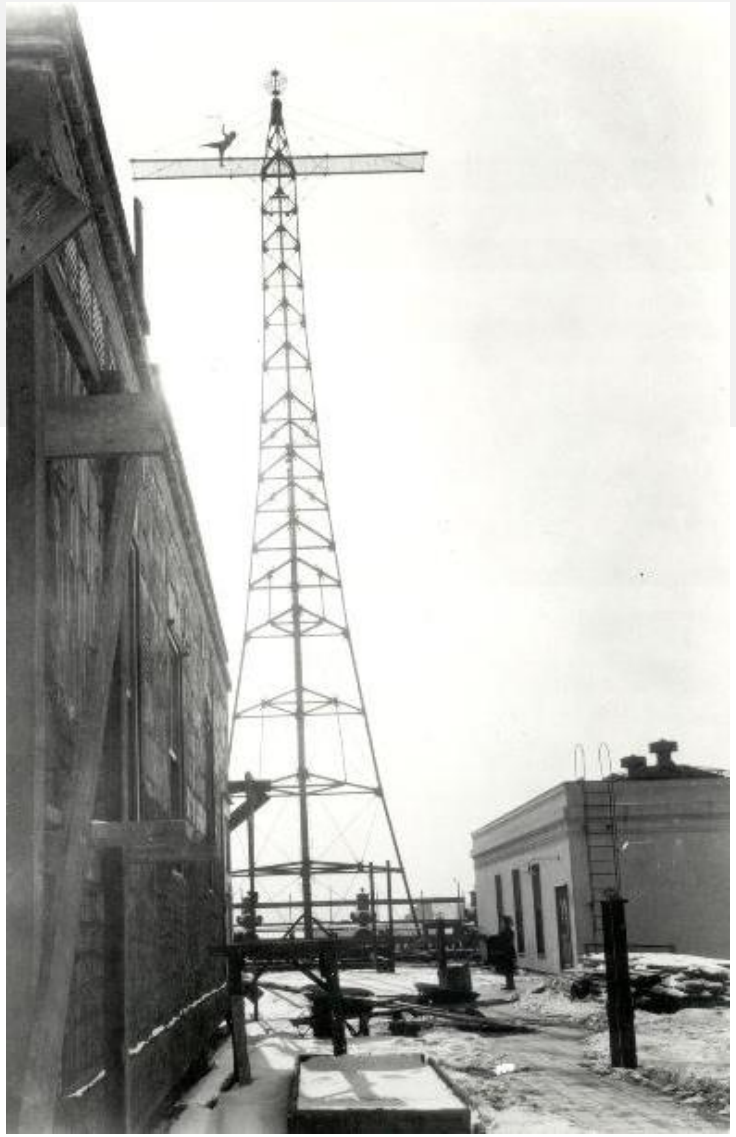




1BCG
transmitter & antenna

More successes

- In 1921, Armstrong developed the superregenation circuit which increased amplification even further.
- In 1922, RCA paid Armstrong $200,000 plus 60,000 shares of RCA stock for superregeration.
- RCA also got first refusal of any more of Howard Armstrong's inventions.
- Superregeneration proved to be impractical commercially.
- Armstrong became RCA's single largest stockholder



In May 1923…

- Howard Armstrong, that lover of heights, climbed RCA's NYC radio tower, 400' above 42nd street.
- He did this to impress David Sarnoff's secretary, Marion McInnes.
- Sarnoff was displeased.
- Marion married Howard 7 months later.

Getting the superheterodyne to market

- RCA recognized the superhet was a superior circuit
- It was having difficulty in designing a superhet that they could mass produce.
- In the summer of 1923, RCA approached Howard Armstrong for help.
- With the assistance of Harry Houck, who had worked with Armstrong in the Army on the original superhet design, Armstrong and Houck developed a workable superhet design in 6 weeks.
- Armstrong received 20,000 more shares of RCA stock.
- Houck received a personal check from Armstrong for $100,000.

The superheterodyne was a big hit… but Armstrong also received another blow

- RCA released the Radiola AR-812, the first mass produced superheterodyne radio in 1924.
- It wasn't until 1930 that RCA began to license others to manufacture superhet radios.
- In May 1924, the courts ruled that Deforest invented regeneration.
- A shocked Armstrong appealed the decision.

