

REGINALD A. FESSENDEN AND THE DEVELOPMENT OF RADIOTELEPHONY

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PART I: CONTINUOUS WAVES AND THE NEEDED DETECTOR

At the turn of the century, Reginald A. Fessenden was convinced that the approach most people were taking toward the development of wireless telegraphy systems was wrong. Marconi and virtually everyone else at that time continued a commitment to using spark gap transmitters to generate pulses of damped oscillations. It was clear to Fessenden that these pulses of damped oscillations had numerous drawbacks.

Attempts to tune receivers, transmitters, and antennas were made difficult by the high harmonic content of the damped oscillation pulses. Equally importantly, Fessenden knew that the system of radiotelephony that he wanted to develop required a source of continuous, undamped radio frequency waves.

The spark gap transmitters generated pulses of damped high frequency oscillations at an audio fre-

quency pulse rate. Fessenden knew that these pulses of oscillations produced a convenient audio frequency tone in the headphones for the receiving telegraph operators to copy. However, he also knew that, if modulation of these pulses of oscillations were attempted, a loud audio frequency "buzz" would occur in the received signal which would drown out the voice or music being transmitted.

Fessenden had begun his electrical career by working with dc power distribution systems under Thomas A. Edison, but soon joined a branch of the Westinghouse Company which was developing ac power systems. As a result, he viewed radio frequency oscillations not in terms of pulses of spark-gap-produced oscillations, but rather as an extension of the continuous alternating current oscillations generated by alternators for electrical power systems.

Reginald Fessenden believed that the continuous radio frequency oscillations he wanted could be produced using specially designed alternators. The technology to do this, however, would require much developmental work. John Ambrose Fleming, who later would invent the first thermionic diode "valve" detector, insisted that an alternator like Fessenden wanted never could be constructed and would not produce useful radiation even if it were built.

Another major problem faced Fessenden in the development of a radiotelephony system. He needed a detector which was continuous in its operation. Fessenden knew that the coherer, which was then the most widely used detector for radiotelegraphy, was incapable of the continuous operation required.

The development of a continuously acting detector was the first significant success achieved by Fessenden toward his goal of achieving radiotelephony. He worked out this device, which he called a "hot-wire barretter," while on the faculty of the Western University of Pennsylvania (now the University of Pittsburgh) in the late 1890s.

The hot-wire barretter consisted of a small "U" shaped loop of very thin silver-coated platinum wire (labeled W in Fig. 1), which was enclosed in an evacuated glass envelope (labeled A) and connected to lead-in wires (L). This envelope, in turn, was surrounded by a second glass envelope (B), which was silvered to shield the wire loop from external radiation. The silver coating on the middle of the wire loop

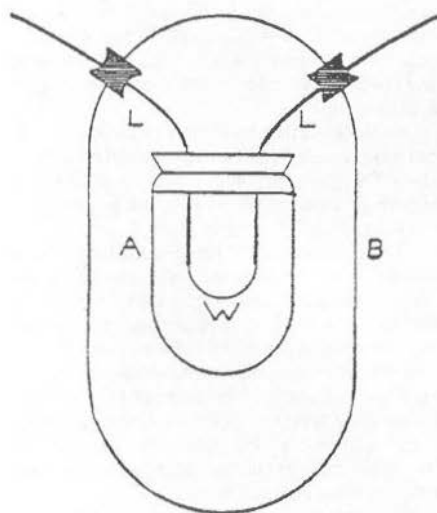


Fig. 1. The "hot wire barretter" (see text for key to callouts) was Fessenden's first continuously operating detector.

was removed by a nitric acid etching process to increase the resistance of that portion of the wire.

The resistance of the hot-wire barretter changed when a wireless signal passed through the wire loop. The result was an audible response if a telephone receiver was connected in series to ground with the barretter, a battery, and a resistor.

This hot-wire barretter had low sensitivity but it did operate continuously. It provided a response which was approximately proportional to the amplitude of the received wireless signal and, therefore, would serve as a detector of amplitude modulated continuous oscillations if they could be generated.

Fessenden contacted the General Electric Co. in June of 1900 to see if it would design and build for him a high frequency alternator. GE agreed but indicated that it likely would take several years to achieve the design he wanted.

Later in 1900, Fessenden left his faculty position to work for the U.S. Weather Bureau. He was assigned to Cobb Island, MD, where his job was to develop a wireless telegraphy system which would enable remote stations to report weather conditions. Fessenden now could work on wireless telephony only in his spare time because radiotelephony was of no interest to the weather bureau.

Before leaving Pittsburgh, Fessenden had ordered made a rotary, mechanical "interrupter" which would increase to a much higher value the discharge rate of a spark gap transmitter. With this, the train of oscillation pulses produced, hopefully, would be less highly damped and could be more effectively amplitude modulated. Also, Fessenden hoped, the audio frequency "buzz" accompanying the detected signal now would be high enough in frequency so as not to be too objectionable.

Using this interrupter, late in 1900 Fessenden succeeded in sending the world's first radiotelephone transmission to a colleague over a distance of approximately one mile near Rock Point, MD. The audio quality of the received signal was poor but his transmitted spoken words were recognizable. Fessenden was still convinced that he needed a high frequency alternator producing continuous oscillations with a frequency of at least 100 kHz to achieve commercially acceptable radiotelephony.

The hot wire barretter was not adequately sensitive to be used as a commercial quality radiotelephone detector. Consequently, Fessenden continued his efforts to develop a better detector.

