

**DOCTOR LEE de FOREST,
PROFESSOR WARREN JOHNSON,
AND THE AMERICAN WIRELESS TELEGRAPH CO.**

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It was only a century ago that a young man entered these words in his journal: “At last, at last, after long planning and plotting, years of study, and weeks of patient, weary waiting, I have the opportunity offered for the work that I have chosen, experimental work in wireless telegraphy. ... It is the opportunity of a lifetime to enter first at the start on a scientific art all new, all to be developed, of a boundless, ever-widening, ever-enriching future.” [1, 2] The date was April 8, 1900, the location was Chicago, Illinois, and the author was Doctor Lee de Forest. His great enthusiasm was prompted by a new job in the service of Professor Warren S. Johnson at the American Wireless Telegraph Company of Milwaukee, Wisconsin. While the story of Dr. Lee de Forest is familiar and well documented, the stories of the American Wireless Telegraph Co. and its founder Warren Johnson are more obscure, but every bit as interesting. The good news is that a wealth of information is available to wireless historians about AWTC and Professor Warren Johnson.

Doctor Lee de Forest

Bored with his first post-doctoral employment as a new engineer and sometimes mechanic in the Western Electric dynamo department, de Forest applied for transfer to the Experimental Lab under William Dean. Lacking an immediate opening, Dean arranged for de Forest's transfer to the Telephone Cable Section, pending a position in the lab. As his impatience to enter the wireless field grew, Prof. Henry Bumstead, one of de Forest's Yale mentors urged him to “Work on your own if you must...Set up a laboratory at home...in the basement if need be.” [3] Taking this advice to heart, de Forest set about searching the contemporary technical literature for clues to the secret of wireless and assembling a laboratory at his rooming house.

During this time he acquainted himself with the disadvantages of the coherer. [3] The detector was slow and clumsy, not self-restoring, and subject to atmospheric interferences. It was during one of his systematic searches of the French and German physics journals that he discovered the work of Achkinass and Neugschwender in the journal Wiedemann's Annalen. [2] Their device consisted of alcohol placed over a narrow razor cut separating two pieces of tin foil mounted on a glass slide. This form of electrolytic detector had the advantage of being self-restoring. Unfortunately, its responsiveness to wireless impulses was short-lived in service and it functioned for only minutes of use.

During his attempts to verify and improve on their work, de Forest was promoted to the Experimental Lab in October of 1899, [4] noting; "now at last can I be fascinated in my work." [5] His efforts for Western Electric at the time must have been of merit, as he received a raise to \$10/week by December 30 of 1899. [3] It soon proved to be an assignment that involved less and less work on the telephone as he began spending increasing efforts in the development of a wireless detector.

Eventually, de Forest approached the lab supervisor Wm. Dean and asked for extra-curricular use of the Western Electric facilities for experimentation on his wireless apparatus outside of the expected working hours. Dean approved de Forest's request, provided he would not take time from his assigned telephone work. [4] Subsequently, the wireless apparatus was brought into the lab. This arrangement was not to last long. De Forest began to extend his experiments with the device he had named the 'Responder' into his working hours. The lab staff grew interested in de Forest's devices. The beginning of the end came when his co-workers "wasted" one half-hour of working time listening to the Responder's reception of a spark transmitter located across the lab. At this point, Dean told de Forest "You'll never make a telephone engineer. As far as I'm concerned you can go your own way. Do as you please." [3] Surprisingly, de Forest was not dismissed, but he took his supervisor's comment to heart. He spent most of his working hours on the Responder, a work pattern that was to be repeated throughout his life.

De Forest continued to look for more promising employment. Applications to work as an assistant for both Nikola Tesla and Guglielmo Marconi had been rejected. [6] One of his friends and colleagues in the Experimental Lab was Ed Smythe, who took interest in the young engineer's pursuit of wireless opportunities. Smythe had heard of a recently organized wireless firm and urged de Forest to apply for a job. [3] It appears that de Forest heeded the advice and sent a letter of introduction to the head of the American Wireless Telegraph Company, Professor Warren S.

Johnson. Johnson apparently found the young doctor's credentials of interest and arranged an interview during a business visit to Chicago. De Forest was offered and accepted a job with the new firm at an agreed upon salary of \$15 per week. [2] That date was April 8, 1900.

Professor Warren Johnson

Warren Seymour Johnson was born in Leicester, VT, on November 6, 1847. He was the son of Charles de Forest Johnson and Emeline (McCollough) and a ninth generation descendent of John Johnson, Constable of Roxbury, MA in the 1630s. [7] By 1850, his parents chose to leave the familiar New England states to seek their fortunes in the developing western frontier. First by boat, and later by wagon, his mother, father, an older brother, and young Warren emigrated as far west as Waukesha, Wisconsin. [8] Although he obtained some formal education locally, much of his youth was spent working and most of his learning was done on his own. The growing frontier proved ripe with vocational opportunities. By age 18, Warren Johnson was a print shop foreman. At various times he worked on the family farm, lumbered in northern Wisconsin, and served as County Surveyor in Dunn Co., WI. He began teaching in the county schools, eventually reaching Menomonie, WI. Here he married Cora E. Smith in 1873. [7,8] From this marriage, two children would be born, Paul Franklin (10/13/1874) and Carl Francis (6/21/1879). [7]

In addition to caring for a new family, 1874 found Mr. Johnson beginning work as Superintendent of Schools in New Lisbon, WI. By 1876, Warren Johnson accepted a position as teacher of drawing and penmanship at the Wisconsin State Normal School in Whitewater. [8,9] This move would set the stage for a profound change in Mr. Johnson's career. During his tenure at Whitewater, he has been variously credited with additional responsibilities for instruction in Chemistry and Physics, [10] Mathematics, [11] and as Professor of Sciences and Arts. [12] We do know that in 1881, he was appointed Professor of Natural Science. [9,13]

Concurrent with his teaching responsibilities, Professor Johnson constructed a private laboratory in his home. [8] The home laboratory included a 1-hp Shipman steam engine with kerosene-fired boiler to power a dynamo for charging electric accumulators (storage batteries). [14, 15] Some of his activities included experiments with accumulators while working both at Whitewater [14, 15] and at Madison. [11,16]

It was during this same period, that the Professor realized that his students would perform better in a room which was not frigid one hour, and near sweltering the next. [11,13,17,18] He directed his creative powers toward the institutional heating plants of the day. Contemporary

temperature control consisted of periodic visits to each classroom by a janitor, whose subsequent task was to manually readjust dampers for each of the rooms. Clearly this was not a very efficient way to regulate a multi-story building. Johnson's first attempt at improved temperature regulation consisted of an electrically operated annunciator to alert the janitor in the furnace room that a readjustment was necessary. [9,11,13] As distributed electric service was not available in the building, a 6-volt battery furnished current to the temperature regulating annunciator system. Recognizing that the janitor was not always available to respond to the annunciator, the Professor developed a temperature sensitive switch that would automatically activate an electric damper positioner. One set of apparatus was installed for each room being controlled.

