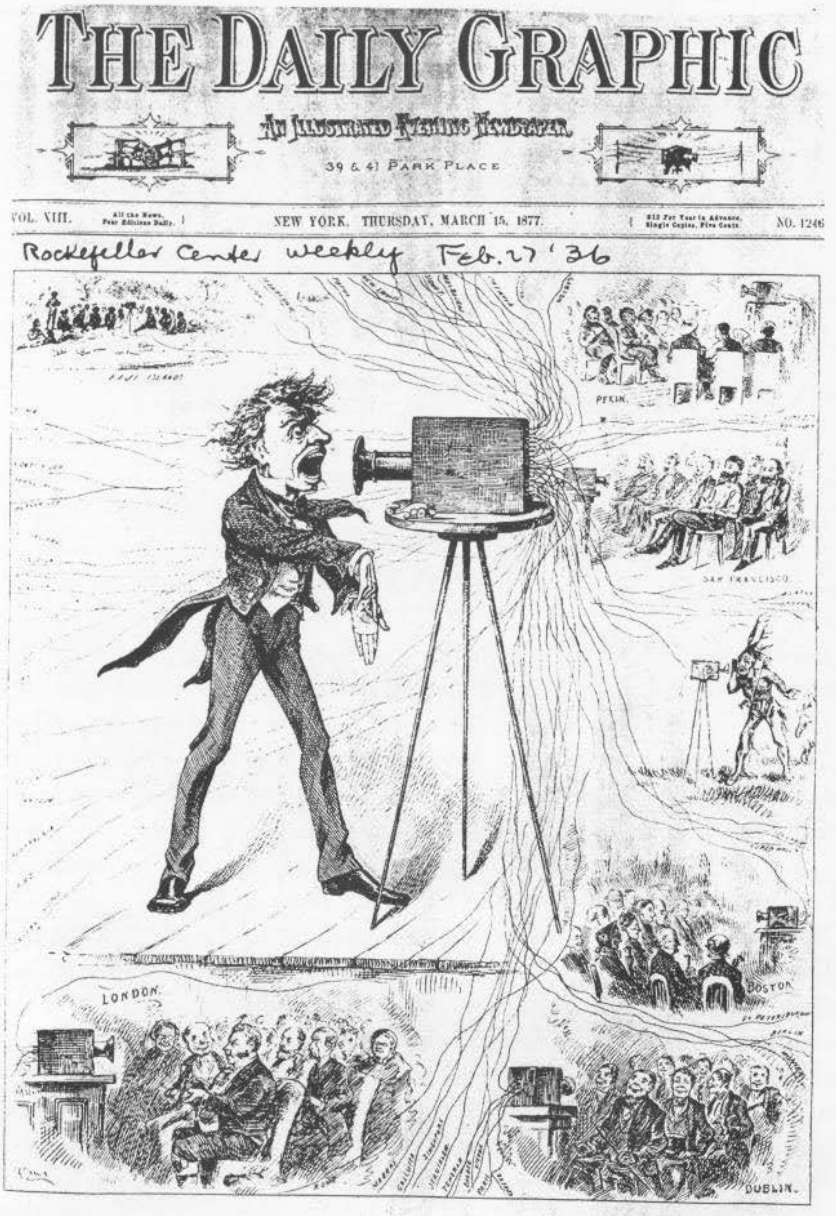

TERRORS OF THE TELEPHONE—THE ORATOR OF THE FUTURE.

From the collection of Culver Service

The National Broadcasting Company, Radio Corporation of America, Bell Telephone Laboratories in the New York Museum of Science and Industry in the RCA Building, and you and you and you will be interested to note that way back in 1877, when the telephone was new, this artist didn't miss the 1936 radio broadcasting idea very far.

Figure 1. *"Terrors of the Telephone" from the Daily Graphic, March 15, 1877. (Clark Collection)*

THE RACE FOR RADIOTELEPHONE: 1900-1920

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INTRODUCTION

Imagine a race for which there is no clear prize or finish line, a contest of which most participants didn't even realize they were a part. Years later the race would be viewed as one of finding the right technology and a greater social purpose for the talking wireless, one resulting in an electronic mass media totally different from its original prototype, the telephone and the telegraph. Before this race ended, before the finish line had been reached, some of the contestants would have dropped out, the Federal Government would finally get involved, and world events would alter its outcome. Major industries, corporations and fortunes would be established and their power would be felt for decades. Both the race and the prize would have lasting influence.

There was such a race for the radiotelephone. It took place between 1900 and 1920, the years when the radiotelephone came of age, twenty years in which we saw this device evolve from an original emphasis on two-way wireless telephone communication experimentation into broadcasting for an audience. Within these two important decades the transmitting technologies of spark, arc, alternator and vacuum tube were tried, improved, discarded or embraced. This important transition period will be explored through the work of five individuals, most of whom began as scientists and inventors, but later some became businessmen and promoters. The five are Reginald Fessenden, Valdemar Poulsen, Lee de Forest, Charles Herrold and Frank Conrad.

This article evolved out of a larger research and writing project. I started out looking for supplementary material for an in-progress biography on early broadcaster Charles Herrold and I ended up with this story of five men whom I believe were primarily responsible for either the discovery, the invention or the realization of the broad uses of a talking wireless. I found that more than any others, it was probably this group of five who led the early race for the radiotelephone. And while the evidence suggests that it began for all of them as a quest for a wireless replacement for the wired telephone, it ended with the broadcasting of entertainment programming for an audience. Of course, this is my list based on my unique research experiences. Important technical and business contributors like Edwin

Armstrong and David Sarnoff are missing from the list because the purpose of this story is to focus narrowly on the invention and the public uses of early radiotelephone transmitting technology between 1900 and 1920.

PRELUDE AND PERSPECTIVE

Early rumblings of the possibility of what radio might become sounded several decades before Marconi's wireless became part of the lexicon of the Twentieth Century. Books like Edward Bellamy's *Looking Backward: 1887-2000,* and other political and social satire in the form of editorial cartoons, encouraged public discussion of what might result if a system of sending a speech or the music of a live orchestra simultaneously to a number of receivers were to be developed. Some editorial writers thought it would be an intrusion, others believed it would destroy society as it kept people out the concert halls and away from the orator's public soapboxes and isolated them in their homes. Nevertheless, from time to time there was speculation about such a system, and in several European countries, such music and news subscription systems actually existed for a time. Of course those fictional and real systems all used connecting wires. Their precedents were the existing communication systems of the era; the telephone, the telegraph and the transatlantic cable.

There were also a handful of pre-wireless inventors who constructed and even patented voice transmission systems using modulated light, ground conductivity or magnetic inductance. Some of these individuals, such as Alexander Graham Bell, were already well known for other inventions. Others, like Nathan Stubblefield, went to their graves believing they had been foiled by unknown conspirators, or that if they could have found one more financial backer, or the time and money with which to make one more improvement, their system would be the one in use today. Before Heinrich Hertz, Oliver Lodge and Guglielmo Marconi experimented with the sending of small signals from a spark gap from one side of a room to another, there were the theories and writings of James Clerk Maxwell and others that at least suggested that a better system, perhaps a wireless one, was waiting to be discovered and exploited.

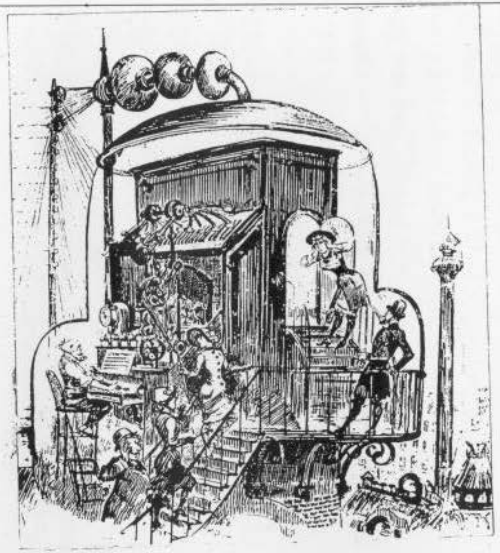
Compared with the wired systems of speculative fiction, compared to the very limited range of the modulated light and inductance methods, the wireless telegraph popularized by Marconi was to be the base on which was launched every new system of sending voice and music to an audience of more than one. The issues raised by this new electro-magnetic method of long-distance communication changed forever the thrust of the invention that would ultimately lead to radio broadcasting. The important work leading to a practical radiotelephone began with the arc systems of

Poulsen and Duddel, the spark and alternator voice experiments of Reginald Fessenden, and the early arc and later vacuum tube work by Lee de Forest. It was from this basic work, most of it in the first decade of the century, that inventor Charles Herrold entered the picture. Herrold's significance was twofold: He made Poulsen's arc work well enough and long enough to be a dependable carrier of voice and music, and before anyone else he used this technology to start and maintain the first radio station. Finally, as these two decades ended, engineer Frank Conrad found himself in a position to set the stage for the ultimate practical use of the radiotelephone. As the RCA agreements clarified ownership of the technology, the broadcasting of entertainment and information into homes by radio became a reality.

THE NINETEENTH CENTURY IMAGINATION

Before the radiotelephone experimenters introduced their competing wireless systems, there already had been some discussion in the newspapers and periodicals about how the technology of sending music into homes might be accomplished. More than talk, there actually were a couple of systems in place that today might be categorized as "subscription music services," Nineteenth Century versions of the current TV cable-delivered *DMX, Digital Music Express*. Likely influenced by the Bell telephone, all of those systems, whether actual or imagined, used wires for distribution. The significance of those early non-Hertzian systems to this story is that for the first time they introduced into the public debate a possible family entertainment service that was closer to what radio would become than the then in-home fare of books, magazines, stereo-opticon cards, and the piano. What those few non-wireless systems attempted were certainly ahead of their time, perhaps unknowingly awaiting a successful wireless telephone.

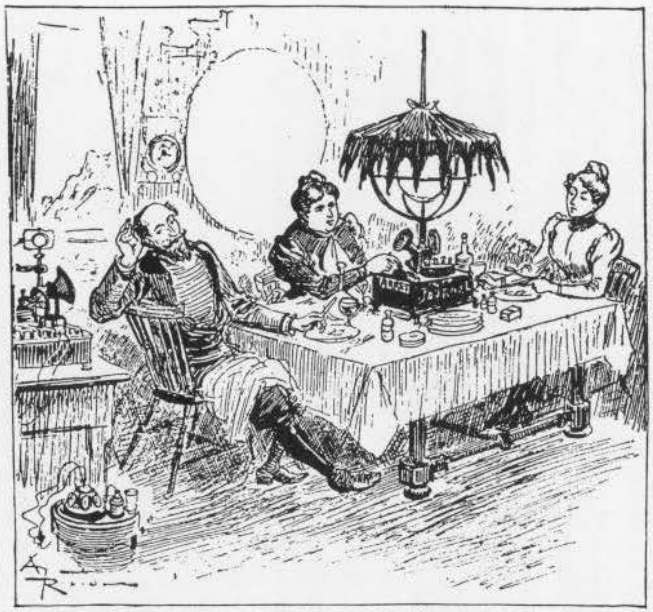
In Bellamy's best-selling 1887 novel *Looking Backwards*, its discussion of the wired music system of the future and its influence on the public cannot be minimized. As one of the most exciting, most read stories of speculative fiction, it placed a system of musical entertainment in every home in the context of a utopian, albeit benevolent socialist society in the year 2000. There was no poverty and everyone had a job and a home. Within each home there was a future version of the radio: "They have devised an arrangement for providing everybody with music in their homes, perfect in quality, unlimited in quantity . . . you can hear by merely pressing a button." (1) But even before Bellamy's ideas went into print, there was a prophetic cartoon on the front page of the March, 1877 issue of the



Radio Broadcasting station,.
1882
Lithograph by Albert Robbida
Radio Journal,Feb. 1943
(SRM 14 265)

Note the wires leading up to the pole, and thense outward to subscribers. Note also the large "spark gap" above the station. This may have been a combined wired-wireless and radio broadcasting station!

