Fessenden on Roanoke Island and the Outer Banks, NC, 1901-1902

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Preamble

John Belrose was invited by Rob Bolling, Historian, Ft. Raleigh National Historic Site, Roanoke Island, NC, to present talks on Reginald Aubrey Fessenden on the 6th and 7th December, 2006. Three presentations were made: at the Ft. Raleigh National Historic Site Auditorium, Roanoke Island, on 6th December; at the Roanoke Island Festival Park, Manteo, on the morning of the 7th December (to Park Staff concerned with the history of Roanoke Island); and at Buxton, on the Outer Banks, on the evening of 7th December. The talk at Buxton was presented at the Community Fessenden Center, near the location where Fessenden had installed his wireless station.

The Roanoke Island and the Outer Banks areas have an interesting early history: the Ft. Raleigh National Historic site is the location of the first English settlement in the United States; Kitty Hawk is the location where the Wright Brothers carried out their aircraft development research and where they made the first flight of an aircraft; and Reginald Aubrey Fessenden, Canadian born wireless pioneer, carried out important research while in the area (1901-1902).

In Manteo we stayed at The Tranquil House Inn, facing the old waterfront, not to be confused with the original Inn with that name, where Reginald stayed when he came to Roanoke Island without his family (the original Inn across the road was destroyed by fire).

Historic Site Markers: Weir Point, north end of Roanoke Island, on the left and center; Buxton, Hatteras Island, Outer Banks, on the right [photographed by John Belrose, 8 December 2006]

In 1900 Fessenden left the University of Pittsburgh to work for the **United States Weather Bureau** with the objective of proving the practically of using a network of wireless stations to transmit weather information, thus avoiding the need for telegraph lines. The terms of the contract gave the Weather Bureau access to any devices Fessenden invented, but he would retain ownership of his inventions. The initial work took place on Cobb Island, MD, about 80 km South of Washington, where Fessenden and his wife lived in accommodations that were decidedly Spartan. While some experimentation using the arc method to generate continuous waves was carried out, recall Fessenden's interest to transmit sound, the spark gap method in this time period was clearly superior, and so following the work of Prof. Elihu Thompson, another one of Fessenden's heroes, he experimented extensively with spark technology; work directed toward obtaining sustained oscillations, with the spark gap and condenser in a primary circuit, and with a secondary circuit connecting to the antenna, suitably tuned to achieve resonance. Marconi in this time period was conducting straight aerial experiments, the spark gap across the input terminals of the antenna.

But the receiver was the problem of concern. The coherer detector used by Marconi and others, was useless to differentiate between signals and atmospherics, and absolutely useless to receive telephony. In November 1999, while experimenting with a receiver employing various types of detectors, listening to a spark transmitter with a Wehnelt interrupter operating the induction coil used for sending, Professor Fessenden noticed that when the sending key was kept down at the sending station for a long dash, the peculiar wailing sound of the Wehnelt interrupter was produced with absolute fidelity in the receiving telephone. This immediately suggested to Fessenden that by using a spark rate well above audibility, wireless telephony might be possible.

The receiver used a curious sort of detector, comprising the ring of a short-period Elihu Thompson oscillating current galvanometer, resting on three supports, two pivots and a carbon block, with a telephone receiver and a storage battery in a circuit with the carbon block.

Prof. Kintner made drawings for a mechanical interrupter designed to make 10,000 breaks/second, which was constructed by Mr. Brashbear, a celebrated optician. The apparatus was completed in January or February 1900, but experiments were not made until the fall of 1900, since Fessenden was busy with moving his stations from Allegheny, PA, to Rock Point (Cobb Island), MD. After many many experiments, probably using the same primitive detector described above, on 23 December 1900, as darkness fell, and a light snow dusted Cobb Island, Fessenden succeeded in making the first wireless transmission of voice ever, sending the signal between two 15 meter towers 1.6 kilometers apart. The reception was described as “poor in quality, but quite distinct and entirely intelligible”. The transmitter was a spark transmitter operating at 10,000 sparks/second, perhaps less, employing a carbon microphone in series with the antenna circuit.

In my view anyone reading about this experiment would agree that the voice signal if heard at all would be buried in a disagreeable noise, but words perfectly clear?? So I decided to duplicate Fessenden’s experiment using a small home brew laboratory spark transmitter, and a carbon microphone in series with an equivalent antenna circuit, just like Fessenden did (see http://www.hammondmuseumofradio.org/spark.html) --- but we did not try to duplicate the type of detector he may have been using --- our receiver was a crystal, receiver.

Fessenden also succeeded during his experiments on Cobb Island in transmitting Morse code signaling over a distance of 80 km to Arlington, VA.