Confident in his approach, Johnson partnered with William Plankinton, a wealthy Milwaukee businessman, for financial support in perfecting his inventions. [17] The Professor resigned his teaching position at Whitewater in 1883. As a fitting tribute, one of his colleagues, Professor Lewis H. Clark stated, "He was, perhaps, one of the most versatile teachers ever connected with the school. Whatever branch he undertook to teach, he taught well...His work in science led him into inventions and away from teaching....Professor Johnson was one of the most striking original teachers I have known." [9]

Johnson's concept proved to be most novel, forming the basis for the Electric Thermoscope Patent 281,884, issued April 1883. This patent, along with five others of similar vintage, provided the basis for a complete, automatic temperature control system. [8, 19] On May 1, 1885, the Johnson-Plankinton partnership was incorporated as the Johnson Electric Service Co. Plankinton and Johnson jointly assigned patents previously obtained by Johnson to the newly founded Company. Plankinton served as President and Johnson as Secretary/Treasurer. The Professor agreed to assign all future patents that he might obtain related to temperature regulation to the Company. [17, 20] About this time, the Professor was persuaded to move to Milwaukee. There the Company grew and prospered. Five years later, it was reported that "At the time the company was incorporated, the matter of heat regulation had received little or no attention, and this still remains the only company in the world that offers what may be considered an efficient and complete system for the regulation of temperature." [21] By 1898, total sales were nearly \$160,000 and dividends amounted to just over \$21,000. [19] The Professor was involved not only in the development of temperature controls but also a myriad of inventions, some successful, others long since forgotten. Included in this list are: trucks and automobiles, railroad steam couplings, pneumatic clocks, pneumatic bicycle seats, beer carbonators, springless door locks, push-button toilets, and, yes, wireless. [11]

American Wireless Telegraph Company

An association between Warren Johnson and Charles L. Fortier developed during the fall and winter of 1899. [11, 22] It is not known how Johnson and Fortier became acquainted. Fortier was a telegraph operator by occupation [23] as well as an electrical experimenter and inventor. The earliest reported public demonstration of the Johnson-Fortier wireless system took place on November 22, 1899, at the Plankinton House Hotel in Milwaukee. The Professor presented a talk on the general theory of wireless telegraphy, but avoided revealing detailed descriptions of the workings of their system. As proof of theory, witness' messages were sent from a private second floor dining room to the club room about 400 feet away. Attendees included Geo. W. Peckham (a former East High School Principal), Jeremiah Quinn, C.E., Dr. E. W. Bartlett, "Chambie" (an internationally known spider and wasp expert), M.C. Lenegan, and R. Bruce Douglas (a real estate and insurance representative). Mr. Fortier transcribed the messages as they were received. Of those present, R. Bruce Douglas suggested the first message, "This is a practical demonstration of wireless telegraphy." It took two tries to complete reception of the entire message. The message, as received, was transcribed on Form No. 2 of the Electric Wave Telegraph Company, which proclaimed: "Etherial Lines Around the World. No Pole or Cable Franchise Needed. Johnson-Fortier System." The document has survived in the hands of Mr. Douglas' daughter. [24]

The technology must have proven very promising, because a written agreement between the two men was signed on January 30, 1900, establishing their mutual interests and activities. It states in part, "in consequence of the concerted action and effort...(they) made certain new and useful improvements in the art of telegraphy, to be practiced without the use of wires, and in that behalf have devised, invented and created certain new and useful apparatus, devices, processes and agencies and combinations thereof, which have contributed to the accomplishment of said invention...in the apparatus now in their possession." [25] The agreement continued, establishing joint and equal sharing of all inventions, gain, and profit. This document was witnessed by Paul F. Johnson, Warren's son and the superintendent of the Johnson factory at the time. [25, 26, 27]

In only two months, the fruits of their efforts must have proven very encouraging, as a second agreement was executed on March 17, 1900, regarding "present and future inventions in the field of wireless telegraphy." [26, 28] The agreement went on to establish the formation of a corporation, the American Wireless Telegraph Company, hereafter abbreviated AWTC. The company was established "for the purpose of carrying on the business of wireless and other telegraphy, as fully set forth in the articles of association." All inventions set forth in the January 30, 1900 agreement

were assigned to AWTC for the consideration of 10,000 shares, to be divided equally between the two partners. This agreement set the stage for the actual organization of the AWTC.

By March 20, 1900, the first meeting organizing the AWTC was held. [26, 29] The AWTC “has been organized for the express purpose, among others, of acquiring the said inventions and of exploiting the said discoveries” of Warren S. Johnson and Charles L. Fortier. It noted, “the stockholders of the AWTC having heretofore investigated the merits and values of the system of wireless telegraphy recently discovered and invented by Warren S. Johnson and Charles L. Fortier, of Milwaukee, and having satisfied themselves that the same are of very great value, to wit: of the value of more than one million dollars.” During the subsequent first directors meeting of the same date, Warren Johnson was elected President, Henry Herman, Vice President, and Charles Fortier, Secretary and Treasurer. Up to 3000 shares were to be sold initially at \$100/share. [22] Early shareholders, representing friends and family of the inventors were: [26]

Frank Bigelow	60 Shares	\$1000
William Bigelow	60	\$1000
Frank J. Kipp	60	\$1000
Charles F. Pfister	60	\$1000
Henry Herman	60	\$1000
Benedictus Schwartz	50	For Services Rendered
Henry Winkenwerder	25	For Services Rendered
Paul F. Johnson	100	Gift from WSJ
Carl F. Johnson	100	Gift from WSJ

Clearly the actual share price was somewhat less than \$100. No other stock was issued except to Johnson and Fortier. [26] The first certificate of AWTC stock, serial number 1, to Warren Johnson, is illustrated in Figure 1.

It appears that in addition to Warren Johnson and Charles Fortier, the other early operators were Paul F. and Carl F. Johnson. Collectively, they operated both transmitter and receiver. The American Morse Code was used for signaling and this appears to be a logical extension of Mr. Fortier’s telegraphic experience. [30]

Except where noted, the following material was excerpted from documentation prepared by Paul F. Johnson at a later date in reference 30.

Early experiments covered a broad range of major topics:

- Coherer materials
- Coherer shape and dimensions
- Methods of decohering
- Spark gap tips and spacing

As a means of comparison, a Marconi Coherer was borrowed from the U.S. government.



Figure 1. Copy of AWTC Stock Certificate #1

Transmitting and receiving locations were many and varied, depending on the state of development, throughout the Milwaukee area. Known AWTC operating locations are highlighted on a section of a contemporary Milwaukee County map in Figure 2. Locations, with approximate distances from the Johnson building, include:

- (1) The five-story Johnson Service Co. building at 120 Sycamore Street [31]
- (2) A boathouse at the foot of Mason Street, 0.2 mile [26]
- (3) Fortier's room at the Aberdeen Hotel (909 Grand Avenue), 0.6 mile [26]
- (4) A flagstaff in Juneau Park, 0.7 mile
- (5) Lohmann's saloon on Jones Island, 1.2 miles
- (6) The end of the pier on the mouth of the Milwaukee River, 1.1 miles [26]
- (7) The water tower at North Point, 3.1 miles
- (8) A 150-ft. steel tower erected for the purpose on South Point, near present-day Cudahy, Wisconsin (blown down on July 3, 1900), 6.2 miles
- An unspecified house on Milwaukee's South Side [26]
- A small boat out on Lake Michigan, up to 2 miles [31]

- Several Goodrich Line steam ships sailing between Milwaukee and Chicago (The Virginia, the Columbus, and the Racine departed from the Goodrich dock at the foot of Sycamore Street and the Milwaukee River for daily round trips to Chicago.) [32]

The choice of the pier location was particularly expedient. Operators at the transmitter and receiver could alternately view wigwag (flag) signals to communicate the status of a particular experiment when wireless reception was not accomplished.