RCA AR-812, 1924

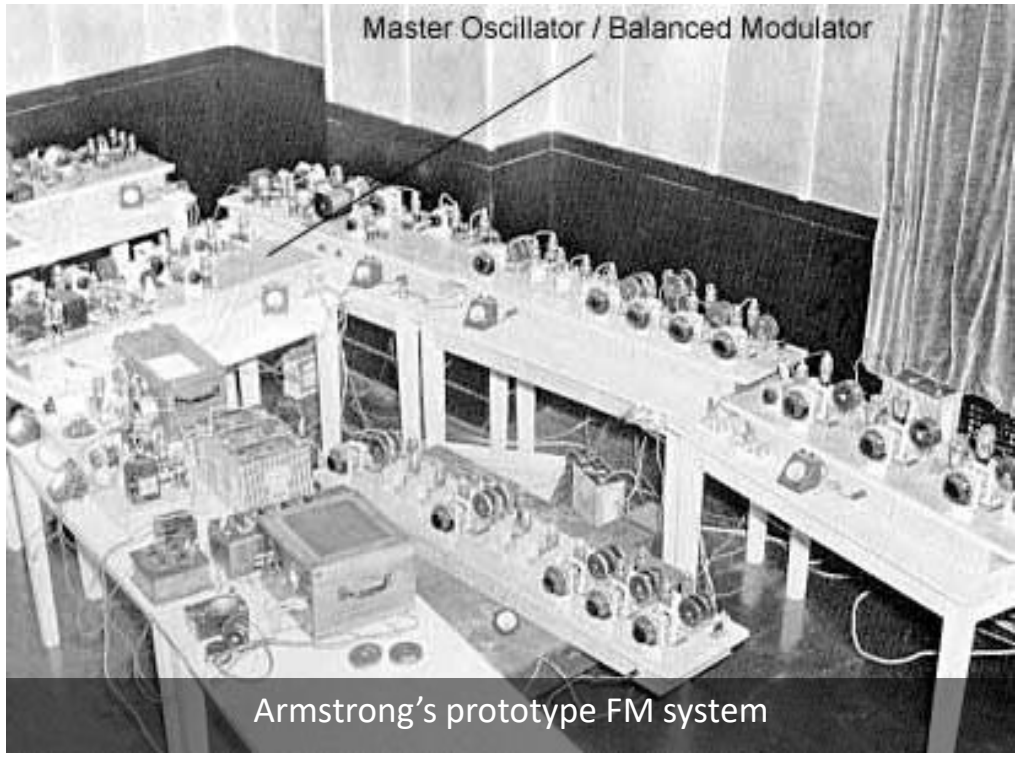
The problem of static

From its start, radio has been plagued by static.

- By the mid 1920's Howard Armstrong began work on solving the static problem.
- His initial attempts to somehow modifying AM failed.
- Armstrong then turned to wideband FM, selling some of this RCA stock to fund his efforts.
- In 1928, the US Supreme Court allowed a lower court's ruling stand… DeForest was the inventor of regeneration.
- More appeals were to follow.

FM took time

- It wasn’t until 1933 that Armstrong received the first patent for his FM system.
- In 1934, Armstrong demonstrated his FM system to Sarnoff and RCA engineers.
- RCA was hoping for an “add on” to existing AM system which FM was not.
- In May 1934 the Supreme Court again decided in favor of DeForest ending 14+ years of litigation.
- The technical community was appalled.



Armstrong’s prototype FM system

RCA in the 1930s

- By the mid 30s RCA-Victor was a corporate powerhouse
  - Manufacturer of radios, vacuum tubes, phonographs, records, more.
  - Founder of the NBC radio networks (NBC-Blue & NBC-Red)
  - Built Radio City in NYC.
  - Part owner of RKO motion picture studios.
  - Technical researcher developing radio technology for market and a major developer of television

…and running all of this.

- David Sarnoff was the head of *all* of RCA.
- He was one of the most powerful business leaders in the country.
- Sarnoff ran RCA “*his way*”.