Figure 2. *Albert Robida's 1882 lithograph re-titled "Radio Broadcasting Station, 1882" by George Clark in Radio Journal, February 1943. (Clark Collection)*



Historia Mondiale

AN ANTICIPATION OF THE WIRELESS RECEIVER

A futuristic sketch, by Albert Robida in 1883, of a telephonic installation by which newspaper reports are to be transmitted. The apparatus is constructed in the table lamp and is marked "Journal" and "Stop (Arrêt)." On the neighbouring table is another apparatus which transmits information

Figure 3. *Albert Robida, 1883 lithograph, re-later titled "An Anticipation of the Wireless Receiver."(Clark Collection)*

New York Daily Graphic. Captioned, "Terrors of the Telephone," it depicted an angry-looking orator yelling into a floor-mounted oversized telephone microphone. From the back of the device are hundreds of tiny wires connected to large receivers in a dozen places; London, New York, Dublin, Boston, San Francisco, Peking, and curiously, a lone Indian, outdoors, on the American prairie. With the exception of the Indian, all of these receivers are in public halls, none in a living room setting. (2) (Figure 1)

That same year a similar idea had been advanced in the form of a song. Written by Thomas P. Westendorf, *The Wondrous Telephone* predicted lyrically that: "You stay at home and listen to the lecture in the hall or hear the strains of music from a fashionable ball" (3) Then there was Albert Robida, a political cartoonist and lithographer who in 1882-83 did a series of lithographic drawings depicting broadcasting, but this time aimed at a home listener rather than an audience in a public hall. At the "transmitting" or originating end, a musician played what appeared to be a combination organ-steam calliope, its sound somehow gathered and connected to many wires. The late George Clark, RCA Historian in the 1920s and 1930s, added a note to the bottom of the cartoon calling it "Radio Broadcasting Station, 1882." In Clark's words, "Note the wires leading up to the pole, and then outward to subscribers." (4) In Robida's 1883 lithograph a home receiving setup was portrayed, with the husband, wife and daughter sitting around a table listening in rapt attention to several telephone loudspeakers. It's described by Robida as: "a telephonic installation by which newspaper reports are to be transmitted." (5) (Figs. 2, 3)

If the systems described in the books and editorial cartoons of the day seemed more like science fiction than reality, consider the actual working systems. In an operating demonstration system patented in 1881 by French inventor Clemen-Agnes Ader, microphones were installed next to the footlights of a stage, connected to listeners by wires. According to Ader's patent, "The telephone allows us to convey songs, music and the spoken word to distant places." (6) Apparently, the existence of wired systems was more commonplace than realized: "European capitals had a service of wired broadcasts via the telephone system. Paris naturally had such a system. London telephone subscribers could participate in the two-tier tariff *Electrophone* service at five or ten pounds per year, and eavesdrop on concerts, music halls, theatres or church services. The London system ran from 1899 until radio finally killed it in 1925." (7) And, "In 1893 the *Telephon-Hirmondo* in Budapest was transmitting news, weather reports, market quotations, lectures and music over the telephone from 8am to 11pm for a large number of subscribers." (8) Wouldn't those systems and the publics they served have benefitted from a successful wireless telephone? Could the transition have been made from a reliance on wires to a technology less onerous? Were those early attempts simply "radio" waiting to happen?

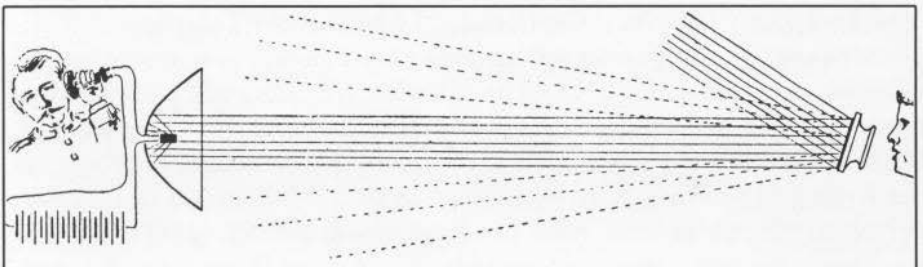


FIG. 1.
Bell's Original Photophone.

AT+T 1904 E
St Louis Expo

The Radiophone.

How It Is Possible to Talk Over A Light Ray Miles in Length.

The radiophone, which forms a part of the exhibit of the Bell Telephone Companies at the Louisiana Purchase Exposition, is the only practicable method of telephoning without the use of wires yet discovered. By its means the blinding rays of a searchlight may be made the path for human speech and other sounds. The rays of light will carry for miles every tone and inflection of the voice, the delicate shading and varying effects of orchestral music, every note and cadence of a song. With the help of the radiophone electric lights may be made to talk or be transformed into musical instruments. The radiophone is the embodiment of much that is wonderful in the transmission of sound, and it suggests the marvelous possibilities hidden in articles of common use. A bit of the black worsted which a woman uses in knitting, a tiny fragment torn from a silk dress, particles of rubber scraped with a pen knife from an old overshoe, these and many other substances may be made to repeat words flashed to them from an electric light miles away. So may the fine hairs found on the milkweed and the thistle-down which is the sport of the summer's breeze.

Alexander Graham Bell, the inventor of the telephone, also discovered the means by which wireless telephony has been made possible, and constructed the first apparatus to which the name of the radiophone was given. This was later perfected by an officer of the Bell Telephone system, and the wonderful results now attained are due to the scientific knowledge and skill of American inventors and engineers. In the experiments which led to the making of the radiophone Mr. Charles Sumner Taintor was associated with Professor Bell. They found that a great many substances could be made to give out sounds under the action of the heat car-

Figure 4. *Bell's Photophone: "How it is Possible to Talk Over a Light Ray Miles in Length," 1904, unidentified article. (Clark Collection)*

EARLY RADIOTELEPHONE SCIENCE

Early on, there were a number of individuals who apparently saw a need for a non-wired voice communication system. Much of this activity, if not all of it, happened prior to and around the time of Marconi's wireless telegraph introduction. Before the successes of Fessenden, Poulsen, de Forest and others, most early experimenters had based their devices on non-Hertzian principles. Whether over land or water, most of the early attempts to send voice without wires fell into one of two categories of technology: modulated light or inductance. There were systems that used

a bright, focused light source modulated or made to "flicker" analogous to the varying currents caused by speaking into a carbon button telephone in series with a DC voltage. The receiver used a light sensitive element, selenium, in combination with batteries and earphones. The flickering of the received light falling on the selenium created tiny currents representative of the voice transmitted which could be heard in a telephone receiver. The range was limited to a few miles, and depended on the atmospheric conditions and the brightness of the light. The most successful of those limited devices was known as the "Photophone." Originally introduced by Alexander Graham Bell in 1878, this light telephony system had been improved by 1904 where it was demonstrated at the Louisiana Purchase Exposition in St Louis. Bell called it the "Radiophone," and while it may have attracted attention it never found practical use. (9) (Figure 4)

How did the press greet Bell's discovery? The word "radio" was used in a 1904 report: "The radiophone, which forms a part of the exhibit of the Bell Telephone Companies at the Louisiana Purchase Exposition, is the only practicable method of telephoning without the use of wires yet discovered. By its means the blinding rays of a searchlight may be made the path for human speech and other sounds. The rays of light will carry for miles every tone and inflection of the voice, the delicate shading and varying effects of orchestral music, every note and cadence of a song. With the help of the radiophone electric lights may be made to talk or be transformed into musical instruments. The radiophone is the embodiment of much that is wonderful in the transmission of sound, and it suggests the marvelous possibilities hidden in articles of common use." (10) While Bell clearly saw and marketed his device as a wireless accessory for his wired telephone, at least one member of the press was beginning to look at the future.

Other less well-known scientists were also working on variations of modulated light voice transmission using an arc as a light source. Moving closer to the Poulsen system of wireless arc transmission, in 1897 Professor H.T. Simon discovered that a DC arc would give out tones and speech by superimposing telephone currents on an arc used for a line-of-sight transmitter. This may have convinced Bell to use an arc for his Photophone. Around this same time the German inventor Ernst Ruhmer equipped several naval vessels with his version of a light telephone device. Distance limitations and the soon-to-be-invented wireless telephones would rapidly doom all development of this and other line-of-sight devices.

Then there was the strange case of Nathan B. Stubblefield, 1860-1928. His two radiotelephone systems, one based on ground conductivity and the other induction, both caused quite a stir in his native Kentucky. He claimed to have sent the first non-wired voice transmission over land as early as 1892. In an attempt to free the telephone from its wires, Stubblefield

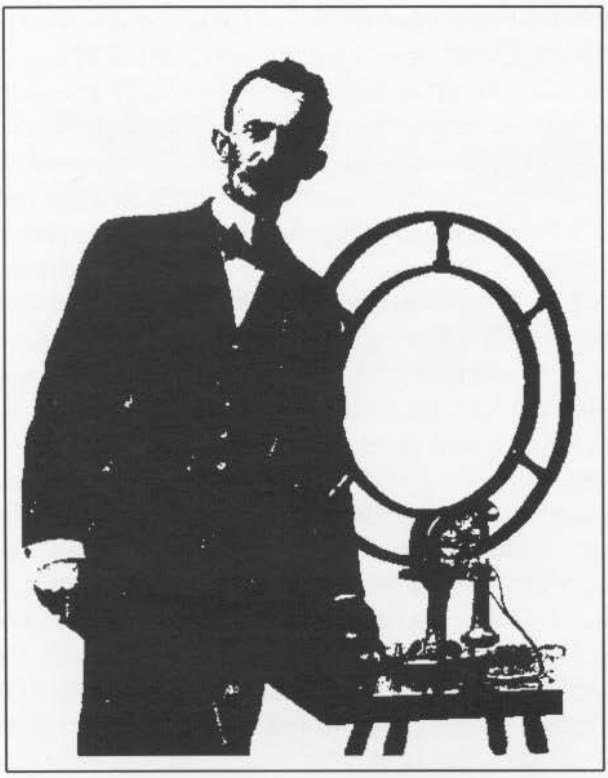


Figure 5. *Stubblefield and his induction device. (Murray State College, KY)*

did not use true wireless methods, but rather, two non-radio systems. The first of his systems used the conductive characteristics of moist ground, and featured a carbon telephone transmitter, many batteries in series, and long rods stuck in the wet earth. It was big news by 1902: "Nathan Stubblefield, a Kentucky truck farmer, claims to have discovered telephoning without wires. At a public exhibition in Murray, Calloway County, Ky., on Jan. 1, he convinced a thousand people of the truth of his claim. . . Stubblefield placed his transmitter in the courthouse square and ran two wires from it into the ground. He established five 'listening stations' in various parts of the town, the furthest six blocks from the transmitter. Then Mr. Stubblefield's son took his place at the transmitter and talked, whispered, whistled and played a harmonica. Simultaneously everyone at the receivers heard him with remarkable distinctness." (11)