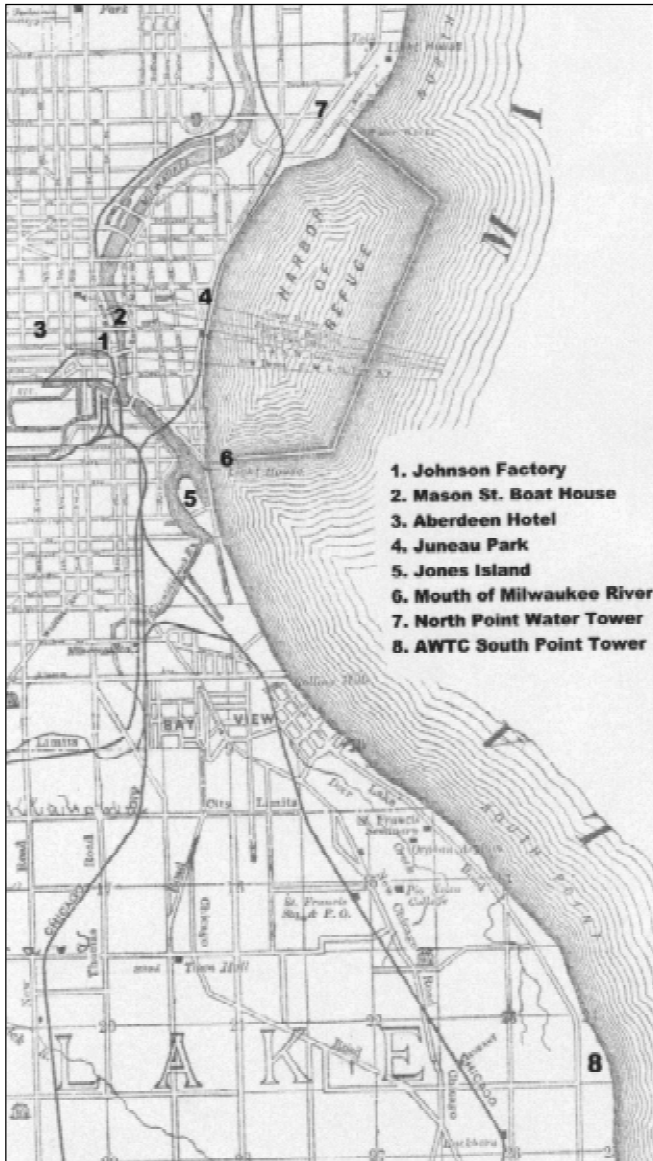


Figure 2. Map of AWTC operating locations (based on Reference 59)



Figure 3. *Wireless Station in Johnson Electric Service Co. factory*

Early message transmissions were sent at approximately ten words per minute, which was the maximum coherer operating speed. The greatest distances covered were five to seven miles during daylight hours. The potential increase in signal distance at night was unknown and no one thought to try the apparatus after dark.

The transmitter consisted of a battery-powered induction coil with built-in condenser, operating a straight spark gap mounted on the coil. An otherwise undated photograph, Figure 3, shows the experimental apparatus located in the Johnson Electric Service Company factory. In the foreground are the accumulators, four boxes of three cells each, which would generate 24 volts. Directly in front of the gentleman is the induction coil and spark gap. This appears to be the 12-inch spark coil. The small apparatus to the left of the induction coil appears to be the coherer. The gentleman shown is unidentified, but believed to be Paul Johnson. Various coils were available and capable of producing 6-inch or 12-inch sparks with correspondingly sized storage batteries or motor generator. The motor generator (Figure 4), was manufactured by the Browning Mfg. Company of Milwaukee. The 12-inch spark coil is illustrated in Figure 5. Transmitter operation typically was at less than $\frac{1}{2}$ -inch spark. [33] The antenna and ground were connected directly to the spark gap terminals. In Paul Johnson's words, "Nothing was known about tuning," "Fortunately there were no other stations to either interfere or be interfered with, as the waves must have been as broad as they were long, and no one knew how long they were."

The receiver consisted of a coherer with aerial and ground connected directly to the coherer terminals. Decohering in early designs was accomplished by pneumatic disruption, either by directing a blast of air through the cohered particles or by a pneumatic tapper, as Marconi had already patented the electric tapper. In later designs, the optimum coherer filling was

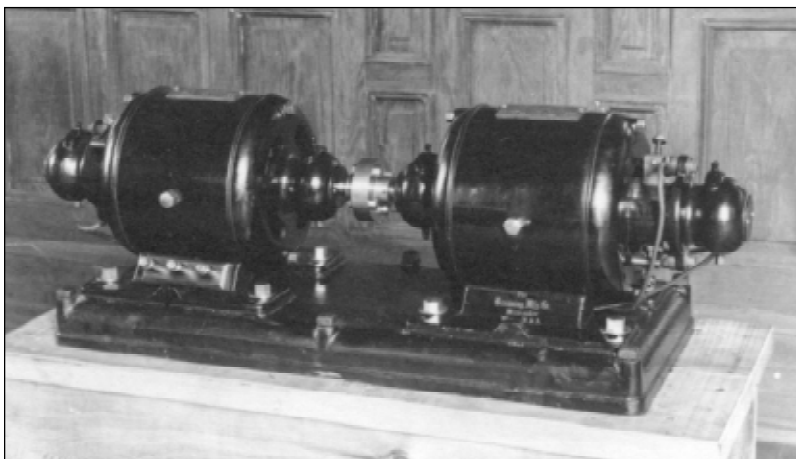


Figure 4. Above
Motor generator,
Browning Mfg. Co.

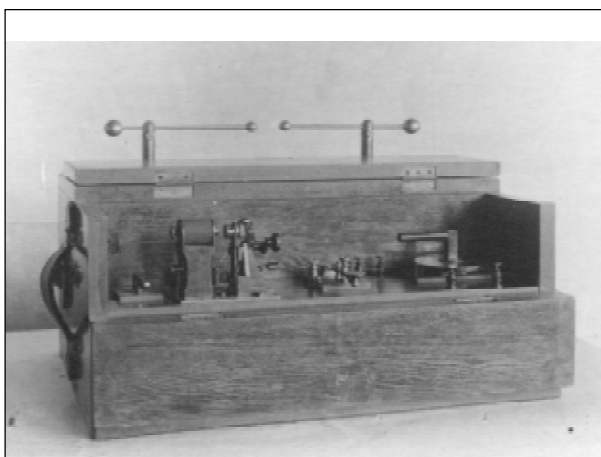


Figure 5. Left
Twelve-inch
induction coil
transmitter

found to be magnetic iron oxide from Labrador, which was used in the form of small grains similar to those of sand. It proved more stable than any other material tested and was self decohering - eliminating the need for tapping. [20, 33, 34] A bottle of surviving material is shown in Figure 6. An ordinary telegraph relay and sounder, powered by a local dry cell battery completed the assembly.

A later public demonstration was reported, in which the apparatus was operated at the April 17, 1900, meeting of the Northwestern Associates of the Massachusetts Institute of Technology. [22, 35] The Bismarck Hotel at 180 Randolph Street in Chicago was the site of this room-to-room exhibition. A message speed of 25 words per minute was claimed. A clipping from an unidentified (Chicago?) newspaper the following day reports that the apparatus was “investigated a short time ago by the War Department (with) messages being sent from Fort Wadsworth to Governor’s Island, a distance of 7 miles.” In addition, plans for the construction of a 150-foot tower on the Lake Michigan shore between



Figure 6. *Labradorian iron oxide coherer filling*

Milwaukee and Racine were described. The intent was to communicate with each city and with ships offshore. [35] The location was referred to as South Point. The tower was reportedly located about 400 feet from the Lake Michigan shore on the highest point of a bluff in present-day Sheridan Park, just east of the skating lagoon. [36] Although shoreline erosion has claimed most of this bluff, what appears to be a single concrete footing remains today near the described location.