The Weather Bureau was pleased with his research in both telegraphy and telephony. His work also included careful experiments to determine the course of the wireless waves, how far they went, and what happened when the receiver was buried in the ground or put under the surface of the sea.

In 1901 the bureau decided to move Fessenden and his apparatus from Cobb Island, MD, to Roanoke Island, NC. Here Fessenden built three stations, on Roanoke Island, at Weir Point, and Buxton (on Hatteras Island), NC, and Cape Henry, VA. Prof. Moore, of the US Weather Bureau, envisaged that stations on the Outer Banks could yield an invaluable way to warn ships away from approaching weather systems. Military, maritime and merchant interests were poised to gain the advantage of trans-ocean communications.

At the time of Fessenden’s experiments, the Outer Banks of North Carolina were known as “the graveyard of the Atlantic”, because of the large number of vessels lost along its shores. And, when Fessenden was leaving the area in 1902, a large local storm sank four schooners, with the loss of twenty lives.

Fessenden’s work on Roanoke Island was devoted to achieving a continuous wave like transmitter; and toward improving signal reception by devising a wave-detector, suitable for wireless telephony.

HF Alternator

The General Electric Company, in 1900 took on the task for Fessenden to construct a HF alternator providing an output of 1 kW at a frequency of 100,000 Hz (100 kHz). In 1902 GE delivered their best design, which gave an output frequency of only 10 kHz. While this was a far cry from the machine Fessenden wanted, nevertheless it could be used to generate a more CW like output from his spark transmitter --- vastly superior to the 10,000 breaks/second provided by a mechanical interrupter used for his early experiments. Using this alternator as the power source for his spark transmitter, arranged to fire the spark on both positive and negative peaks of the sine wave, he had a coherent spark transmitter operating at 20,000 sparks/second, simulating a continuous wave transmitter. With this transmitter he could not send Morse signals, on-off-keying of the carrier frequency.

A Spark transmitter is an intermittent (on-or-off) source of RF power, an RF “carrier” signal which is in effect “modulated” by the spark rate. Thus if the spark rate was 800 sparks/second, and the sparks were regular and of short duration, one would hear in a receiver with a suitable detector, a rather clear 800 Hz tone --- a frequency very suitable for listening to. But if the spark rate is very high, 10,000 or 20,000 sparks/second, one would hear nothing, excepting the clicks associated with the making and breaking of the Morse key contacts

Use of Musical Tones to send Wireless Telegraphy

So the idea came to Fessenden that he could in fact by applying a musical tone or several tones of different frequency, he could (in principle) send one or several Morse code messages over a single radio frequency carrier. This technique for which Fessenden was awarded US Patent 715,203, “Selective Signalling by Electromagnetic Waves” (multiplex transmission and reception) --- December 1902 , was a logical precursor to applying the human voice to a radio frequency carrier.

Fessenden himself in what he said at the time was not clear about how he generated the tones, he said “we have four or five methods, all of which have been successfully tested in practice”, but the reference patent shows the use of a tuning fork.

Achieving a Suitable Detector

But he still had to develop a suitable detector. In 1901 he was experimenting with a device he called a barretter, a hot wire barretter (US Patent 706,744, “Current Actuated Wave Responsive Devise: (“barretter” detector) – August, 1902). This device consisted of a minute platinum wire a few hundred thousands of a cm in diameter and approximately two hundredths of an inch in length. This hot wire detector was no more sensitive than the coherer, but since it lacked the coherer on-or-off nature (current change due a changing amplitude of the RF signal changed the resistance of the small bit of wire, and so the current of a series connected DC voltage), it could reproduce speech --- but poor sensitivity was only a part of problem --- electrical charge on his antenna system, typical of a coastal environment, resulted in discharge currents which constantly burned out the delicate wire.

The commercially available fine wire he was using for his hot wire barretter was silver coated, and to make it work he had to remove the silver coating by immersing it in nitric acid. While engaged in this process Fessenden discovered by chance his electrolytic detector. A small test station had been constructed at the south end of Roanoke Island, where signals were sent to the Laboratory. One morning while listening to the signal from the sender at the south end, which was sending “D’s”, Fessenden noted that the received signal was coming through loud and clear.

At the Laboratory, Professor Fessenden had just inserted in the circuit one of his hot wire barretters, just taken from the acid solution, and (as noted above) he was surprised to note the clearness and steadiness of the signal reception, although static (a problem) was present to some degree. He took the barretter out of the circuit, and placed it under a microscope. What he saw was that the platinum wire had been broken, but both ends were encased in a bubble of acid that had been left on the wires. This lead to many further experiments, and to the development of his liquid barretter or electrolytic detector, which became the standard of sensitivity for many years, until germanium crystal detectors or vacuum tube diode detectors were devised in c1913. The term barretter comes from the French word exchanger, implying a change from AC to DC (US Patent 727,331, “Receiver for Electromagnetic Waves” (improved barretter) --- May 1903).