The importance of this demonstration was not in the technology employed for it was primitive and limited. Its significance was in the sending of voice and music without wires to more than one receiver in a public, non-message application. This demonstration, organized by the Wireless Telephone Company of America, also preceded their purchase of the rights to 500,000 shares of stock in the Stubblefield inventions. For a while it

looked as if Stubblefield might become rich: "The company also organized an experiment in Central Park, New York City, in June, 1902. This event, however, was nearly a total failure, due primarily to the rocky soil in the park which would not conduct electricity. Company executives suggested that Stubblefield surreptitiously run a wire underground to connect the rods. Nathan became immediately suspicious and, upon further investigation, discovered that the company was nothing but a stock fraud. He returned to Murray and urged all his friends who had invested to demand their money back. The company collapsed and the swindlers involved eventually went to prison." (12) (Figure 5)

Perhaps influenced by Sir William H. Preece who in 1899 used telephones and a parallel-wire induction system to transmit voice three miles (13), Stubblefield's second system was based on magnetic induction, a technology similar to modern day systems that connect to a hi-fi receiver which allow a music listener to walk around a room wearing headphones but with no connecting wires. He received a patent in May, 1908 for his magnetic induction system, which, unlike the Preece system, used a telephone and a battery fed into large inductance coils, like the primary of a giant air core transformer. The secondary coil was connected to a telephone receiver. After his earlier experience with ground conductivity Stubblefield refused to show his induction system to potential investors for fear that they would steal it from him. He used the induction system for a while but later gave it up, having unsuccessfully spent four years trying to raise the money needed to develop it. Its range was probably limited to less than half a mile. In the March, 1930 issue of *Kentucky Progress* Magazine, an article, "Murray Kentucky, the Birthplace of Radio" tells of the plaque placed on March 28, 1930, at Murray State Teachers College to honor Stubblefield as, "The first man to broadcast and receive the human voice without wires. Although he undoubtedly gave the world its greatest invention, the radio, he failed to get the honor due him." (14)

MARCONI'S IMPORTANCE

But then around 1900, there was publicity surrounding a true technical revolution, actual wireless as we now know it. The first stories to appear in the national press were about Guglielmo Marconi, a young boy with an Italian father and British mother. When the Italian government would not support his work, he took his inventions to the British. From sending Hertzian waves across a room as early as 1894 to the highly publicized transmission of the letter "S" from Poldhu, England to Newfoundland, Canada in December, 1901, Marconi's system made obsolete all non-Hertzian

systems of wireless communication. Today some believe Marconi's success was mostly because he was a "systems man," the first to successfully combine the relevant practical and theoretical wireless ideas and experiments of others into a business. Said historian Hugh Aitken: "What differentiated Marconi from his contemporary rivals was not his scientific knowledge nor, initially, the distinctive excellence of his technology. It was his sense of the market, of where a demand for this new technology existed or could be created." (15) And Marconi had little interest in wireless beyond dependable two-way commercial communication and the safety of ships at sea. Contrary to broadcasting by voice, Marconi believed messages should remain private.

By 1902 Marconi's wireless telegraph was an established fact. It was in that context that a new group of experimenters began to look at better ways of sending voice through the air. After all, the light and induction systems were limited to a few miles and never would be taken seriously, especially if a voice transmission system with the range of Marconi's wireless telegraph could be found. So in the future invention history of radio, wireless by Hertzian waves was where all the action was going to be centered. And between the time of Marconi's wireless in 1900 and the broadcasting decade of the 1920s, systems based on spark, alternator, arc, and the vacuum tube quickly overshadowed all earlier non-Hertzian systems as a carrier of voice. Determining which one was best would consume the first two decades of the new century. Scientists and inventors like Poulsen, Fessenden and de Forest led the way. While none of the participants knew it at the time, it would be a race for the radiotelephone.

Another limiting technology that for a time delayed the transition from modulated light systems to a wireless-based radiotelephone was that of the receiver. For translating the dots and dashes of spark, the major device used in the Marconi system was a variant of Branley's Coherer, a small tube containing iron filings which closed like a switch when receiving the electromagnetic pulses of the Morse code. It both looked and worked like a Rube Goldberg creation: Each time the filings "cohered," or caused the circuit to close, current from an in-series battery flowed and a buzzer sounded or a telephone receiver clicked or an inking device recorded a coded symbolic component of the message, a dot or dash. Then a small hammer would "tap" the filings apart, and the entire process began again in order to detect the next dot or dash. In addition to being extremely slow, the mechanical coherer could not receive sound which we know to be audio frequency. A coherer did not allow a receiver to "hear" audio, obviously a serious technical impediment to the development of the wireless telephone. New systems of detecting like Fessenden's "Liquid Barretter" and Picard's "galena" had to be discovered before an operator could "hear" a human voice using a headphone. A new generation of detectors which

converted or "rectified" RF, radio frequency, into AF, or audio frequency really opened the door for the Hertzian-based radiotelephone.

THE NEW RADIOTELEPHONE PIONEERS

So in the first few years of the new century, the stage was likely set for a practical radiotelephone system or systems based on Marconi's success with the Hertzian principles. In the beginning, some of the five pioneers profiled here only wanted to discover and reap the financial rewards from finding a replacement for the wired Bell telephone, just like Marconi had done with the land-based telegraph. Fessenden and de Forest were serious scientists, and Herrold a wireless tinkerer, but all three tried to invent and profit from a practical system. And perhaps accidentally, these three began to discover that they had small audiences listening to their experimental transmissions of voice and music. Poulsen's importance was that his arc system was the major transmitting technology used between 1907 and 1916, a technology which was brought from Denmark to the Bay Area of California by a Stanford engineering graduate. It was the Poulsen arc transmitter and the wireless company built around it that became the basis for the development of the modern electronics industry and Silicon Valley. Conrad became important toward the end of the two decades. By then he and others saw a potential for a mass entertainment system out of the finally perfected radiotelephone. The result was that the 1920s would become broadcasting's defining decade.

REGINALD FESSENDEN AND THE FIRST BROADCAST

Reginald Aubrey Fessenden was born in Bolton, Quebec, Canada in October 1866. As the son of a minister, he was educated in New York and Canada, and "at an early date manifested a particular liking for mathematical and scientific subjects." (16) Between 1887 and 1890 Fessenden worked for Thomas Edison, then as a professor of electrical engineering at Purdue University and at Western University of Pennsylvania, 1892-93, and finally at the US Weather Bureau, 1900. Described by colleagues as a hard working, hard driving intellectual, by 1902 Fessenden had 13 wireless patents issued in his name. He was an early primary contributor to the science of wireless and radio; in 1902 his inventions covered "improvements in construction of antennas, means of amplifying received signals, wireless telephone." (17) Probably his most important early contribution was the 1903 invention of the Liquid Barretter, "an electrode-electrolytic

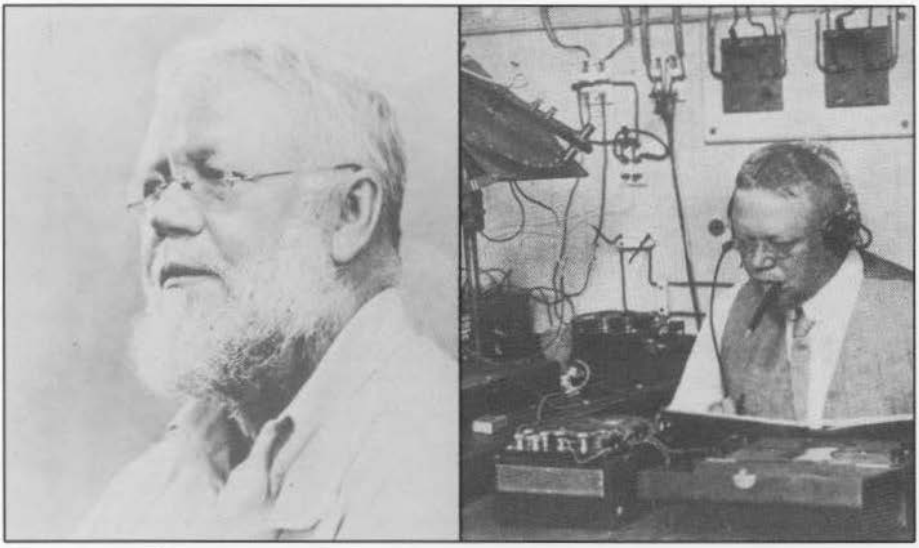


Figure 6. *Reginald Fessenden. (Communications Research Centre, Canada)*

Figure 7. *Fessenden in his lab. (CRC, Canada)*

interface rectifier which was used for both radio-telegraphy and radio-telephony – initially for reception of synchronized rotary spark gap transmissions, another one of his inventions, and later for reception of amplitude-modulated wireless signals." (18) In simpler terms, Fessenden invented the first audio receiving device that made the hearing of wireless voice transmissions possible! (Figure 6)

The Liquid Barretter was no small accomplishment since, unlike all the previous mechanical detectors like the above mentioned coherer, audio could finally be heard with it over headphones. Using it, Fessenden had listened to the various musical notes of the spark stations and noticing their distinct audio sounds believed that if he could put a voice over the air, it too could be "heard" by the Barretter. And Fessenden was probably the first to send and have received a voice transmission using Hertzian waves, this as early as 1900. Writing in *Scientific American*, Fessenden in 1907 describes his work with all three systems: spark, arc, alternator. About his early spark experiments during his employment by a wireless company, The National Electric Signaling Company (NESCO), he wrote how he, "transmitted speech wirelessly for the first time in the summer of 1900 by the method disclosed in US patent 706,747. While the speech transmission could be understood, there was a great deal of extraneous noise in the telephone, and various devices were devised for eliminating this." (19)

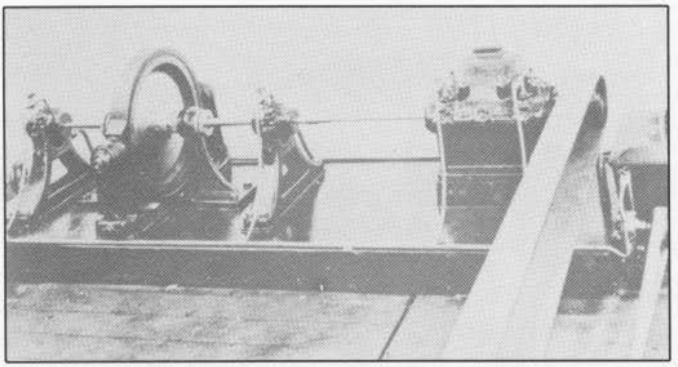


Figure 8. *The Alexanderson/GE built alternator used for the 1906 broadcast. (CRC, Canada)*

