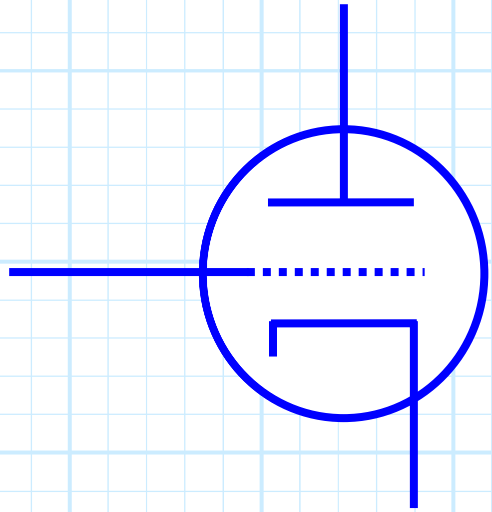
Oscillators-A Brief History

In September of 1912, **Edwin Howard Armstrong** was experimenting with Lee DeForest's new device—the **audion** (what we now call the **triode** vacuum tube).



The Triode Vacuum Tube

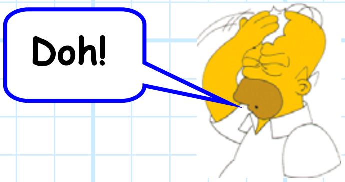
These devices had been successfully used as an AM **detector**, but no one (especially DeForest!) quite knew how or why the device worked, or what other **applications** of the device there might be.

By coupling one terminal of the device to another, Armstrong found that he could achieve large signal **gain**—he had built the first **electronic amplifier**! He called the process "**regeneration**"; we know it today as positive **feedback**.

The electronic amplifier would **revolutionize** radio, but Armstrong was **not** yet finished!

Armstrong found that as he **adjusted** his amplifier to achieve **maximum** gain, the circuit would suddenly begin to "squeal". Of course, this was disappointing at first, but then Armstrong realized this "squeal" was a high-frequency signal—the circuit was **oscillating**!

Armstrong had of course increased his feedback to the point that the circuit had become **unstable**—his poles where in the **right**-half plane!



Armstrong had made the first **electronic oscillator**—this too would revolutionize radio!

Armstrong had created the components necessary to make **Continuous Wave** (CW) radio **practicable**. Recall that radio at that time was primarily wireless **telegraphy** (i.e., dots and dashes). CW radio is required to transmit **audio** information (e.g., music and voice).

Engineers had **already** created some CW radio systems, using **electromechanical** oscillators, but they could create signals only in the kHz range at best.

With Armstrong's oscillator, CW signals at high frequencies (e.g. kHz and **MHz)** could be **easily** generated!

Along with the **amplifier**, the electronic **oscillator** allowed for the creation of **reliable**, "**low-cost**" radio systems with **clear** and **audible** sound!

Although these inventions gave a **tremendous** boost to the radio industry, a major technical problem still remained.

But guess what? Armstrong would solve **this** problem too!

ARMSTRONG, EDWIN HOWARD (Dec. 18, 1890 -- Jan. 31, 1954), electrical engineer and inventor of three of the basic electronic circuits underlying all modern radio, radar, and television, was born in New York City, the first child of John and Emily Smith Armstrong, both native New Yorkers. His mother had been a teacher in the public schools and his father was vice president of the United States branch of the Oxford University Press. The family soon moved to the suburban town of Yonkers, N.Y., where they lived in a house on a bluff overlooking the Hudson River.

Armstrong decided to become an inventor when he was fourteen and began filling his bedroom with a clutter of homemade wireless gear. His imagination was fired by the *Boy's Book of Inventions* and by Guglielmo Marconi, who a few years before had sent the first wireless signals across the Atlantic. But wireless telegraphy was still in a primitive state. Its crude spark-gap transmitters produced electromagnetic wave signals so weak that sunlight washed them out through most daytime hours, while its iron-filing or magnetic receivers were cruder still, requiring tight earphones and quiet rooms to catch the faint Morse code signals that were all the early wireless was capable of transmitting. As a student at Yonkers High School (1905-1910), Armstrong built an antenna mast, 125 feet tall, on the family lawn to study wireless in all its aspects. He worked with every new device that came along, among them the so-called audion tube invented in 1906 by Lee deForest. But none of the instruments were able to amplify weak signals at the receiver, nor yet to provide stronger, more reliable power at the transmitter. On graduating from high school, Armstrong began to commute by motorcycle to Columbia University's school of engineering to pursue his studies further.