Armstrong set up in the Empire State Building

- Armstrong was frustrated by the lack of support by RCA for his work on FM.
- Sarnoff had other plans for the future of RCA
- This future did not include scrapping the current money-making AM radio system to switch over to FM.
- By the summer of 1935, Armstrong was “asked” to leave the Empire State Building so that RCA could install experimental television equipment.

Convinced that FM was a far superior system,

Armstrong set out to advance FM on his own.

Let’s pause to look at Howard Armstrong’s personality

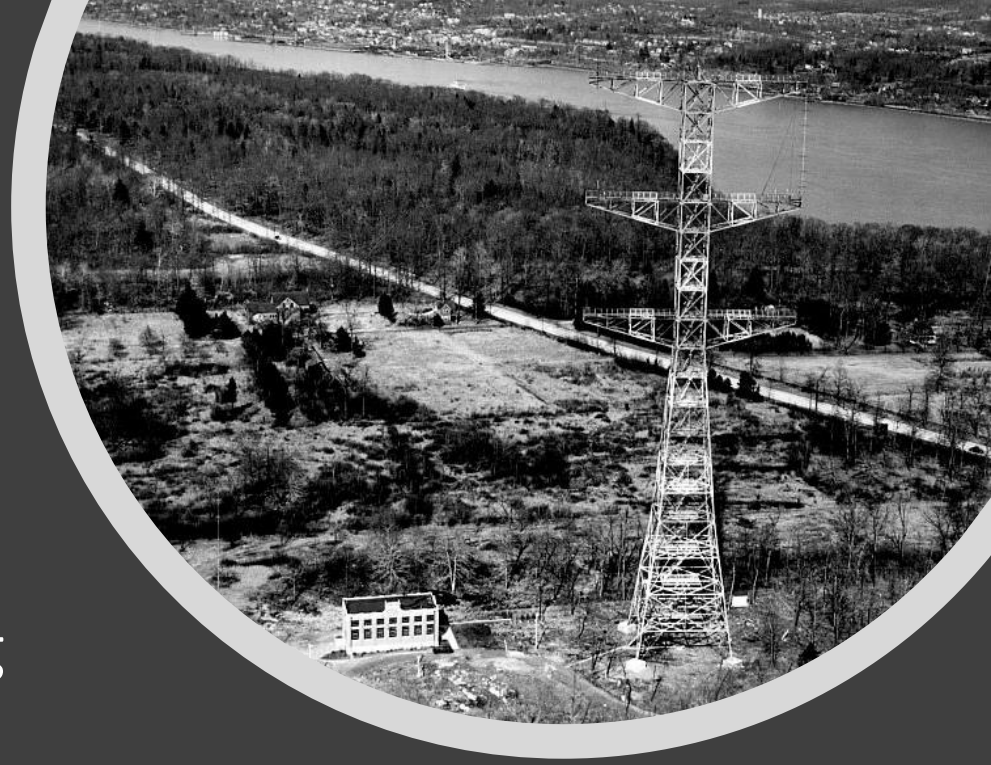
- The lone inventor was how inventors were described in the books Armstrong read as a child.
- Through perseverance, skill, and honest hard work, an inventor could succeed.
- Armstrong rigidly held on to this belief.
- By the 1930s the day of the lone inventor had pretty much passed.
- Armstrong saw things in black in white. People could only be good or bad, things could only be right or wrong.
- Compromise was not in Howard Armstrong’s nature.
- This helps to explain his lengthy legal battle with DeForest and the legal battles he was yet to have.

Moving ahead with FM

- November 1935: Demonstration to members of the Institute of Radio Engineers showed once and for all the superiority of FM over AM.
- Armstrong set up the transmitter for this demonstration at his friend's (Randy Runyon, W2AQ) ham station operating on the 2 ½ meter band.
- After initially being declined for a license, Armstrong lobbied the FCC and received an experimental license to transmit FM.
- In 1937, Armstrong sells more RCA stock in order to build FM station W2XMN in Alpine, NJ.

W2XMN

- W2XMN went on the air in June 1938 operating on 42.8 megacycles.
- A year later, in 1939, W2XMN is began regular full power (40KW) transmissions.
- W2XMN covered a radius of 100 miles, the same as a 50KW AM broadcast station in daylight.