Next, he turned to an arc with "an improvement on the original Thomson singing arc method, recently discovered by Poulsen and others, but which was used by the National Electric Signaling Company in 1901 and patented in 1902." (20) Fessenden also described his work with General Electric engineer Ernst Alexanderson in developing his alternator for NESCO: "During this test not only speech but phonographic talking records and music were transmitted, all being received with perfect clearness and distinctness, the wireless telephone being in this respect markedly an advance over the regular wire lines." (21) (Figure 8)

As an eccentric genius, he was reported to be tough on his staff: "Fessenden and Alexanderson worked well together, although that was not the case for many others who fell into Fessenden's orbit. His assistants, for example, grumbled about his high-handed ways with them. 'Don't try to think - you haven't the brains for it!' was one of the kinder ways he addressed them. Alexanderson recalled that Fessenden was domineering and bombastic with people he thought were beneath him. When something went wrong, he sometimes would fire everyone only to rehire them the next day." (22) While he continued to work with Alexanderson on the design of a super-alternator for radiotelephone communication, he continued to intimidate his staff: "As Fessenden's prowess in wireless grew, so did his eccentricities. He experienced growing paranoia that any number of people were out to steal his inventions. His Brant Rock, Massachusetts laboratory became a top-secret outpost, where information and apparatus were kept under lock and key at all times. His visions of industrial espionage were not entirely imaginary. A casual visit by de Forest to one of Fessenden's workshops in 1903 resulted in a round of court battles regarding de Forest's theft of the Barretter receiver design." (23) After three court appearances, he finally received an injunction against de Forest for patent infringement. It cost Fessenden over $100,000 and increased his paranoia.

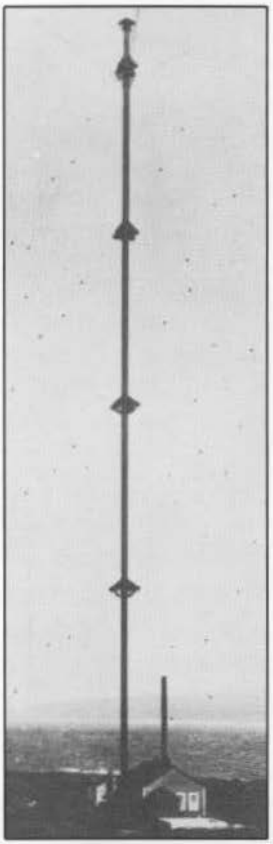


Figure 9. *Brant Rock antenna. (CRC, Canada)*

Fessenden's longest lasting and most public claim was his 1906 Christmas Eve broadcast from Brant Rock, a small Atlantic coastal village north of Cape Cod Bay. In a letter he wrote to Westinghouse Vice-President S. M. Kintner in 1932, he reflected on this event: "This broadcast was advertised and notified three days in advance of Christmas, the word being telegraphed to the ships of the U.S. Navy and the United Fruit Co., which were equipped with our apparatus that we intended broadcasting speech, music and singing on Christmas Eve and New Years Eve. The program on Christmas Eve was as follows: first a short speech by me saying what we were going to do, then some phonograph music, Handel's Largo. Then came a violin solo by me, being a composition by Gounod called 'O, Holy Night,'' and ending up with the words 'Adore and be Still' which I sang one verse of, in addition to playing on the violin, though the singing, of course, was not very good. Then came the bible text, 'Glory to God in the highest and on earth peace to men of good will,' and we finally wound up by wishing them a Merry Christmas and then saying that we proposed to broadcast again New Years Eve." (24) (Figure 10)

While today many historians categorize the 1906 Brant Rock musical program as a "broadcast," Fessenden's stated goal was simply to build a radiotelephone for commercial purposes. He was a musician by avocation, as evidenced by his performances on the 1906-07 Brant Rock transmissions, and he admitted sending phonograph music many times to "rest my voice," but other than Brant Rock, he never made any claim to being a broadcaster. His two most important contributions to actual broadcasting were in the technology, not the art. The Alexanderson Alternator used in the 1906 Brant Rock broadcasts demonstrated early that clear speech and music could be transmitted. And most important, his earlier invention of the Liquid Barretter detector forever changed the receiver from its earlier mechanical roots. It was, "the first device to enable operators to receive signals 'by ear." (25)

Reginald Fessenden was truly an original thinker. But that he was also an eccentric caused his early undoing, and by 1910 his backers, NESCO,

Figure 10. *Fessenden in lab, Brant rock, 1906. (CRC, Canada)*

fired him and removed his equipment. According to a witness, "He needed a bathtub of especial size to accommodate his huge frame, and had one installed at Brant Rock, covering it by a requisition as 'Blueprint Washing Machine.' Fessenden had just returned from a voyage to Europe and had turned in a prodigious expense account, which the backers would not pay. So he was fired. The workers chose sides. The order came to dismantle the plant, and especially to get the records packed in boxes and sent to Pittsburgh. Up came a van with large packing boxes, into which the papers were hastily stowed. Then arose a battle between the ins and outs, and the upshot was that the pro-Fessendenites sat on the box covers all night to prevent them being taken away by the renegades. The matter was settled amiably and the records put back." (26) But after that insult, and with a divided staff and little or no money with which to continue, Fessenden got out of the radiotelephone business. Others like Lee de Forest and Charles Herrold learned from his work, his successes and his failures, and continued to find new ways to use the talking wireless.

VALDEMAR POULSEN, THE DANISH EDISON

Another early and important influence on radiotelephony was Valdemar Poulsen, who was later known by the complimentary title, the Danish Edison. For most of the first two decades of the Twentieth Century his DC arc-based system of transmission was the model on which most inventors based their devices. Poulsen, who had earlier discovered the fundamentals of

Figure 11. *Early Poulsen magnetic recorder. (Ampex Museum)*

magnetic recording used today, improved on the theories of others to develop a system of arc telephony. Just as Marconi built on the work of Hertz and Maxwell, Poulsen based his arc system on "William Duddell's discovery of the singing arc. The principle of this discovery was that when an arc lamp, fed by a direct current of about two-hundred and fifty volts, is shunted with a suitable capacity, and an inductance, alternating currents of a frequency of 40,000 per second were established." (27) Poulsen discovered that when the singing arc was placed into an atmosphere of hydrogen or other gas, the frequency of the oscillations increased to almost 500,000 cycles per second, putting it in the radio frequency range where it could be detected as audio. He was also the first to introduce the use of "six arc lights in series as generators of an oscillating current of high frequency." (28) The Poulsen-Duddell system was introduced in 1903. For the transmission of voice most inventors used and attempted to legally improve upon Poulsen's technology.

In 1903 Poulsen patented, "an improved arc oscillation generator using a hydrocarbon atmosphere and a magnetic field." (29) The modifications of the Poulsen-Duddell discovery continued with Telefunken. Their arc telephone system in 1906 covered 25 miles: "The arcs used by the Telefunken Company were burned either six in series on 220 volts direct current, twelve in series on 440 volts, or twenty-four in series on 880 volts." (30) Then there was the problem of the microphone: Every Poulsen-based arc radiotelephone system required a microphone capable of handling high-current, the most popular of which used a carbon microphone with some form of circulating liquid to keep the element from overheating. In 1906 the Italian Count Majorana used a variant of the Poulsen arc system but

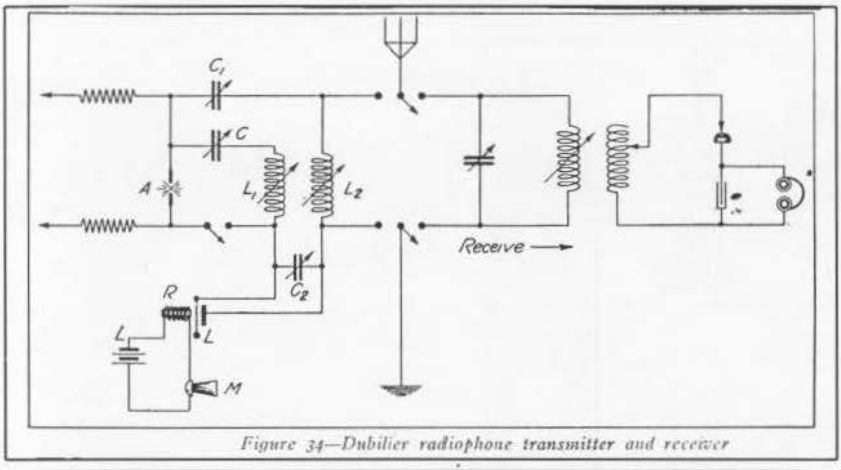


Figure 34—Dublier radiophone transmitter and receiver

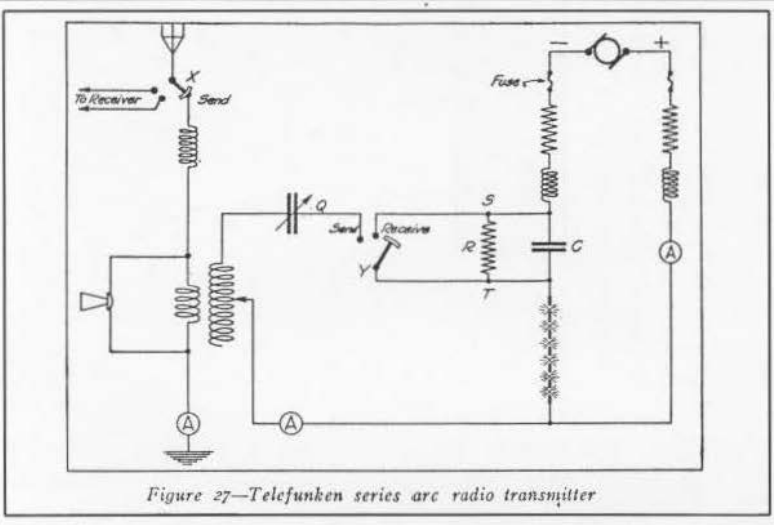


Figure 27—Telefunken series arc radio transmitter

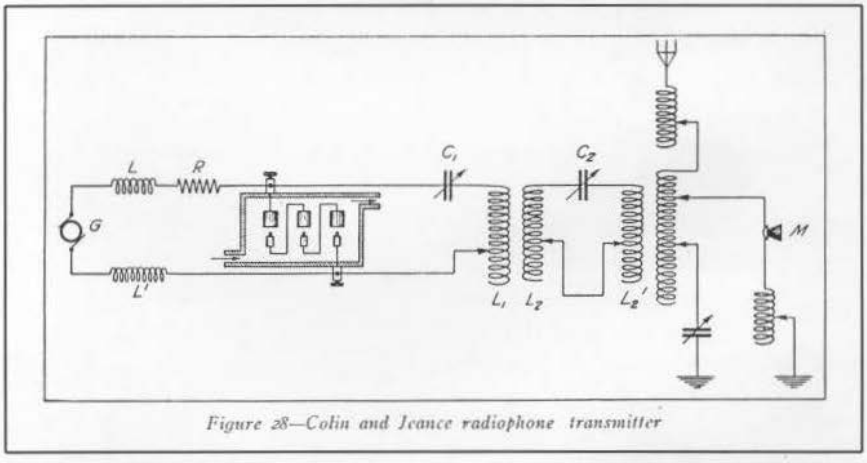


Figure 28—Colin and Jeance radiophone transmitter

Figures 12, 13, 14. *Three schematics of arc systems based on Poulsen principles: Dublier, Telefunken and Colin & Jeance. (Clark)*