Based on early successes, a decision was made to exhibit the Johnson-Fortier system at the Paris Exposition in the summer of 1900. To make the system portable, a transmitter was built using a Queen & Co. portable induction coil, capable of producing a 4-inch spark (Figure 7). A compact receiver with telephone headset completed the assembly. [33] Charles Fortier traveled to Europe to demonstrate the apparatus, apparently in the spring of 1900. Aside from participation in the Paris Exposition, Fortier's activities in Europe during his four-month absence are unknown. His travels left a

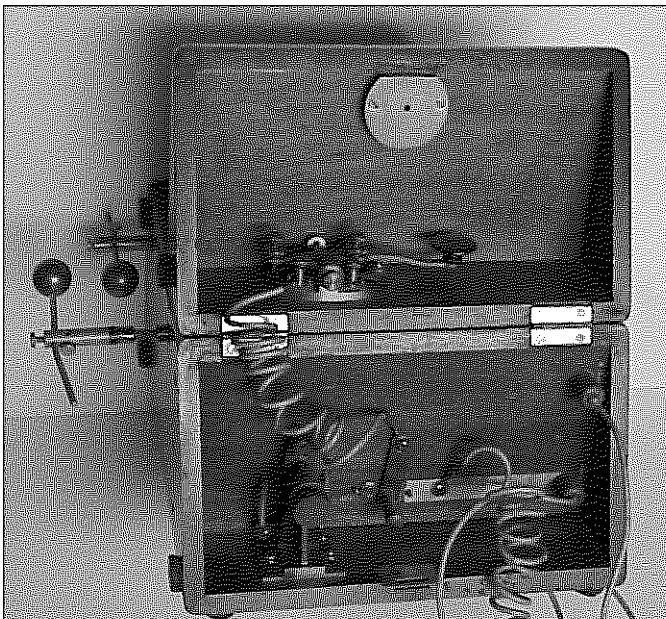


Figure 7. *Queen & Co. 4-Inch induction coil from Paris Exhibition*

vacancy at AWTC, which Warren Johnson set out to fill. His choice was young Dr. Lee de Forest from the Western Electric Company in Chicago. On May 1, de Forest took up residence at 809 Grand Avenue in Milwaukee and “Started on my work at last” for AWTC. [1] Unfortunately, de Forest’s personal journal lacks any significant technical description of the experiments or responsibilities that he may have engaged in while working for AWTC.

In a personal letter many years later, de Forest described his affiliation with AWTC as follows. [37] Warren Johnson, or his assistant, Fortier, had recently invented a new form of coherer using wire filings and a periodic puff of air to blow the filings apart. De Forest’s chief occupation with AWTC was at the South Lake Shore, where a wireless station (Figure 8), had been erected to receive signals from a transmitter erected on the roof of the Johnson Service Company building. De Forest had earlier described the South Point location: “There I have the Lake, the fresh and boundless water prairies! My work is mostly there on its brink and far above the tossing line of surf, far from the town. It is a privilege of life to sit here.” [1] Unfortunately, the experiments met with “only indifferent success” and “the device was very insensitive and quite discouraging to me.” During these experiments, de Forest stated that he had surreptitiously

tested his Responder at the South Point station and it “responded beautifully to the signals from the city.” De Forest described his Responder of this period as: tinfoil fastened to a glass plate. The tinfoil was razor cut into two pieces. The gap was bridged with a solution of glycerine and “certain other liquids.” [37] Electrically the Responder has been described as an anti-coherer. An anti-coherer interrupts the local circuit when a radio signal is received,

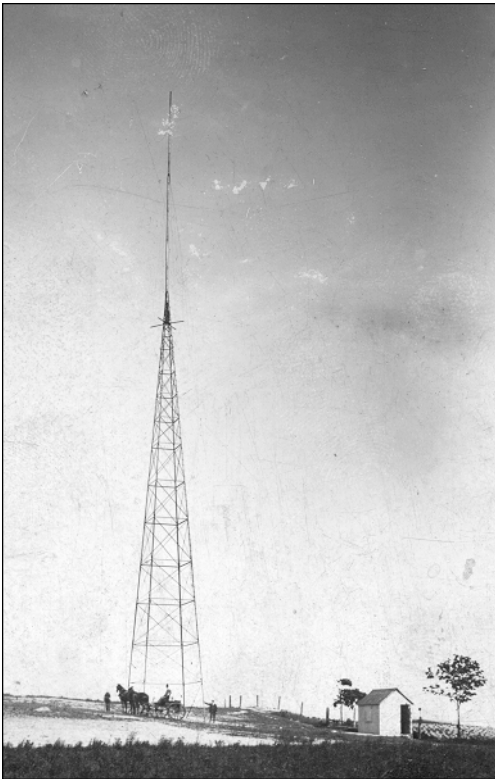


Figure 8. South Point Station

resulting in a click. This is in direct opposition to the operation of the Branly coherer, which completed the local circuit with each pulse received. [38, 39]

From a surviving notebook describing some of the AWTC experiments, [31] the work in progress during the June-July period consisted of testing different coherer fillings. An entry dated July 17 states: "We have then two kinds of filings, both magnetic, one (the iron-brass) being quite sensitive to waves and yet never breaking down by itself from engine's running; the other iron-silver No 2, extremely sensitive. By mixing these two in proper proportion a very sensitive filling can be had which yet will not break down from the engine's running." The "engine" apparently was an apparatus used to develop the compressed air used for decohering. Although a detailed description of this device has not been found, it apparently was often the source of vibration that interfered with proper coherer operation.

"The best proportions of these two vary with the form of coherer used. In the cup-coherer, 3 parts of brass-iron to 2 of silver-iron No 2 break down for bell at 2 ft. (no aerial), yet does not break from engine."

"For the cross-strip coherer a larger proportion of brass-iron is necessary to prevent breaking down from engine (2 to 1) yet the sensitiveness is practically as good as with more of silver-iron."

On July 15 it was noted "After working the 12" coil with Wehnelt Interrupter etc. getting sparks of 10" etc we find all the filings which had been so sensitive virtually non-sensitive – not only those in the coherers but all in the room. Their working distance was not half of that before. S. (Benedictus Schwartz? see ref. 26) made other filings apparently the same but these were not so sensitive as the first." Over the next week, efforts to reproduce the proper filings finally succeeded and "approached the sensitiveness of the first in the double cup-coherer....But next morning their sensitiveness was much diminished" With the clarity of hindsight, it would appear that sufficient atmospheric corrosion of the filings had developed so that their usefulness in the wireless detector was destroyed.

An interesting entry appears for July 25: "Jones Island. Transmitted at Lohmann's Saloon on beach. Wire 40-ft-upright to staff on top the house. 12 volts storage batt'y. Magnetic interrupter ½" gap ground to river behind house. Receiver box on skiff upright 22 ft. Boat out ½ - ¾ mile. Of 12 H's sent 10 came perfect. Two came 2 dots only. Ground here was iron plate 2 X 2.5 ft. dragging in water but signals were as good when plate was out of water."

"The last time I was nearly one mile out. Tried at 1½ to 2 miles out. But lake came up rough and rocking caused the armature to work continually by itself." [31] Unfortunately, the identity of the intrepid sailor is not clear from the entry.



Figure 9. *Medal awarded at the Paris Exhibition*

Meanwhile the Paris Exposition opened to the public on April 15 for a six-month venue. [40] “A brilliant display is expected in the new Palace of Machinery and Electricity.” [41] There, “In the centre of the Palace of Electricity was found Class 26, or the class embracing Telegraphy and Telephony. Here the variety was infinite and displays novel, owing to the fact that so many vast strides had been made of very recent years in both branches of electricity. The Hall of Honor stood in the very center of the Palace...In its immense area, surmounted by a lofty and imposing dome, were collected and arranged the principal gems of the French and foreign electricians. The United States was brilliantly represented by the latest discoveries of Edison, Tesla, and other distinguished electricians.” [42] Roentgen, Wehnelt, and Marconi were among the other electrical specialists represented. With this august group, Charles Fortier was demonstrating the Johnson-Fortier wireless apparatus in competition with three other exhibitors of wireless equipment, including Marconi and a German firm. [43] In fact, AWTC was the only American firm exhibiting wireless apparatus from among some 60 American exhibitors in the Telegraphy and Telephony Class. [43, 45] After Fortier’s return to America, the Germans reportedly were awarded first place. On August 18, AWTC was awarded a silver medal, Figure 9, and a diploma, Figures 10 and 10A, for second place in wireless telegraphy development at the exposition. [11, 24, 44] In the words of one contemporary critic who found little new in technology, [40] “The only significant breakthrough on display was in wireless telegraphy.” [46]

While detailed specifications of the Paris apparatus have not survived, Fortier later stated that the placement of the local battery between the telephone receivers “was used on the Paris Exposition set and was favorably commented on.” [26] Based on Fortier’s post-Exhibition work, [31] it is likely that pneumatic decohering was employed, although it is unclear if this was accomplished by passing a puff of air through the filings or with



Figure 10. *Diploma of Award from the Paris Exposition*

Figure 10A. *Enlargement of Diploma text*



a pneumatic tapper. It is uncertain what other features may have proven attractive to the Exposition judges.