While a junior at Columbia, Armstrong made his first major invention. Long analysis of the action within the audion tube suggested to him that it might be used to greater effect. The tube was based upon Thomas Edison's 1883 discovery in his early lamp of a tiny anomalous electric current that flowed across a gap from the filament to a metal plate. In 1904 an English inventor, John Ambrose Fleming, had shown that this effect could be used as a wireless receiver, two years later deForest had added a vital element, a wire grid between the filament and plate. But in the usual receiver circuit the tube did no more than detect weak signals. In the summer of 1912 Armstrong devised a new regenerative circuit in which part of the current at the plate was fed back to the grid to strengthen incoming signals. Testing this concept in his turret room in Yonkers, he began getting distant stations so loudly that they could be heard without earphones. He later found that when feedback was pushed to a high level the tube produced rapid oscillations acting as a transmitter and putting out electromagnetic waves. Thus this single circuit yielded not only the first radio amplifier but also the key to the continuous-wave transmitter that is still at the heart of all radio operations.

Armstrong received his engineering degree in 1913, filed for a patent, and returned to Columbia as an instructor and as assistant to the professor and inventor, Michael Pupin. Before his new circuit could gain wide use, however, awaiting improvements in the vacuum tube, the United States was plunged into World War I and Armstrong was commissioned as an officer in the U.S. Army Signal Corps and sent to Paris. He was assigned to detect possibly inaudible shortwave enemy communications and thereby created his second major invention. Adapting a technique called heterodyning found in early wireless, but little used, he designed a complex eight-tube receiver that in tests from the Eiffel Tower amplified weak signals to a degree previously unknown. He called this the superheterodyne circuit, and although it detected no secret enemy transmissions, it is today the basic circuit used in 98 percent of all radio and television receivers.

Armstrong returned to Columbia with the rank of major and the ribbon of France's Legion of Honor. By then, wireless was ready to erupt into radio broadcasting. In 1920, on a bid from Westinghouse Electric and Manufacturing Company, he sold rights to his two major circuits for $335,000.00. Later he sold a lesser invention, the superregenerative circuit, to the newly organized Radio Corporation of America (RCA) for a large block of stock. Upon the success of early radio broadcasting, he became a millionaire, but he continued at Columbia University as a professor and eventual successor to Pupin. After a celebratory trip to Paris, he returned to court Marion MacInnes, secretary to the president of RCA, David Sarnoff. On Dec. 1, 1923 they were married.

As the 1920's wore on, Armstrong found himself enmeshed in a corporate war to control radio patents. His basic feedback patent had been issued on Oct. 6, 1914. Nearly a year later deForest filed for a patent on the same invention, which he sold with all audion rights to the American Telephone and Telegraph Company (AT & T). As radio began to boom, AT & T mounted a broad attack to overturn Armstrong's patent in favor of deForest's. The battle went through a dozen courts between 1922 and 1934. Armstrong, backed by Westinghouse and RCA, won the first round, lost a second, was stalemated in a third, and finally, in a last-ditch stand before the Supreme Court, lost again through a judicial misunderstanding of the technical facts.

The technical fraternity refused to accept the final verdict. The Institute of Radio Engineers, which in 1918 had awarded Armstrong its first Medal of Honor for the invention, refused in a dramatic meeting to take back the medal. And the action was reaffirmed in 1941 when the Franklin Institute, weighing all the evidence, gave Armstrong the highest honor in U.S. science, the Franklin Medal.

Throughout this ordeal Armstrong doggedly continued to pursue his research. He had early set out to eliminate the last big problems of radio -- static. Radio then carried the sound patterns by varying, or modulating, the amplitude (power) of its carrier wave at a fixed frequency (wavelength) -- a system easily and noisily broken into by such amplitude phenomena as electrical storms. By the late 1920's Armstrong had decided that the only solution was to design an entirely new system, in which the carrier-wave frequency would be modulated, while its amplitude was held constant. Undeterred by current opinion -- which held that this method was useless for communications -- Armstrong in 1933 brought forth a wide-band frequency modulation (FM) system that in field tests gave clear reception through the most violent storms and, as a dividend, offered the highest fidelity sound yet heard in radio.

But in the depressed 1930's the major radio industry was in no mood to take on a new system requiring basic changes in both transmitters and receivers. Armstrong found himself blocked on almost every side. It took him until 1940 to get a permit for the first FM station, erected at his own expense, on the Hudson River Palisades at Alpine, N.J. It would be another two years before the Federal Communications Commission granted him a few frequency allocations.

When, after a hiatus caused by World War II, FM broadcasting began to expand. Armstrong again found himself impeded by the FCC, which ordered FM into a new frequency band at limited power, and challenged by a coterie of corporations on the basic rights to his invention. Facing another long legal battle, ill and nearly drained of his resources, Armstrong committed suicide on the night of Jan. 31, 1954, by jumping from his apartment window high in New York's River House. Ultimately his widow, pressing twenty-one infringement suits against as many companies, won some $10 million in damages. By the late 1960's, FM was clearly established as the superior system. Nearly 2,000 FM stations spread across the country, a majority of all radio sets sold are FM, all microwave relay links are FM, and FM is the accepted system in all space communications.

Armstrong was posthumously elected to the roster of electrical "greats" to stand beside such figures as Alexander Graham Bell, Marconi, and Pupin, by the International Telecommunications Union in Geneva. He was the great prose master of electronic circuitry, weaving its phrases and components into magical new forms and meanings.