Armstrong on the W2XMN tower during construction

FM seemed to be on its way

- Armstrong began to push for the FCC for a commercial FM broadcast band.
- Hearings for the proposal were held in April 1940. RCA opposed the idea of an FM band.
- A month later the FCC approved setting up commercial FM frequencies.
- Starting on January 1, 1941, FM was on the air on 42-50 megacycles*.

*They weren’t calling it megahertz back then

Getting up and running

- By the time the FM band opened, a handful of FM stations, including W2XMN and W1XOJ (in Paxton, MA) were already networked together.
- This FM network was known as the Yankee Network.
- General Electric, after building 25 FM receivers for use with W2XMN earlier, began producing FM consumer radios as did Zenith.
- Armstrong set up licensing agreements with GE and Zenith to produce FM radios which included royalties on the sets produced.
- Armstrong continued promoting FM. Especially its high-fidelity capabilities by obtaning only the highest quality of studio audio equipment.

The battle begins

- By 1939, David Sarnoff realized that FM was something not to be ignored.
- RCA began negotiating with Armstrong for the rights to his FM patents.
- In June 1940, RCA gave Armstrong their final offer, $1,000,000 for nonexclusive rights to his FM patents.
- Armstrong refused. He wanted a royalty deal as he had set up with GE and Zenith.
- David Sarnoff and RCA did not pay royalties, they bought things outright.

More success for FM

- Along with FM, Television was on the verge of becoming a reality.
- With so many competing TV systems being developed, in 1936, the Radio Manufacturers Association set guidelines for TV.
- In 1940, the FCC formed the National Television Standards Committee (NTSC) to set TV standards once and for all.
- In May of 1941, the NTSC set television's standards:
  - 525 line picture
  - 30 frames per second
  - Picture aspect ration of 4:3
  - *Sound will use FM*

World War II put commercial development of both FM and TV on hold

During the war, Armstrong worked on a long-range FM doppler radar system

Sarnoff became a General in the U.S. Army

Getting ready for the postwar years

- By 1944, the FCC realized that there would be an explosion of TV and FM stations after the war ended.
- The FCC decided to take another look at the frequency allocations for both FM and TV once more.
- RCA/NBC as well as CBS suggested that with the increasing sunspot activity, the current FM band (42-50 megacycles) be moved to a higher frequency to prevent interference between stations.
- Then the old FM band could be used for TV, never explaining how TV signals wouldn’t interfere with each other [they weren’t very subtle].

Changing the FM band

- This would make ~50 broadcast stations and about a half million receivers obsolete.
- The National Bureau of Standards said that the interference concerns were unfounded.
- However a former FCC engineer working for the War Department, using mathematical calculations, said interference would be a problem.
- It was shown that this engineer didn't really understand wideband FM well and that his calculations were flawed.
- In January 1945 the FCC moved FM to it's current 88 to 108 MHz band
- The FCC chairman had previously worked as legal council for CBS and before the war had argued that the FM band should be given over to TV. Hmmmmm…….

Postwar achievements & litigation

- Armstrong continued his FM work
  - 1946 - Using his FM radar system bounced a signal off the moon.
  - 1953 - Developed FM multiplexing, permitting the stereo FM we know today.
- Though television required the use of FM sound, along with the continuation of a smaller FM radio market, RCA (as well as others) were not paying Armstrong for use of his patents.
- RCA claimed that their FM usage was not based on Armstrong's patents.
- In 1948, Armstrong sued RCA for patent infringement. Other cases followed against other manufacturers.

Final years

Armstrong, FM Inventor, Dies In Leap From East Side Suite

Pioneer in Radio, 63, Plunges From River House Window —Left a Note for Wife

Maj. Edwin H. Armstrong, whose inventions provided much of the basis for modern broadcasting, was found dead yesterday morning on a third-floor balcony of River House, 435 East Fifty-second Street. The 63-year-old electrical engineer had plunged from a window of his luxurious thirteenth-floor apartment, apparently late Sunday evening or during the night.

A two-page note, a penciled farewell to his wife, was found in the apartment. Dr. Emanuel Neuren, assistant medical examiner, listed the case as a suicide.