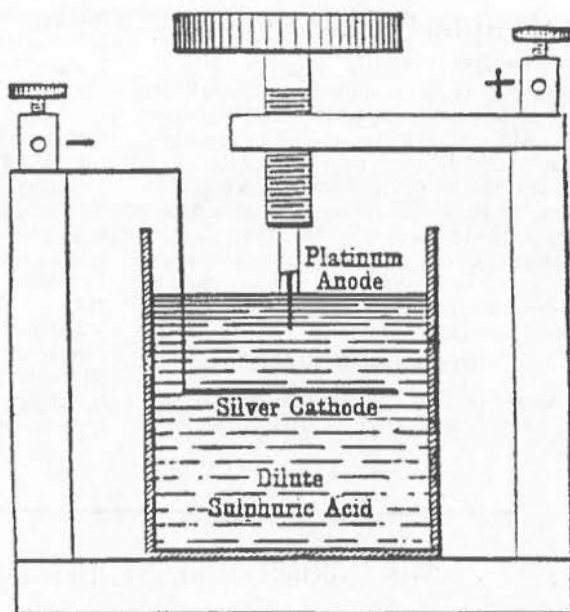


Fig. 2. Wide acceptance and usage of Fessenden's improved "liquid barretter" made it possible for many to hear his first radiotelephony broadcasts. (Figs. 1 and 2 from reference 5.)

The way to achieve a substantially improved continuous detector was found purely by accident by Fessenden in 1902. A wire filament for a hot wire barretter was left too long in the etching acid. The acid had dissolved the wire completely leaving only a stub of the wire in contact with the acid. Fessenden noticed, however, that a meter which had been connected to the wire to monitor the etching process was responding very vigorously to electromagnetic waves being generated elsewhere in the laboratory. He realized that he now had a truly sensitive continuously operating detector. Fessenden called this device the "liquid barretter."

A typical configuration of the liquid barretter detector is shown in Fig. 2. The device was simplicity in the extreme. The tip of a short piece of fine platinum wire barely made contact with the surface of a small pool of 20 percent nitric or sulfuric acid solution. A second, larger, electrode was deeply immersed in the acid solution.

The liquid barretter was not well suited for use on ships rolling on stormy seas because, for proper operation, the platinum wire stub could make only shallow contact with the acid. Nonetheless, this detector was widely used both on land and sea. The liquid barretter was the detector against which all

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others were compared until de Forest's triode audion detector became the new standard many years later.

Although Fessenden obtained a patent on the liquid barretter in 1903, many violated that patent. Lee de Forest, for example, sold many of the devices to the U.S. Navy and to commercial wireless companies until prohibited by court order. Ironically, these infringements of his patent made possible a large "audience" for Fessenden when he later made his first radiotelephony "broadcast," which will be discussed in part II.

RECOMMENDED READING

1. Aitken, Hugh G.J., *The Continuous Wave: Technology and American Radio*, Princeton University Press, 1985.

2. Archer, Gleason L., *History of Radio to 1926*, The American Historical Society, 1938.
3. Fessenden, Helen M., Fessenden - Builder of Tomorrows, Coward-McCann Inc., 1940.
4. Fessenden, Reginald A., "Wireless Telephony," *Proceedings of the American Institute of Electrical Engineers*, Vol. 27, No. 7, July 1908.
5. Fleming, John A., *The Principles of Electric Wave Telegraphy and Telephony* (Third Edition), Longmans, Green and Co., 1916.
6. Kintner, S.M., "Epoch Making Radio Inventions of Fessenden," *The Electric Journal*, Vol. 18, No. 4, April 1921.
7. Kintner, S.M., "Pittsburgh's Contributions to Radio," *Proceedings of the Institute of Radio Engineers*, Vol. 20, No. 12, December 1932.
8. Phillips, Vivian J., *Early Radio Wave Detectors*, The Institution of Electrical Engineers, London, 1980.

THE MAKING OF FESSENDEN'S ALTERNATORS

Not surprisingly, given his former affiliation with Westinghouse, Fessenden first approached that company to get the high frequency alternator he wanted designed and built. Westinghouse declined to accept the job, apparently because the firm was busy designing the hydro-electric plant for Niagara Falls. Fessenden then turned to General Electric.

Charles Proteus Steinmetz was GE's leading designer of a.c. equipment when Fessenden ordered his first alternator in 1900. Steinmetz was intrigued by the challenge offered by Fessenden's request. But despite his best efforts, the first high frequency alternator produced only 10,000 oscillations per second, falling far short of Fessenden's needs. The limiting factor was the inability of the rotating armature to withstand speeds greater than about 3,760 rpm.

The next request Fessenden submitted to GE was for an alternator which could produce 150,000 continuous oscillations per second. This time the job of designing the requested alternator was assigned to Ernst Alexanderson, a young engineer from Sweden who had joined GE in 1902. Alexanderson had quickly impressed his supervisors with his ability to invent useful components for electrical power systems.

Before long, Alexanderson devised an armature which employed a winding on a stationary iron core positioned between two rotating steel disks with magnetic poles cut into their circumferences. A.c. currents were induced in the windings of the armature as the disks rotated. The rotational speed of the disks together with the number of poles determined the frequency of the oscillations produced.

Fessenden feared that the armature's iron core would result in unacceptably high losses due to hysteresis and eddy current effects. He directed Alexanderson to use a wooden armature core. Fessenden also directed that an electric motor, rather than a steam engine, be used to produce the rotation of the steel disks.

By early 1906, Alexanderson had succeeded in producing an alternator with an output frequency of approximately 50 kHz. He soon was assigned to oversee the design of all the high frequency alternators GE would produce for Fessenden and for others. Before long, the name "Alexanderson" became almost inseparable from the term "high frequency alternator."

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