After Fortier's return from Paris in August, before the awards were announced, several events took place:

- A memorandum was drafted by Fortier "after reading the meager account given in this journal of the work done during the period mentioned" i.e. during his absence. In part it reads: "I arrived at Milwaukee from Europe on Saturday, August 4, 1900. Learned of the wrecking of our mast at the South Point, and the condition of affairs generally. When told of the 'leaky' condition of our outfit at Sending station (Boat house, foot of Mason St.) I ordered boxes sent there to be used as a table for the Induction Coil, and 4 large glass insulators to put the coil on, also increased the ground wires and plates. This did away with the "leak" which, I thought, dissipated, or robbed us, of a great deal of our "Energy." The receiving apparatus at the light house was in, apparently, a satisfactory condition as regards Aerial and Ground wires."
- "During the fortnight beginning August 6, I tried several ways of eliminating the mechanical jarring of our decohering engine on the cup

coherer, and of directing the air decohering impulse so as to prevent any prolonged flow of air through the filings, and constructed a pneumatic tapper and electrodes for a 4 point, and a 3 point glass tube coherer, which I had thought of during my trip abroad, the idea being to construct a coherer having a short gap, possessing the sensitive qualities of the Marconi coherer, and at the same time have means for connecting the aerial, ground, and circuit wires an inch away as to avoid the Marconi patent claims containing tube made to seal up so as to prevent the air from affecting contents.” After describing experiments with two coherers in parallel, he concluded, “I arranged the coherer (4 point cup) so that each had a separate aerial wire, and a common ground. The result was a marked improvement over the previous arrangement, but still ‘breaking’ occurred.... I concluded that some of the trouble lay in the sounder. I then started the construction of a polarized Electro-magnetic pneumatic sounder with adjustable magnetic strength.” [31]

- The Johnson-Fortier system was demonstrated at the Milwaukee Exhibition Building. Messages were sent from the Superintendent’s office on the east side of the building and received in the middle of the large exhibition hall. A contemporary newspaper article declared, “It is claimed on behalf of the Johnson system that his is simpler and more practical than Marconi’s, requiring less cumbersome apparatus, thus better for military use. This set does not require experienced operators, as does Marconi’s, because it brings into use the ordinary telegraph apparatus.” The Professor’s sons Carl and Paul operated the demonstration. [11]

- Lee de Forest’s employment at AWTC came to a crashing end. Although the exact date of his termination is not recorded, on September 3, 1900 in Chicago, de Forest stated: “I was fired, with much wrath by the ‘Prof.’ - not at all sorry to leave his presence. Now for our own patent.” [1] The stories of de Forest’s termination as reiterated in various de Forest biographies, revolve around ownership of the knowledge and apparatus embodied in the de Forest Responder. The record appears clear that de Forest had begun development of the Responder before his AWTC employment. It is also clear that he had clandestinely tested the device while conducting reception experiments for AWTC. [36] While the disclosure of the Responder’s existence was blamed on a worker named Lehman, [2, 3, 4] Fortier later indicated that de Forest also was obtaining parts for his apparatus at the Globe Wire & Iron Works while on AWTC errands. This served at least in part as cause for de Forest’s dismissal. [26] The acrimony of the parting evidenced in de Forest’s biographies [2, 3, 4] seems quite likely. One long-time Johnson employee once described the Professor as “eccentric, hot tempered, and a hard worker.” [34]

After de Forest's departure, active experimentation continued at AWTC into the fall of 1900. On September 6, an aerial of 30 - 35 ft and a 1-inch spark were used to transmit to the factory receiver on Sycamore Street. The receiver apparently incorporated a polarized relay. The receiving antenna was a wire about 90 feet long. Good signal reception was reported with very few breaks (requests for repeats). The AWTC experimental record for September 16 -17, 1900, mentions Lehman doing general labor work, apparently moving antenna wires, cleaning transmitter points, sending signals, and "cleaning and tidying the office." During this series of experiments, an iron sheet, 3 ft x 8 ft was nailed to the office wall in place of the usual antenna wires, with the reception of "indefinite signals." [31]

When Marconi succeeded in sending his famous signal, "S," across the Atlantic on December 12, 1901, [47] Professor Johnson reportedly stated: "It is this most marvelous thing that has yet been accomplished in electrical science. If Marconi has really done what he is reported to have done, the results that will follow are almost beyond human prophecy." [11] Although his interest in wireless had begun to wane, it is told that the Professor apparently lost all active interest when he heard the news that Marconi had signaled across the Atlantic. His attention had already shifted to another new and promising technology. After bringing one of the first automobiles to Milwaukee, a Locomobile steam roadster, the Professor embarked on the construction of his first steam-propelled vehicle in 1901. [11, 12]

Experimentation in wireless at AWTC apparently continued for several years, probably carried on by Fortier. The surviving experimental notebook

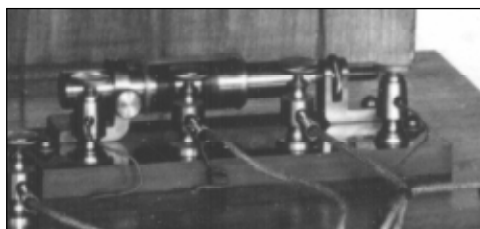


Figure 11A. Above
*Enlargement of coherer
tube*

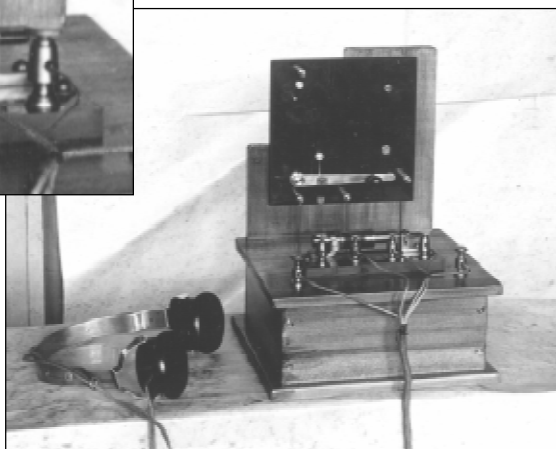


Figure 11. Right
*Johnson-Fortier coherer
receiver*

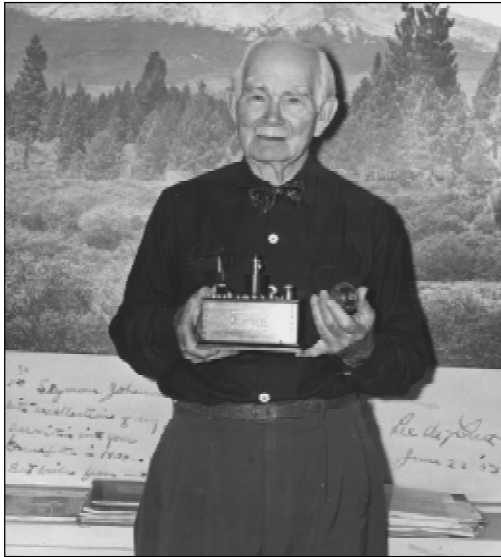


Figure 12. *Autographed photo of Lee de Forest to Seymour Johnson, dated June 22, 1953 Inscribed "To Seymour Johnson with recollections of my association with your Grandfather in 1900."*

lists dates of experimentation between May 18, 1900 and May 14, 1902. [31] Charles Fortier subsequently filed a patent application on April 17, 1903, for a coherer using magnetic oxide and magnetic electrodes. [26] The receiver described in the application is shown in Figures 11 and 11A. The patent was issued to Fortier on August 1, 1905, under the title: Electric Wave Telegraph Receiver, U.S. Patent number 796,403. A copy of this patent can be found in the appendix. Unfortunately, superior methods of detection were already being put into service.