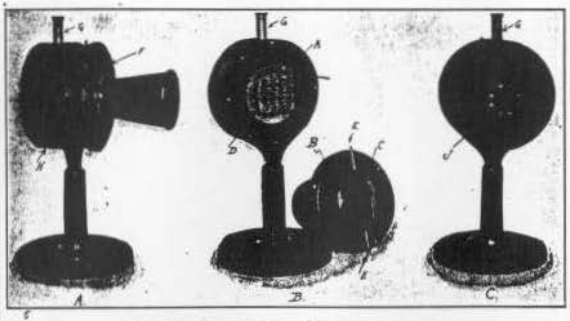


Figure 131—Egner-Holström high current microphone

Figures 15, 16, 17, 18. *Four views of carbon microphones necessary for the high current requirements of the arc radiotelephone system. Most were cooled by liquid. (Clark)*

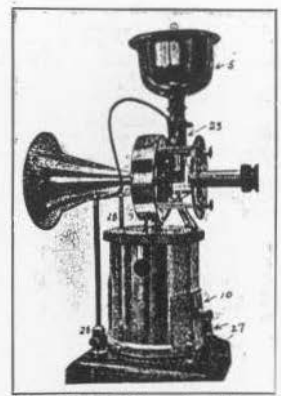


Figure 133—Scheidt-Boon Marzi high current microphone transmitter (relay type)

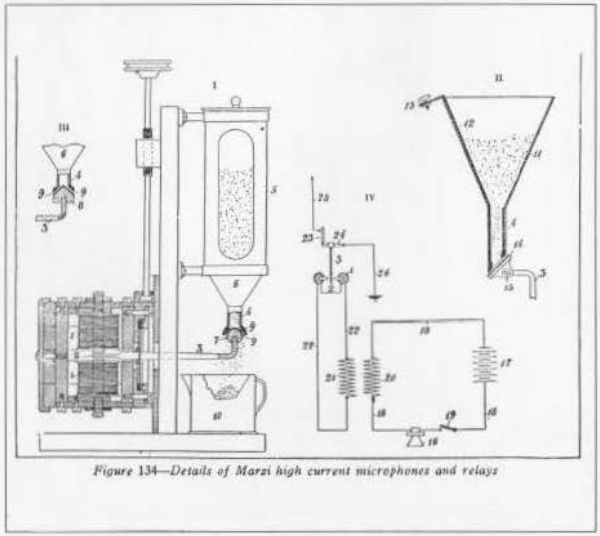


Figure 134—Details of Marzi high current microphones and relays

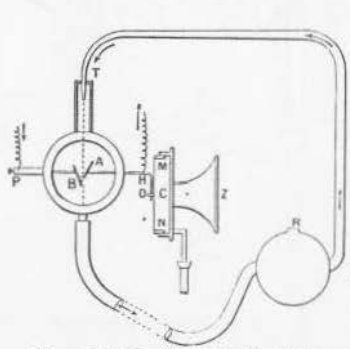


Figure 136—Vanni's liquid microphone

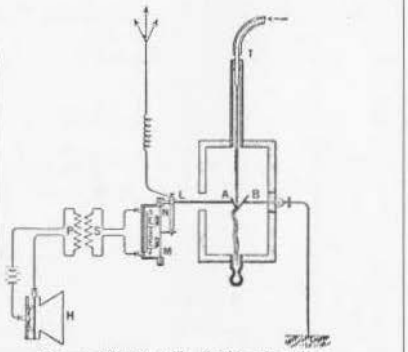


Figure 137—Vanni's liquid microphone relay

JULY 1911

MODERN ELECTRICS 215

A New System of Wireless Telephony

By Victor H. Laughter.

NOTEWORTHY demonstrations have been recently given by William Dubilier of his new wireless telephone. The tests were held between Seattle and Tacoma, a distance of thirty miles, and in every instance the received speech was clear and distinct; and the writer who had the pleasure of witnessing a number of the tests believes that the distance between the stations could be extended many miles farther without detriment to the working of the apparatus. The Government station at Tatoosh one hundred and twenty-eight miles distant picked up the messages on a number of occasions.

Fig. 1

The Dubilier system embodies a number of distinct and original features.

The greatest difficulties heretofore encountered in wireless telephony has been the unstable features of the arc and the low current carrying capacity of the transmitter. These points Dubilier has apparently overcome, for in

Figures 19, 20. *Two arc systems, Dublier & Telefunken. (Modern Electrics, July 1911)*

added his own special invention, a "hydraulic microphone." Majorana's solution was based on the hydrodynamic principle: "Water is made a conductor by the presence of acid or salt and by continuous change so that even the heat produced by the current is removed from the set." (31). His microphone, based on earlier experiments by Chichister Bell, showed that a column of liquid responded to mechanical energy, and was not a carbon system but a liquid-filled microphone; water to which salt or acid is added is used to change electrical current when exposed to acoustic events. (32) (Figures 15, 16, 17, 18)

The obvious significance of Poulsen was that he had introduced the first wireless system that made possible a high quality clear transmission of voice using Hertzian waves. The realization of the vacuum tube as an oscillator was then more than a decade away, and so the Poulsen arc was really the only option for radiotelephone experimentation, even broadcasting, during much of the two important decades covered here. But the story of Valdemar Poulsen and his arc had a hidden significance, one that was important to the development of the modern electronics industry. It began with a young San Francisco wireless experimenter and a Stanford engineering graduate, and it's culmination was the formation of a unique company based in a now famous "garage" in what has become Silicon Valley. Even today, the Poulsen story remains significant because of its direct connection to Cyril Elwell and the Federal Telegraph Company, and the inventions that evolved out of this early association. It is an important but necessary digression, an interesting story in the radiotelephone saga. It was all part of the same race.

Francis McCarty was an early Bay Area radiotelephone experimenter. Using the Collins system of spark, in 1907 he sent music, according to an eyewitness, from a "transmitter erected on the Ferry at the foot of Market Street to the Ferry boats plying between San Francisco and Oakland. This was the system employed by A.F. Collins, consisting of a 1" induction coil, with very nicely adjusted vibrators, so that vibration frequencies or primary interruptions could be obtained up to about 1500 cycles. The oscillating circuit spark gap was composed of two silver discs, spaced from .0005 inch to 3/16" when the microphones were good. There were three to eight telephone type microphones placed in parallel, these in series with a six volt battery in the primary." (33) The fidelity of this spark coil system was limited; Fessenden's earlier experiments with similar technology had already proved that spark transmissions were so overpowered by the noise artifacts of the system that it was next to impossible to hear clear audio. By McCarty's time spark as a carrier of voice and music was already a dead end technology.

Still, McCarty's experiments, unsatisfactory as they were, served as the catalyst for the formation of the Federal Telegraph Company a few years later. McCarty's financial backers, the Henshaw Brothers, approached a recent electrical engineering graduate, Cyril Elwell, to help them evaluate and perhaps improve the McCarty transmission system. In 1907 Elwell set up a transmitting station at Palo Alto and constructed McCarty's device based on the details in his patent. While it produced mostly unintelligible speech, Elwell found that when he closed the spark gaps to as narrow as possible, an arc developed and the voice quality improved. He told the Henshaws not to waste their money on the McCarty spark patents. Case Closed. But based on what he had learned from the McCarty failures

and having read something about arc systems Elwell traveled to Denmark and negotiated the American rights to the arc transmission system of Poulsen. He brought several of the Poulsen transmitters back to Northern California in 1909 where he demonstrated them in Palo Alto for a group of Stanford professors.

The Poulsen Wireless Telephone and Telegraph Company was formed, and by 1910 stations were in operation in nearby Sacramento and Stockton. Earl Daniels worked for the Poulsen station in Sacramento, which used the same arc transmitter as did Stockton: "The microphones were in series with the ground lead, and were multiple, mounted on a disc in a circle, all in parallel. An old style Columbia phonograph of the morning glory horn type was played into this set of microphones. The Poulsen people were represented by Jensen, now with Magnavox. He brought the set from Denmark and installed it. His standard speech in testing was, 'Hello, hello, hello, Stockton. This is the Poulsen Wireless Telephone, invented by Valdemar Poulsen, of Copenhagen, Denmark. Mr. Poulsen has secured the rights to this phone in the U.S. of America. Hello, hello, hello, Stockton. I will play you another record now." (34)

Even though Elwell's goals centered around the two-way radiotelephone message business, not broadcasting, in later years he wrote in his autobiography about the early radiotelephone experiments in Palo Alto, 1909-10: "Little did I realize that we were laying the foundations of broadcasting..." (35) What Elwell accomplished was the formation of a radiotelephone business utilizing a series of high-powered wireless telegraph and telephone stations based on the Poulsen arc, but used to send messages across the country and the world. (The company evolved into Federal Telegraph and the Poulsen arc was used into the early 1930s for high-powered wireless telegraph transmission.) Elwell and his business contemporaries had no use for the "hams" and people like Charles Herrold who would clutter up the air with useless music and talk. Lee de Forest joined Elwell in Palo Alto in 1910, where in that famous garage near the Stanford campus he worked to improve his Audion, first as an amplifier for the telephone company, and later as the oscillator behind the final and successful version of the radiotelephone. And so the connection to the Bay Area of California and the invention and industry that evolved into Silicon Valley and the modern electronics industry remains an important Poulsen-related legacy.

LEE DE FOREST: IN A CLASS BY HIMSELF

The single most important individual in the twenty year evolution from two-way wireless telegraphy as a commercial business to the technical

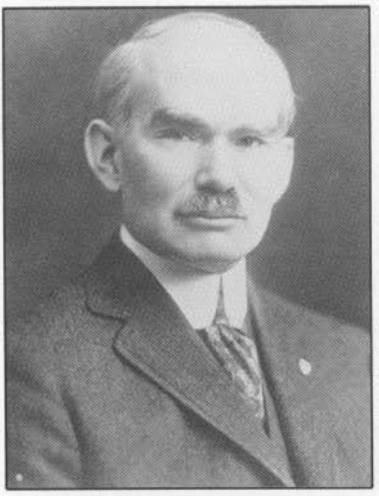


Figure 21. *Lee de Forest. (Perham Foundation)*

perfection and use of the radiotelephone for entertainment broadcasting was Lee de Forest. There were three major events that defined de Forest as a radiotelephone pioneer-cum-broadcaster; his equipping of the Navy Fleet in 1907, his publicized broadcasts of opera in New York City between 1907 and 1912, and his 1916-17 and 1919 broadcast demonstrations over stations in New York and San Francisco. Judging by this early performance, Lee de Forest should have won the race for the radiotelephone hands down.