The Concept of Heterodyning was Born

But this rectifier-detector (liquid barretter or electrolytic detector) would be useless for reception of on-off- keyed un-modulated continuous wave signals (great for receiving tones). All that would be heard would be clicks, as the Morse key was opened and closed. Again Fessenden’s fertile mind worked around the problem, ahead of its time by a decade, since a compact source for generating a CW signal at the receiver had not yet been developed). He devised (in his mind) the methodology of combining two frequencies to derive their sum and difference frequencies, and he coined the term heterodyne, derived from joining of two Greek words hetero, meaning difference, with dyne, meaning force.

Today heterodyning is fundamental to the technology of radio communications. Some historians (Belrose and Elliott **[1]**) consider that Fessenden’s heterodyne principle is his greatest contribution to radio technology. His initial heterodyne circuit is described in US Pat. No. 706,740 dated 12 August 1902, and his advanced heterodyne circuit, Pat. No. 1,050,441 and 1,050,728, is dated 14 January, 1913.

The principle of heterodyning could not be put to practical application until the development of vacuum tube oscillators. Modern communications receivers for reception of on-off keyed CW signals for Morse signaling employ a beat-frequency-oscillator (BFO) for signal reception of the Morse signals by the heterodyne methodology --- and all receivers employ the heterodyne principle to convert the received RF signal to a lower intermediate frequency (IF), a frequency at which the main amplification process takes place.

Wireless Communications Experiments/and Demonstration between Weir Point and Buxton

For those readers who are not cognizant with the technology and problems associated with the development of the art of wireless communications, they should read the article by Alfred Pickells **[2]**, who well describes the difficulties in conducting wireless experiments in the Outer Banks area. All three stations, at Weir Point and Buxton, NC, and Cape Henry, VA used (for the 1902 experiments) 52 meter vertical masts, the development of which required the erecting and re-erecting many times with great difficulty the prototype mast. The first test transmissions conducted between Weir Pont an Buxton occurred in March 1901, employing the hot-wire burretter as the receiving detector. On this test many hot-wire barretters burned out by static discharge on the aerial, as fast as they were inserted in the aerial circuit. But signals were in fact received, from the 30 centimeter aerial coils, on some days when static levels were low.

After many many experiments, in the latter part of April, 1902 preparations were made for an official test of the system, as it stood (the liquid barretter was I believe used for the receiver), to be observed by the Army and Navy, and officials of the Coast and Geodetic survey. On 19 April, the system was successfully demonstrated **[3]**. Professor Fessenden’s assistant at Buxton, 80 km away, had been instructed to make a test which should comprise not only signaling, but sending complete messages. The operator at Buxton was to telegraph hourly, a one way communication link, since at the time there was no receiving apparatus at Buxton. The operator was instructed to begin slowly, sending three to ten words/minute for the first ten minutes, and after that to increase his speed until he was sending as fast as he could. But as luck would have it something turned up which made the test more complete than Prof. Fessenden had counted on. It happened that Bureau Chief Willis Moore had found an urgent need to reach Prof. Fessenden with a message. There were no telegraph wires on Roanoke Island, and therefore Chief Moore decided to try the chance of reaching the inventor by his own system. He wired his message to Fessenden's man at Buxton, directing him to send it by wireless to Ronoake Island, which the operator did. The message was received without a mistake, 127 words in length, the longest message yet received by the Fessenden system.

Difficulties with Chief Willis Moore

As word of Fessenden's accomplishments spread, various US and Mexican government agencies began placing orders for his system. This potential commercial activity provoked Willis Moore, who demanded a share in Fessenden's patents as the price for continued employment. Fessenden refused, and in August 1902 he left the Weather Bureau. The operations of the stations at Weir Point and Buxton was continued by the Bureau for a few months, in a desultory fashion, then the stations were closed down and the equipment sold by auction.

Darwin Wolcott, Fessenden's Pittsburgh patent attorney then put him in touch with two Pittsburgh millionaires Thomas H. Given and Hay Walker, who wanted to back his work. With their funding support the National Electric Signalling Company (NESCO) was created, naming Fessenden president, and agreeing to purchase his patents out of company profits --- but that is a continuing follow-on story **[4. 5. 6, 7, 8].**

Note: Fessenden's 1906 Christmas Eve broadcast is one of his most cited accomplishments, particularly in this year the 100th anniversary of that broadcast. For a simulation of Fessenden's Christmas Eve broadcast see http://www.hammondmuseumofradio.org/fessenden-2006-recreation.html.

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