The American Wireless Telegraph Company apparently ceased to exist in a practical sense when the considerable friction which always existed between Johnson and Fortier, developed to a point where they "busted up" in Fortier's words. [26] The division occurred sometime after Fortier's coherer patent was issued, but the date is not otherwise recorded [26]. Paul Johnson observed that "Both were cranky and never pulled well together." [26] Warren Johnson, having repaid all of the AWTC investors except Fortier and his sons, stated that the wireless experiments had cost him \$5,000. [26] A resolution to dissolve AWTC was proposed on December 18, 1914, but was not acted upon, reportedly due to the dissolution expenses. [22, 48] The dissolution papers passed to Fortier in 1921. [49]

In 1926 a receiving inductance and a transmitter from the AWTC facilities were exhibited as part of a display portraying the progress of local amateur radio activities at the Milwaukee Radio Show. The exhibits were reportedly donated to the Milwaukee Public Museum for 'permanent' display. [50] Unfortunately, the materials eventually were transferred to Chicago's Museum of Science and Industry, where they apparently were disbursed at a later date.

As late as 1944, dissolution of AWTC had not been completed and the American Wireless Telegraph Company simply faded into history. [48] As a final effort to document AWTC activities, the Professor's grandson, Seymour Johnson, contacted de Forest in his later years. The result was the autographed photo shown in Figure 12. However, no new significant technical details were revealed.

Epilogue

After his dismissal from AWTC, de Forest returned to Western Electric and subsequently patented his Responder with assistance from Ed Smythe. [2, 6, 51] The original 1898 electrolytic detector of Aschkinass and Neugschwende with modifications by de Forest and Schloemilch was reportedly one of the most common detectors in use in 1908. [52] Sewell reported that the de Forest responder was the most prominent of the 'anti-coherer' detectors and provided a description of its operation. [53] It was also characterized as "exceedingly sensitive and quite reliable" [39] The device consisted of a non-conducting tube, two metallic electrodes (which may be hollowed out), and an intervening space filled with a paste of metal filings or pulverized lead oxide in glycerine or vaseline mixed with water or alcohol. [38, 39] The rest of the de Forest story is history.

Charles Fortier retained the AWTC materials for a number of years before turning them over to Paul Johnson. He continued to live at the Aberdeen Hotel, listing his occupation as 'electrician' in 1903. [54] Later years find Mr. Fortier living on Milwaukee's northeast side. His occupation was listed as 'mechanical engineer.' [55] Despite their disagreements, Fortier apparently remained in the employ of Prof. Johnson and his company for the rest of his working life. As late as 1931, he listed his occupation as 'inventor' employed by the Johnson Service Company. [56] Charles Fortier died on February 21, 1933 at the age of 80 years. [57]

Professor Johnson lived a long creative life before passing to his eternal rest on December 5, 1911. [7] His legacy of numerous inventions and enterprises has grown through the years. From the humble electric thermoscope, Warren Johnson's business has culminated in today's Johnson Controls, Inc., a multi-billion dollar company specializing in building control systems and automotive systems.

Paul Johnson never lost his interest in radio communications, becoming licensed as 6XR. With his son, Seymour (6OE), he operated the Altadena Radio Laboratory, apparently for the sale of amateur radio equipment in the San Francisco Bay area. [26] In the early 1920s, broadcast station KGO was licensed to Altadena Radio Laboratory and operated commercially on 833 kc (360 meters) using a 500-Watt transmitter. [58]

Acknowledgements

This article is a tribute to Charles Fortier and the Johnson family's sense of technical history, exemplified by the Professor, his son Paul, and grandson, Seymour. Through their efforts to preserve and document their activities, information and materials were assembled, preserved, and rescued many years ago that made retelling of this story possible. As early as 1921, Paul Johnson was to trade Fortier a "compact receiving set, which he can use with a loop or indoor aerial...something on the order of the Amrad reflex" for the Queen & Co. induction coil from the Paris Exposition. This coil and all other AWTC materials now reside in the Johnson Controls archives. Mr. Ken Wirth, JCI Archive Manager, was of great assistance in the preparation of this paper, providing access to the historical materials for viewing and reproduction, as well as thoughtful discussions about these activities. The Humanities Department of the Milwaukee Public Library provided access to all referenced city directories and the original 1896 Milwaukee County map, reference newspaper files, and interlibrary loan of de Forest material.