Arguably, there was no wireless and radio inventor who was surrounded by more controversy than Lee de Forest. He fought for decades to convince the technical community that he deserved to be known as the "Father of Radio," and he spent millions in court battles trying to validate and re-validate his patents. Still, whether you fall into the two opposite camps, whether you love him or hate him, sanctify him or vilify him, (there seems to be no middle ground) the evidence strongly suggests that, more than any single individual, Lee de Forest was the first to want to use the wireless for more than two-way commercial message traffic. Throughout his early career he bordered on the edge of the activities of broadcasting, sending entertainment programs to a defined audience. In all the published reports, in all the historical analysis, it is the name of de Forest that is early and often associated with the sending of music and news using the radiotelephone. And while until 1919 he failed to establish a permanent station, failed to broadcast on a regular basis and therefore failed to gain a regular audience, his contribution to the art and science of radio is unprecedented. The evidence strongly suggests that Lee de Forest could rightfully claim to be what he struggled his entire life to be, the "Father of Radio." (36)

Lee de Forest was born in the Midwest but really grew up in the South. Shortly after his birth in Council Bluffs, Iowa in 1873 young Lee's father accepted a position as the President of a small black college (Talledega) in Alabama. But while de Forest grew up on that rural campus, his education was formal, upper class and thorough. After a local grammar school he went on to the Mt. Hermon School for Boys in Massachusetts, preparatory to his entrance into Yale University's Sheffield Scientific School. De Forest

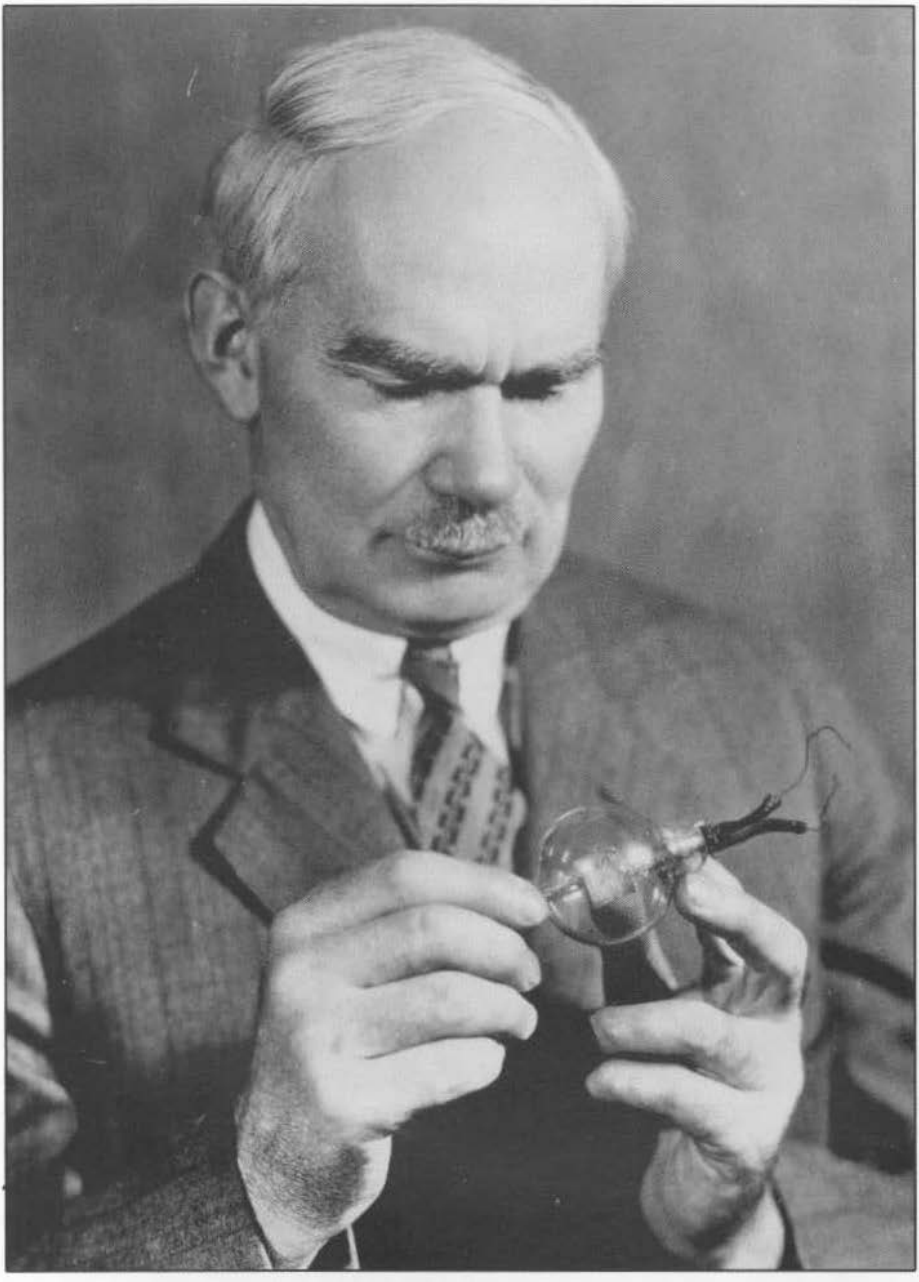


Figure 22. *De Forest with Audion. (Perham Foundation)*

completed his higher education and received the degree of Doctor of Philosophy. His 1898 dissertation was titled: "The Reflection of Hertzian Waves at the End of Parallel Wires." Well-educated, Lee de Forest as an engineering graduate worked for several Chicago companies, Western Electric among them. (37)

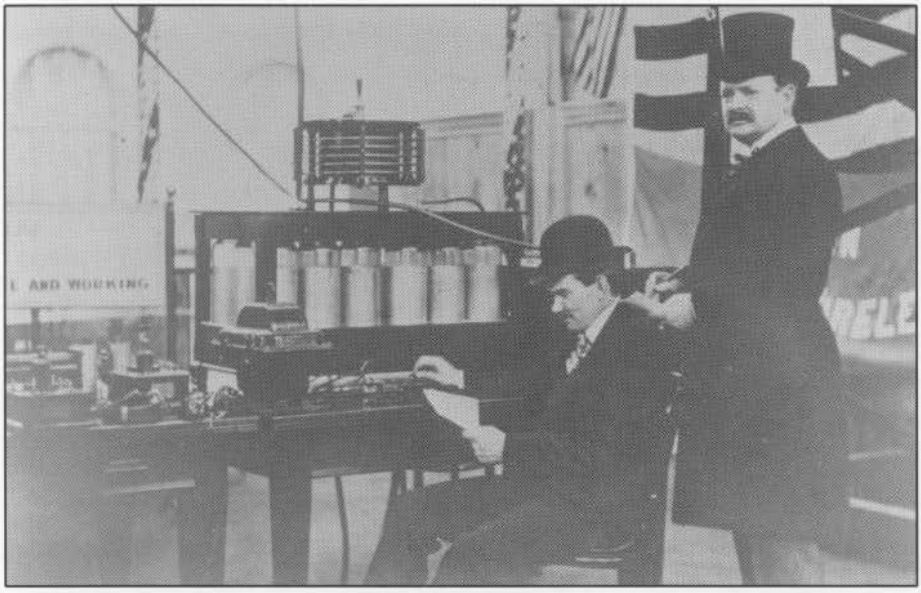
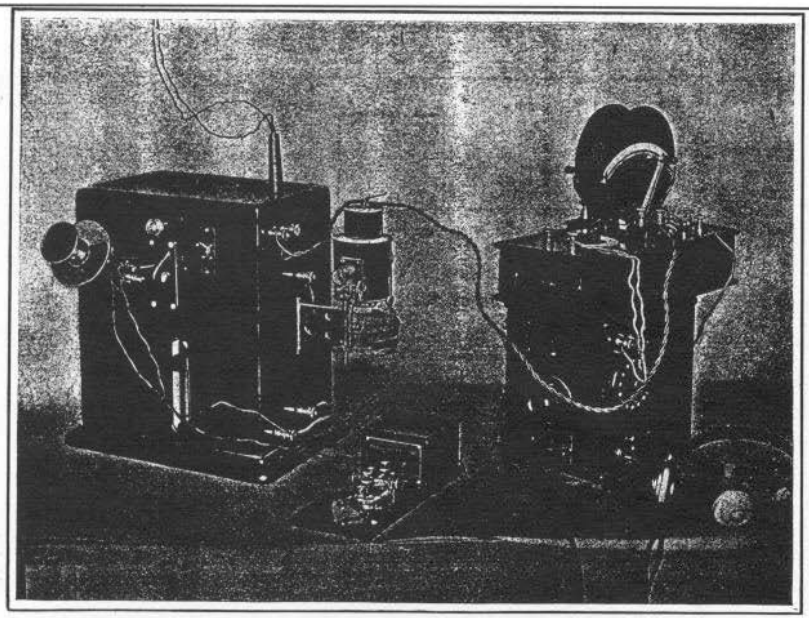


Figure 23. *De Forest at telegraph with wireless promoter White.*

Even though it is the purpose of this article to place de Forest into the context of the transition from radiotelephone to broadcasting, he is most known for his contributions and improvements to the basic invention of all radio and television, the vacuum tube. Thomas Edison's electric lamp earlier had been modified by the Englishman, Ambrose Fleming, who added a second element, a plate, and called it the Fleming Valve. By 1906 de Forest had modified Fleming's Valve by adding a grid (which amplified small signals) and called this device the Audion. (38) And while today it is believed that de Forest did not fully realize what he had invented, and while he battled Edwin Armstrong in court for decades over the regenerative or feedback principle of the Audion, it was really Lee de Forest's work in early radiotelephone experimentation and its broadcast-like applications that proved to be the most interesting of his career. In the beginning he seemed to have followed the work of Marconi, attempting to develop better communication between ships and shore stations. And like Fessenden and Charles Herrold, de Forest first tried spark and later a Poulsen arc in an attempt to give voice to his wireless.

The reality of the early radiotelephone development years did not include the broadcasting of music and information into homes using wireless. If you needed backers, if you wanted to sell stock certificates to raise money, it had to be for a wireless telephone for serious, profitable two-way communication purposes, an addition to the wired Bell telephone. And further, as de Forest and hundreds of inventors lamentably discovered, you had to be a promoter as well as an inventor, and that often meant



Complete Equipment of Transmitting and Receiving Instruments for One Station.

THE DE FOREST RADIO-TELEPHONE APPARATUS.