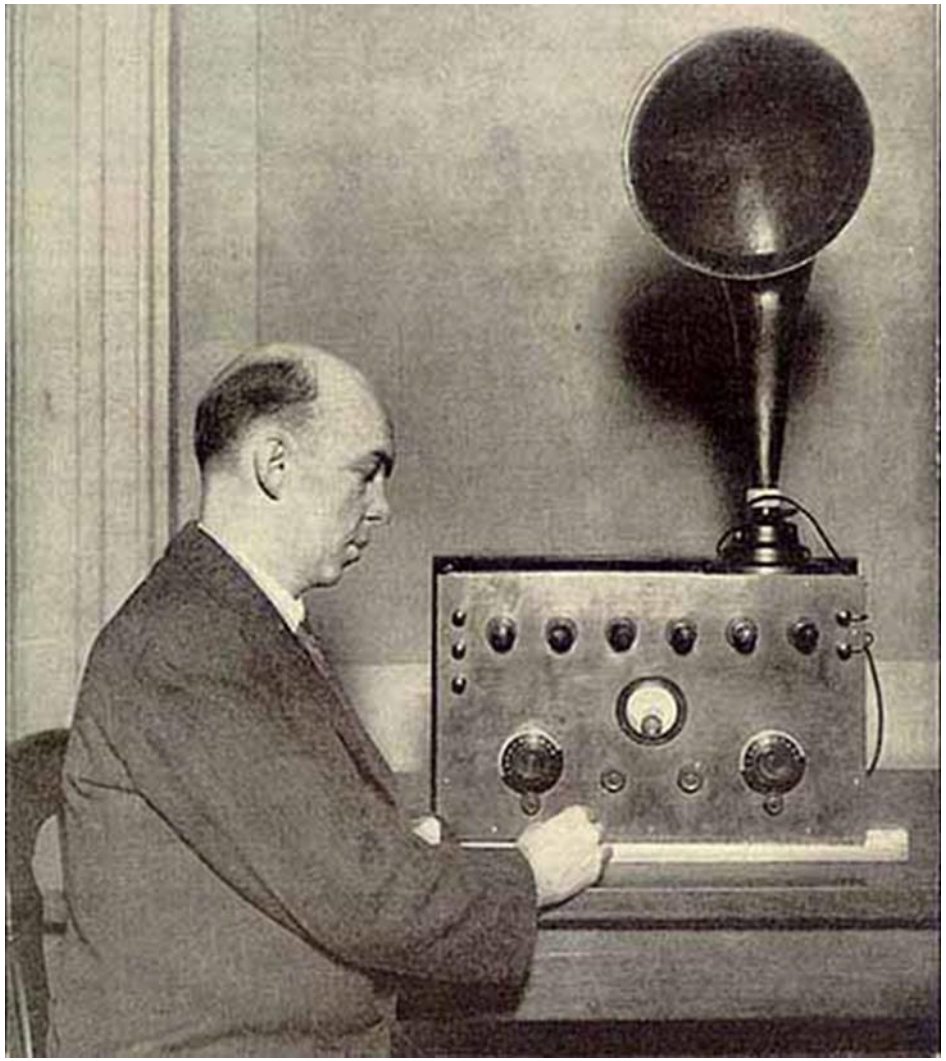
According to detectives of the East Fifty-first Street station, Major Armstrong had been alone after about 1 P. M. on Sunday. Mrs. Armstrong had been with a sister, Mrs. Marjorie Tuttle, in Granby, Conn., for a number of weeks. Three servants had gone out after serving lunch to the inventor Sunday afternoon.

In his message to his wife, the former Miss Marian MacInnis, Major Armstrong said that he was heartbroken at being unable to see her once again, and expressed deep regret at having

Continued on Page 13, Column 2

Maj. Edwin H. Armstrong

- Armstrong's cases dragged on in the courts for years.
- Armstrong said that RCA would drag the case out until he was either broke or dead, these cases consumed Armstrong.
- By 1954 Armstrong's health was failing, he was nearly broke, and he had separated from this wife of 30 years.
- On February 1, 1954, Edwin Howard Armstrong leapt to his death from his apartment window.
- 13 years later in 1967, his widow Marion won the final FM lawsuit. Armstrong won every case.



Armstrong with the first portable superhet receiver

Thanks for listening

For more about Edwin Howard Armstrong

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