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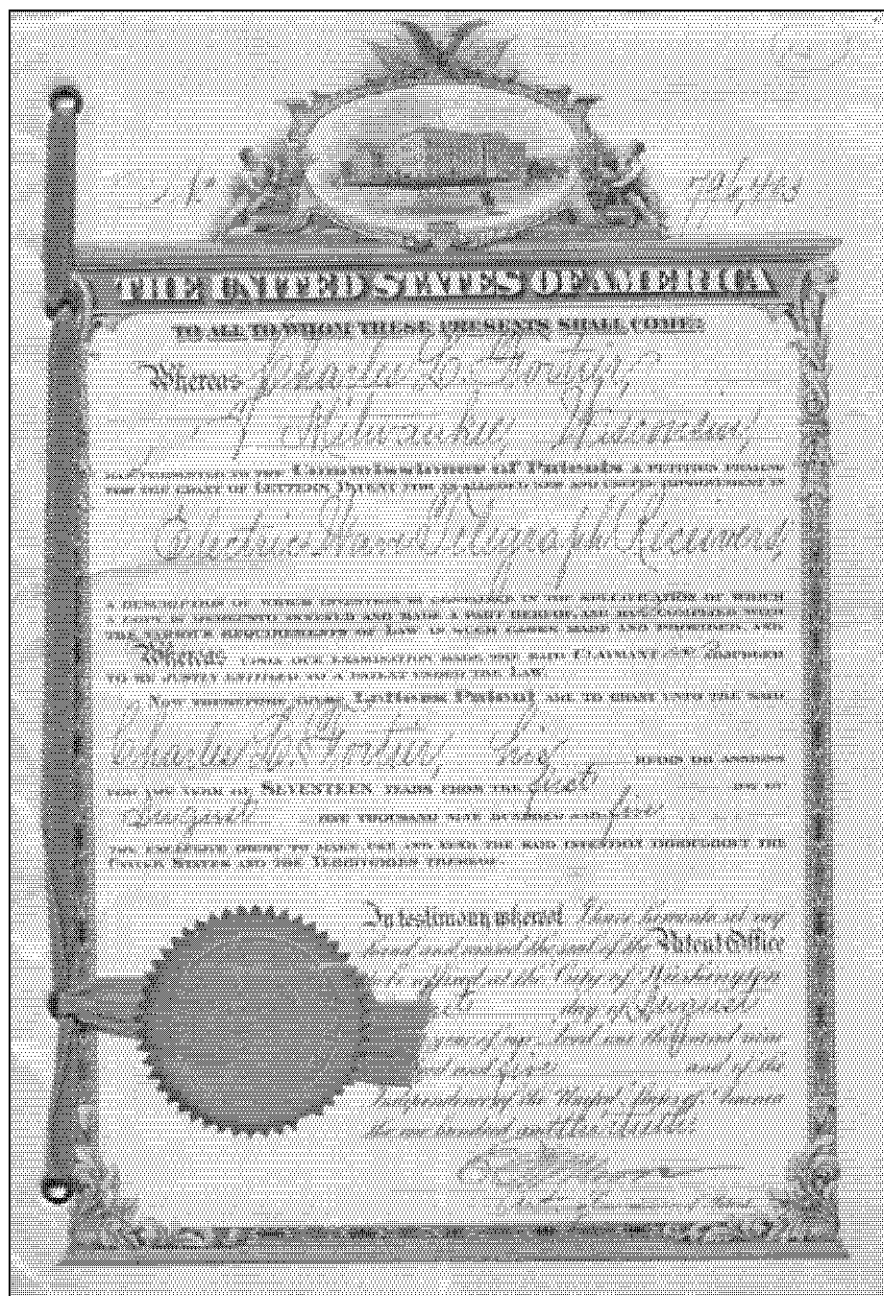
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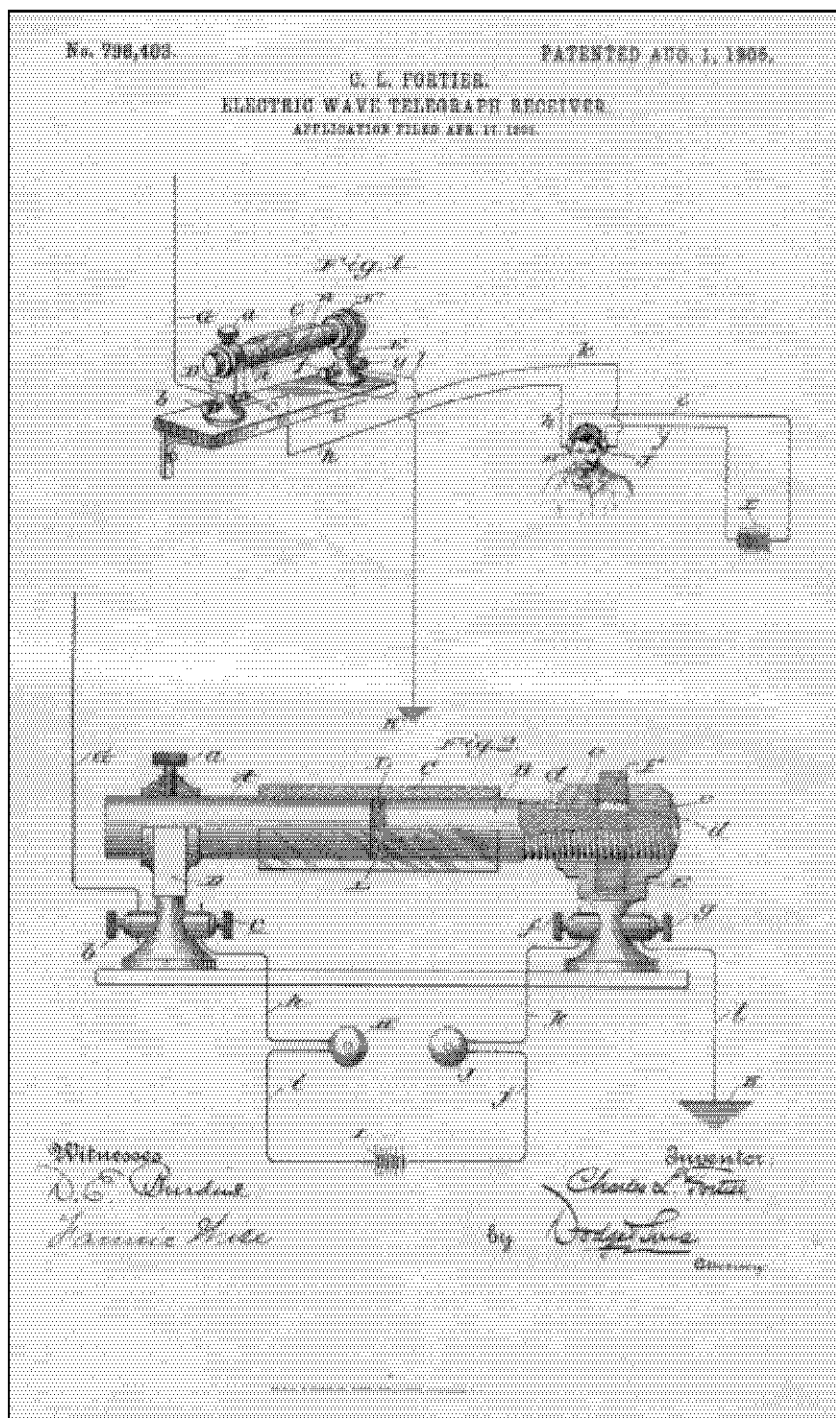
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Appendix

Copy of Fortier's Coherer Patent



Appendix (cont'd) Copy of Fortier's Coherer Patent



UNITED STATES PATENT OFFICE.

CHARLES L. FORTIER, OF MILWAUKEE, WISCONSIN.

ELECTRIC-WAVE-TELEGRAPH RECEIVER.

No. 796,403.

Specification of Letters Patent.

Patented Aug. 1, 1905.

Application filed April 17, 1903. Serial No. 153,125.

To all whom it may concern:

Be it known that I, CHARLES L. FORTIER, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Electric-Wave-Telegraph Receivers, of which the following is a specification.

This invention pertains to wireless or electric-wave telegraphy, and more especially to receivers for use in connection therewith.

The purpose of the invention is to simplify the construction and operation of such apparatus.

The improvements are susceptible of being embodied in different forms having, however, the same general features or principles of construction and may be used either in direct connection with the wave-interceptor and ground or may be operated through a suitable induction device or a condenser or in connection with any suitable synchronizing device or means.

In the drawings, Figure 1 is a perspective view, diagrammatic in its nature, of the receiving apparatus, the telephones thereof being arranged as a head-piece and worn by an operator; and Fig. 2, an enlarged view thereof, partially in section, better to show the construction.

I will first describe the apparatus embodied in a simple and preferred form in connection with the accompanying drawings and then explain its operation.

A and B designate the electrodes, the proximate ends of which are introduced into a tube or shield C of glass or other non-conducting material.

D indicates a post or standard having an opening through it for the introduction of the electrode A, which may be adjusted in the post or standard and secured in any desired position by a binding-screw *a*. The post D is provided with binding-screws *b* and *c* for the attachment of wires or conductors, as hereinafter mentioned. E indicates a second post or standard, also provided with an opening through which to pass the electrode B, the post being bifurcated at its upper end to receive an adjusting-nut F, which encircles and screws upon the threaded end of electrode B or a threaded extension thereof. The threaded portion of the electrode is also provided with a slot *d* to receive a feather or finger *e*, which holds the electrode against rotation while permitting it to move longitudi-

nally as the nut F is turned in one or the other direction. By this construction I am enabled to adjust the electrodes A and B approximately to position in the first instance and thereafter to effect a nicer or finer adjustment of electrode B by turning the nut F in one or the other direction, as required.

The post E is provided with binding-screws *f* and *g* for the attachment of wires or conductors, as will be presently explained.

In practice I find it expedient to make the electrodes about five-eighths of an inch in diameter and of a metal (as iron or steel) capable of being magnetized. Between the proximate ends of the electrodes A and B is introduced a metal oxid L, preferably a magnetic oxid, granular in structure and advisably of uniform or substantially uniform grain. The separation of the electrodes may be varied, but should not be great—say approximately one-eighth of an inch, though this is merely suggestive and may be changed at will within comparatively wide limits.

The oxid having been placed between the electrodes, the tube or shield C applied, and the electrode A clamped firmly in position by screw *a*, the nut F is adjusted to produce pressure upon the granules or particles of oxid lying between the electrodes, the degree of pressure being varied according to the judgment of the user or the particular conditions of use.