Figure 24. *The de Forest arc transmitter and audion receiver built for the US Navy. (Clark)*

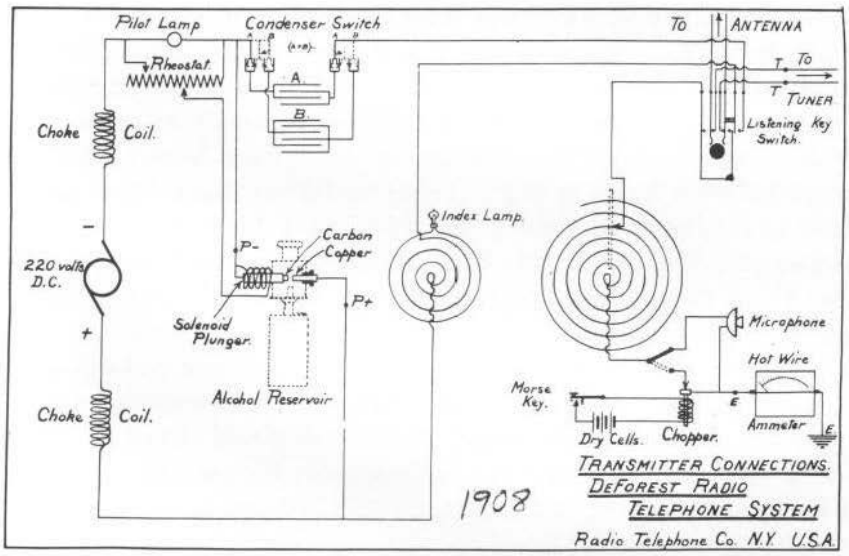


Figure 25. *De Forest Company radio-telephone arc transmitter schematic, 1908. (Clark)*

that you found yourself allied with an unsavory, easy money crowd. De Forest himself was accused, but acquitted of stock fraud, although his backers went to prison. Controversy notwithstanding, de Forest began early and often to find public uses for his version of a Poulsen-like arc radiotelephone transmitter: "In 1906 he devoted his entire energy to the problem of wireless telephony. His first invention of importance was the use of the microphone in the earth connection, where it has been used in practically all (arc) wireless telephone transmitters ever since." (39) That Lee de Forest was both a promoter and a music lover led him and his arc radiotelephone into two areas; one is practical, a demonstration for the Navy, the other reflected his penchant for bringing culture to the masses, the use of opera music to demonstrate his wireless telephone for newspaper reporters. (Figures 24, 25, 26, 27)

An early recipient of the de Forest arc radiotelephone system was the Navy: "In 1909 I was manufacturing wireless telephone sets for the US Navy; each set was tested by means of phonograph records. Much to my surprise, many wireless amateurs and professional operators intercepted and enjoyed these test transmissions. They came to look for these 'programs.' And quite naturally, the idea of mass communication occurred to me, whereby attractive music and interesting talks might be placed on the air, thus creating a profitable demand for wireless equipment by those desirous of listening in." (40) De Forest equipped the Navy Fleet's lead ship *Ohio* and others with his arc transmitter and a wind-up phonograph for the fleet's trip around the world between 1907 and 1908. This is a well-publicized event, and while on the West Coast, de Forest, aboard the *Ohio,* played music from the phonograph and communicated with Mare Island during June, 1908. Radio operator Herbert J. Meneratti of the *U.S.S. Ohio* documented these events well in correspondence with historian Clark in 1948: "We gave music regularly to the Mare Island Station. Our record shows that from June 1 to July 5 (1908) we did not miss a day in giving out music to the fleet in the Bay at the time." (41) Meneratti claims that on January 12, 1908, his ship, the *U.S.S. Ohio*, was sending out band tunes to other ships, even responding to requests, a "date he considers the beginning of broadcasting, although we didn't call it that." (42)

Another early claim of "broadcasting" by de Forest was connected to his love of opera. He had long admired this form of music, and while he realized it appealed to the upper classes who could afford the time and money with which to attend live performances, the evidence suggests that he believed that in the future even the less affluent would be exposed to opera using the wireless telephone: "It will soon be possible to distribute grand opera music from transmitters placed on the stage of the Metropolitan Opera House by a Radio Telephone station on the roof to almost any dwelling in Greater New York and vicinity. . . The same applies to large

Mazarin Sings by Wireless

"Carmen" Heard a Mile Off

Mme. Mazarin and diagram sketch showing how her songs from "Carmen" were transmitted by wireless.

2-25-1910

A. Grand Opera by wireless telephone. Mazarin singing into wireless.

B. Wireless station Metropolitan Bldg. in which Mme. Mazarin's song was heard.

Notes of Aria Carried Over Skyscrapers by Radio Sound Waves.

of this system of handbook manipulatio attaches has been gathered by The Am has been going on, an extensive trade, bookmakers, has been built up.

Exactly what the telephone employ

Reprinted from NEW YORK GLOBE and Commercial Advertiser, Jan. 8, 1910

GRAND OPERA BY TELEPHONE

The Metropolitan Will Send Music by Wireless, Beginning Next Wednesday

Grand Opera by wireless telephone from the Metropolitan Opera House will be ready within a few days. Already there is opera by the regular telephone, and during the performance of "Walküre" this afternoon telephones about town were connected with the opera house and some of the singing of Mme. Homer was heard miles away from the opera house.

That, however, was part of the wireless scheme. The apparatus for the wireless opera has already been installed back of and above the stage. For several days Lee de Forest and Mr. Turner have been at work putting in this plant, and they have about finished their work. Now there is nothing to do but to prepare the outside stations which shall receive the opera at a distance and make it possible to hear the music for miles away.

The connection will be made with several wireless stations of Mr. De Forest's system, and every performance at the Metropolitan may be heard far off. The first test will be made when on Wednesday Mme. Fremstadt sings "La Tosca."

Reprinted from NEW YORK COMMERCIAL January 14, 1910

HEAR OPERA BY WIRELESS

Novel Entertainment Feature of Dinner Aboard Royal Mail Ship Avon

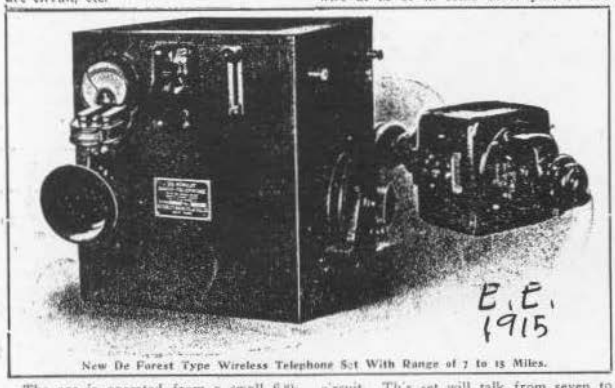
The 250 guests who attended the inspection and dinner on board the Royal Mail Steam Packet Avon last night, were entertained by the Metropolitan Opera House Co. by means of the ship's wireless apparatus and the radio telephone, during the dinner served in the main dining saloon. The guests could distinctly hear Caruso and Mme. Destinn singing on the Metropolitan Opera House stage. The opera was dispatched from the roof of the Metropolitan to the mast-head of the Avon.

Figures 26, 27: *1910 newspaper headlines about de Forest's opera broadcasts. (Clark)*

A New 100-Watt Wireless Telephone

One of the latest productions of the De Forest Radio Telephone & Telegraph Co. is a small-size wireless telephone outfit of improved type, which bids fair to find extended commercial application. The illustration shows the complete transmitting equipment, which comprises a special form of arc gap, together with heavy current microphone, regulating apparatus for the arc circuit, etc.

In the diagram here shown K is a large-size choke coil in the dynamo circuit, and a switch is indicated at S. The arc gap is placed at AG. An oscillatory circuit, of course as usual, composed of a condenser C, with inductance or helix H, is shunted across the arc gap AG. A heavy current microphone into which the words are spoken may be connected in the ground wire at M or in some other part of the

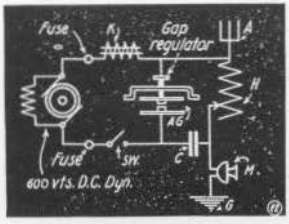


New De Forest Type Wireless Telephone Set With Range of 7 to 15 Miles.

The arc is operated from a small 600-volt D. C. dynamo, which is also shown in the illustration. This machine is driven by a gasoline engine or electric motor, whichever may be convenient.

Considerable tests have been made in the past few months of this radiophone transmitting set around New York City, and it works very well indeed. It may be said that the principal feature is the arc, and this takes place between the two platinum buttons or electrodes of small size, which are mounted on two large copper or other good heat-conducting plates. These will be observed mounted on the right-hand side of the transmitter cabinet.

A schematic diagram is given, which shows the general arrangement of these new sets, and in some of the larger sets, supplied for ship service in transmitting undamped radiotelegraphic waves, the arc is started by momentarily short-circuiting the dynamo through a large choke coil and a switch. This new set, however, is claimed to be self-starting as regards the arc, and this can be managed in several



Schematic Diagram Showing Relation of New Radiophone Apparatus.

circuit. This set will talk from seven to fifteen miles.

Figure 28. *A 1915 de Forest story introducing his latest arc radiotelephone.* (Electrical Experimenter, *1915)*

cities. Church music, lectures, etc., can be spread abroad by the Radio Telephone." (43) And so between 1907 and 1912 the press was invited to a half dozen of his opera experiments using his arc transmitter. Featuring the voices of the well-known divas Mazarin and Farrar, stories of these one time only promotional events were reported in all the major papers. (44)

Of course in later years, in the 1920s and 1930s when broadcasting was an established fact, all inventors, Charles Herrold and Lee de Forest included, reflected back on their radiotelephone work as broadcasting. But in those early years, their major purpose was to make a fortune either by finding a dependable wireless replacement for the wired telephone or an acceptable system that the Navy would use to equip their ships. Nevertheless, there is some evidence that in the early days de Forest, before the others, had ideas of how to use his radiotelephone for purposes other than two-way. Around the time of the Navy experiments, de Forest wrote, in an article about his radiotelephone, an early harbinger

Long Distant Broadcasts of Speech and Music, 1915,

by Bell System in cooperation with the Navy.

A newly developed vacuum tube transmitter installed at the Arlington, Va. Naval Radio Station was heard at: the Panama Canal Zone; Mare Island, Calif.; Pearl Harbor, Hawaii; and Paris, France. Here H.W.Everitt toots into microphone at Arlington. Phonograph in left background.

Figure 29. *De Forest's work in Palo Alto led to making his vacuum tube oscillate for this 1915 Bell System/Navy experiment in voice transmission. (Espencheid Papers)*

of what broadcasting might become: "still another feature of the invention . . . the supplying of music and other forms of entertainment to passengers traveling on the passenger vessels. A service of this kind, aided by a large receiver, so that all of the passengers gathered in a large salon could hear the music or operatic air. . . " (45)

The radiotelephone years, 1900-1920, were known more for the competing voice transmission technologies than for broadcasting. While spark was quickly rejected as too noisy and the alternator as too costly, it was the many permutations of the Poulsen arc that clearly dominated radiotelephone inventions and early broadcasting for an audience. Even today many people apparently believe that early radiotelephone science was dominated by de Forest's vacuum tube. The evidence suggests otherwise. De Forest himself was manufacturing, marketing and using an arc radiotelephone as late as 1915.(Figure 28) This was not an aberration; de Forest, Charles Herrold and all other radiotelephone inventors had between 1910 and 1916 spent countless dollars perfecting the arc as a carrier of voice and music. (Of course much of that money was spent on lawyers in attempts to somehow get around the basic Poulsen patents) It is ironic that the individual responsible for bringing the Poulsen system to America, Cyril Elwell, and the company he founded based on the Poulsen patents, Federal Telegraph, had long abandoned as impractical the use of the arc for voice and instead concentrated on high- power, long-distance arc telegraphy. Likely because of the high current demands of a microphone in an arc circuit, only low-power, limited- range arc radiotelephones were ever satisfactorily developed and employed.