G indicates a wave-interceptor of any usual form and arrangement electrically connected to electrode A through the binding-screw *b* and post or standard D. Said post D (and consequently electrode A) is in turn connected by a wire or conductor *h*, held by the binding-screw *c*, with a telephone H or other translating device, said telephone being in turn connected by a wire *i* with one terminal of a battery I or other source of electric energy. From the opposite terminal or pole of the battery a wire *j* passes to a second telephone J, which is in turn connected with electrode B by a wire *k*, held in binding-screw *f* of post or standard E, the post E and its adjusting-nut F affording the necessary electrical connection with electrode B. Post E, (and consequently electrode B,) battery I, and telephone J are connected by a wire *l*, held by binding-screw *g*, with a ground or capacity K.

As above stated, the electrodes A and B are preferably magnetized and the oxid employed is advisably a magnetic oxid. As a conse-

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quence, the magnetized electrodes attract the particles of oxid and hold them spread evenly over their faces. Better to insure the even distribution of the particles or granules, it is preferred to make the facing poles of the electrodes of like sign, or mutually repellent. By so doing the granules are divided into two bodies each tending to repel the other. This assists in the self-righting process. The tube or shield C serves to confine and retain any loose particles which might otherwise fall from between the electrodes.

The operation of the apparatus is as follows: Proper adjustment of the electrodes having been made and consequent pressure applied to the oxid L, an initial or normal conductivity is secured, the conducting power increasing as the pressure increases and the resistance increasing or the conducting power diminishing as the pressure decreases. If the particles were left to lie loosely between the electrodes and without pressure, the resistance to the local circuit would be so great that incoming waves would not sufficiently change or reduce the resistance to permit any of the local current to pass; but with the initial pressure the resistance is so far reduced that some of the local current may pass. A galvanometer included in the local circuit shows on the reception of the first waves a further reduction in the resistance of the circuit or an increased flow of the local current. A wavering motion of the galvanometer-needle follows with succeeding waves, and sometimes the waves accomplish a restoration to the initial conductivity, succeeding waves again increasing the conductivity and reducing it at intervals. This double action serves to keep the receiver constant without tapping or jarring. The changes in the conductivity of the oxid affect the flow of the local current through the same and through the telephones, alternately strengthening and weakening the current, and sounds are consequently produced in the telephones corresponding to the duration of the waves received. These sounds, clearly audible, are readily interpreted and afford a means of receiving and making intelligible the signals.

Of course instead of telephones other translating devices may be employed; but telephones are found eminently satisfactory. When arranged as shown in the drawings, they also render unnecessary the choking-coils usually employed in apparatus of this character to prevent the oscillations set up by the transmitting instrument and which should pass through the electrodes A and B from passing over the local-battery circuit, and thereby weakening its effect.

In practice it is preferred to arrange the telephones H and J as a "head set"—that is, to mount them upon a band or carrier which, passing over the head, shall support and hold the instruments at the ears of the operator,

thus leaving the hands free for transcribing messages, arranging switches and connections, and the like.

Heretofore it has been customary to allow the granular particles to lie loosely between the electrodes, and pressure thereon has been studiously and, according to general belief, necessarily avoided. Means have also been provided in some instances to prevent oxidation of the particles when using a metal or metals. My plan renders unnecessary the care hitherto commonly deemed requisite in both these regards and produces a peculiarly constant receiver requiring no tapping, jarring, or other mechanical action or manipulation.

A clear distinction is to be noted between a body of granules of metal oxid and metallic particles having a film of oxid formed upon their surfaces, as in the case, for instance, of broken steel beads partially and irregularly or unevenly oxidized. With granules of metal oxid a certain definite and essentially uniform action results, particularly if the oxid be magnetic, whereas with metallic particles having merely a film or skin of oxid more or less uneven such uniform and definite action is not obtainable.

Having thus described my invention, what I claim is—

1. A receiver for electric-wave telegraphs, consisting of suitably-mounted electrodes; particles of homogeneous metal oxid normally under pressure between the proximate exposed surfaces of the electrodes; means for producing and varying the pressure upon the oxid; and means for rendering the received waves intelligible.

2. A receiver for electric-wave telegraphs, consisting of suitably-mounted electrodes; particles of homogeneous metal oxid under pressure as a conducting medium between the electrodes; means for adjusting the pressure on the conducting medium; and means for rendering the received waves intelligible.

3. A receiver for electric-wave telegraphs, consisting of suitably-mounted electrodes; granular particles of homogeneous metal oxid under pressure between the electrodes; means for regulating the pressure on the oxid; and means for rendering the received waves intelligible.

4. A receiver for electric-wave telegraphs, consisting of suitably-mounted magnetized electrodes; granules of magnetic oxid between the electrodes; and means for rendering the received waves intelligible.

5. A receiver for electric-wave telegraphs, consisting of suitably-mounted magnetized electrodes, the proximate ends of which have the same polarity; a conducting medium between the electrodes; and means for rendering the received waves intelligible.

6. A receiver for electric-wave telegraphs, consisting of suitably-mounted electrodes;

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granules of homogeneous metal oxid as a conducting medium between said electrodes; means for establishing an initial intermediate conductivity between said electrodes, the received waves operating to intermittently increase and restore said conductivity; and means for rendering the received waves intelligible.

7. A receiver for electric-wave telegraphs, consisting of suitably-mounted electrodes; a conducting medium composed of granules of homogeneous metallic oxid under pressure between said electrodes, whose resistance is decreased and increased intermittently by the received waves; and means for rendering the received waves intelligible.

8. A receiver for electric-wave telegraphs, consisting of suitably-mounted electrodes; a conducting medium between said electrodes; a local circuit including said electrodes, conducting medium, telephone-receivers, and a battery, a telephone being located between the positive pole of the battery and one of the electrodes, and another telephone being located between the negative pole of the battery and

the other electrode; a suitable wave-interceptor connected to one of the electrodes; and a capacity or ground connected to the other electrode, substantially as shown and described.

9. In a receiver for electric-wave telegraphs, the combination of two electrodes; an interposed body of finely-divided homogeneous oxid normally under pressure; and means for adjusting one electrode relatively to the other to produce and vary pressure upon the oxid.

10. In a receiver for electric-wave telegraphs, the combination of two magnetized electrodes; an interposed body of finely-divided magnetic oxid normally under pressure; and means for adjusting one electrode relatively to the other to produce and vary pressure upon the oxid.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHARLES L. FORTIER.

Witnesses:

PAUL F. JOHNSON,
J. M. DOESBURG.

Author's Biography

At an early age, Glenn displayed an interest in the family Zenith (Kenwood Model 12H689), which he still possesses, both now a great deal worse for the wear. Family, friends, and colleagues will attest that Glenn is a certifiable pack rat. He and his wife, Edna, have been participating in radio meets since the early days of Radiofest, when women participants were unusual. Most recently, Glenn served as the secretary/treasurer of the Wisconsin Antique Radio Club in its formative years. Glenn's primary collecting interest is in products and materials from the Globe Electric Co. of Milwaukee. More broadly his interests include pre-AC wireless and radio equipment manufactured in Wisconsin and Iowa and the corresponding company histories.



Glenn has been an employee of Johnson Controls, Inc. for 20 of his 50 years. The Johnson Controls centennial anniversary provided the first leads to a little documented corner of wireless history and the relevant artifacts. The 100th anniversary of the AWTC experiments provided the incentive to publish a detailed article about the company and its activities, a task that Paul Johnson apparently intended to do, but apparently never completed.

Glenn has had only one formal course in electronics and that based on applications of integrated circuit devices. He is an Analytical Chemist by training and currently manages the Analytical Services Department at JCI-Battery. Glenn and his understanding wife of 21 years reside in the Milwaukee area. Correspondence may be addressed to Glenn Trischan, Johnson Controls, Inc., B-3, P.O. Box 591, Milwaukee, WI 53201. Email Glenn.M.Trischan@jci.com.