By the beginning of 1916, de Forest had finally perfected his Audion for its most important task — that of an oscillator for the radiotelephone.

Figure 30. *An older Lee de Forest looks at an early version of his vacuum tube (Oscillion) radiotelephone. (Perham Foundation)*

Earlier in Palo Alto he had made his tube perform as an amplifier and sold it to the telephone company as an amplifier of transcontinental wired phone calls. —Returning to his home in New York City, by late 1916 de Forest had begun a series of experimental broadcasts from the Columbia Phonograph Laboratories on 38th Street, finally abandoning his version of the arc transmitter and using for one of the very first times his Audion as a transmitter of radio: "The radio telephone equipment consists of two large Oscillion tubes, used as generators of the high-frequency current." (46) One early broadcast received mixed reviews: "Columbia phonograph records played from the laboratory of the company at 102 West Thirty-Eighth Street were distinctly heard in the receiving room of the (Hotel) Astor, with the exception of a few interruptions by the powerful naval wireless apparatus at the Brooklyn Navy Yard, when the warning of a storm was heard intermittently with the music." (47) One month later, de Forest told a *New York Sun* reporter that he, using a 'wave length' of 800 meters, "will be setting another record by giving the first public concert by wireless in history." (48)

A few months later, de Forest moved his tube transmitter to High Bridge, New York, where one of the most publicized pre-WWI broadcasting events took place. Just like Pittsburgh's KDKA would attempt exactly four years later in 1920, de Forest used the most public of events for his broadcast.

650 THE ELECTRICAL EXPERIMENTER January, 1917

RADIO DEPARTMENT

Election Returns Flashed by Radio to 7,000 Amateurs

SEVEN thousand wireless telephone operators within a radius of 200 miles of New York City received election returns from the *New York American*. Three hundred and fifty moving-picture theaters; special bulletin boards in different parts of the city, and the principal hotels of Manhattan obtained the news from the above office, as fast as it was received. Fifty extra telephone lines were run into the *American* office, the theaters were placed on lines that were in continuous operation, and while the news of the closest Presidential election in years was being given to the public thru these channels, the editorial staff compiled the returns without the slightest confusion.

When the returns came in, indicating the election of Hughes, and the first edition was prepared for press at 11 p.m., the heads and the reading matter inclined that way. Later there was a change, a doubt was cast, and then the tide drifted Wilsonward. It ebbed and flowed, from one candidate to the other, for several hours. Thru the clearing house all outlying district information was gathered, in an effort to sweep aside the uncertainty. Then the headings, which were studies in clarity and terseness, were altered, the introductions and summaries were changed, and Wilson was featured as the winner. The wireless-telephony feature was remarkable. The 7,000 amateur radio operators were all notified in advance, and the news was supplied in the most systematic manner, thru the circulation department, by an expert from the editorial rooms, who took his bulletins from the same source as the fifty operators who supplied the moving-picture shows, hotels, and bulletin-board operators.

Realizing that all men cannot grasp a spoken message alike, or in the same time, and because it was impossible to stop and answer questions, a black-board was erected, in view of all the operators. The bulletins were written on this and reading from it, the operators telephoned the news to the different points. In the picture theaters the messages were transmitted to slides and flashed on the screen.

The amateur wireless operators located in different towns about New York gave out the information, and allowed others to *listen in*. They heard not only election returns, but music as well.

Over their heads, reaching from that droning desk in the *New York American's* office to the white bulletin boards on which their eyes were fastened, a vast network of electrical waves were meshing and passing. On these unseen waves the news they sought was carried.

From the deep semi-circular desk the news had been flung by telephone to the de Forest Wireless Telephone Laboratories at Highbridge on the Harlem River. Up in the de Forest tower sat Walter Schare, an unassuming chap, who listened thru a receiver clamped to his ear.

At Schare's hand was the wireless telephone transmitter switch. As he heard the news from the seventh floor of the great red building near Brooklyn Bridge he snapt it forth to 7,000 anxious amateur wireless operators within that great 400-mile circle.

Between the bulletins, music was sent thru the clouds. The crowds heard "The Star Spangled Banner," "Dixie," "Columbia, the Gem of the Ocean," "America," "Maryland," "Yankee Doodle" and all the other anthems, songs and hymns that Americans love.

The radiophone equipment consists of two large Oscillion tubes, used as the generators of the high frequency current, which may be seen on the panel. They develop one-half kilowatt of energy and this charges the antenna. The high potential current is obtained fro volt direct current generator, d constant speed motor. This high fr rent is controlled by suitable rheostats and shunted with capacities so as to reduce the inductive reactance as much as possible in the oscillating current. The filaments are lighted by 110 volt direct current. The oscillating circuit comprises a number of capacities and inductances properly balanced in the circuit. The voice-current modulations are derived from a microphone, inductively coupled to the high frequency circuit. Another microphone connected in parallel with the first by a switch, is used in conjunction with a phonograph. The operator standing near the microphone is Charles Logwood, chief engineer to Dr. de Forest, and a great deal of credit is due him in the development of the radiophone employing the Oscillion tube as a generator of radio frequency currents.

Dr. Lee de Forest gave a demonstration of transmitting music by wireless at the Hotel Astor New York, on the evening

How the "Election Returns" Gathered by the "New York American" Were Spread Broadcast to 7,000 Waiting Amateurs by Wireless Telephone From the de Forest Laboratory Near New York.

AIR WILL BE FULL OF MUSIC TO-NIGHT 11-6-16

First of Series of Wireless Concerts to Be Given by Lee De Forest.

From Toots Paka on the west to Tschaikowsky on the east and from "Die Walkure" to the "Kangaroo Hop," the bull fiddles and the slip horns and the inevitable ukelele will throb to-night through the hot air which has settled over the Atlantic seaboard since the campaign began.

For to-night's the night that Lee De Forest, inventor, working hand in hand with the Columbia Graphophone Company, will begin a series of wireless telephone concerts with the aid of graphophone discs supplied by the Columbia firm and the wireless telephone apparatus invented by Dr. De Forest. Within a radius of 200 miles of Manhattan the 2,000—or 2,000,000,000, or whatever the number is—owners of amateur wireless plants may tune in and listen to the band and the singers tum-te-tumming across the ether.

Dr. De Forest and the Columbia firm gave a wireless telephone concert at the Hotel Astor a week ago last Thursday, the music being sent by wireless from the roof of the Columbia firm's manufacturing plant in West Thirty-eighth street to telephone receivers in the Astor. That was the first wireless concert in history, but it was a semi-private affair. When Old Bill Bailey starts to twang his ukelele to-night, however, the ukelele—plus the bull fiddles and slip-horns and vocal bulabaloneys—will be setting another record by giving the first public concert by wireless in history.

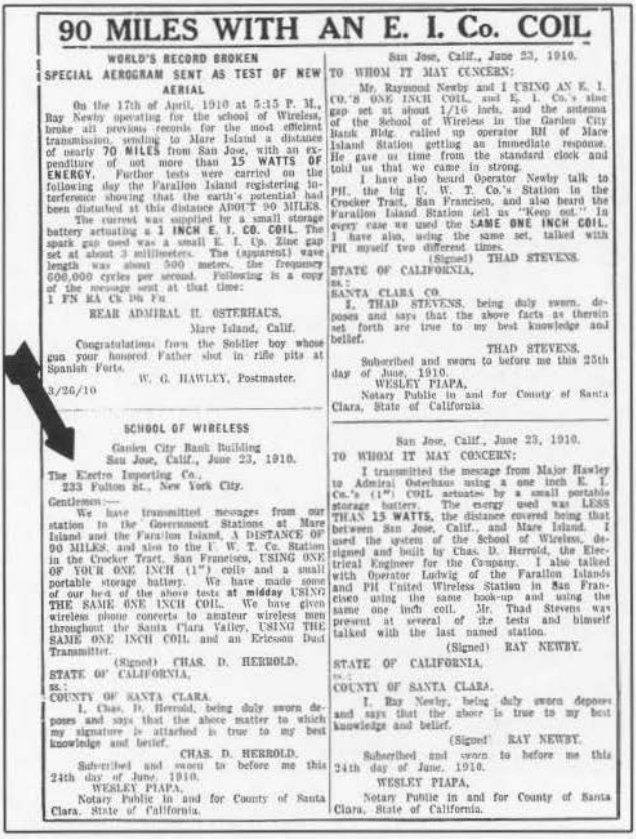
Figures 31, 32. *News stories of de Forest's High Bridge transmissions, 1916. (NY Times, November 6, 1916 and Electrical Experimenter, January 1917)*

This time it was the Hughes-Wilson presidential election of November, 1916: "The *New York American* installed a private wire and bulletins were sent out every hour." (49) This time the listener reports were more positive: "Seven thousand wireless telephone operators withing a radius of 200 miles of New York City received election returns from the *New York American*. They heard not only election returns, but music as well. Between the bulletins, music was sent thru the clouds. The crowds heard 'The Star-Spangled Banner,' 'Dixie,' 'Columbia, Gem of the Ocean,' 'America,' 'Maryland,' 'Yankee Doodle' and all the other anthems, songs and hymns that American's love." (50) Because it happened in New York, was listened to by a large audience, and received so much press attention, it was

one of the single most important pre-World War I events in radio broadcasting. (Figures 31,32)

Years later, de Forest wrote to Charles Herrold about how he saw the art and science of broadcasting in 1916. He discussed both his and Herrold's early experiments in the context of the vacuum tube: "Until the 3-electrode tube had been developed sufficiently to serve as a reliable oscillator for radio telephone purposes, and the audion amplifier could be used at the receiver in connection with the detector, those early efforts at radio broadcasting were necessarily unsatisfactory. In 1916, after we had learned how to build 'Oscillion' tubes of 50 to 100 watts power, I began a regular nightly broadcasting service from my station at High Bridge, NY. This service was regularly maintained until the federal government caused a suspension of all non-military radio communications shortly before our nation entered the European War." (51) Were it not for the Great War and the closing down of all non essential, non defense uses of radio, de Forest, already exciting small audiences with interesting, entertaining and informing broadcasting, might have succeeded with this new service four years ahead of KDKA.

After the war Lee de Forest was anxious to return to the air. After his near-success in 1916, he was prepared to broadcast again. De Forest later told Herrold: "I resumed these operations in December, 1919, as soon as the governmental ban was lifted. The U.S. Federal Inspector in New York clamped down on me in February, 1920, however, acting on the technicality that I had voided my license by moving my station downtown without his authorization. Whereupon I promptly moved the High Bridge transmitter to San Francisco and installed it in the wings of the California Theatre, running my antenna up to the roof of the bank tower next door. This station was maintained in daily operation, broadcasting the orchestra music of the Weber Orchestra in the theater. In the fall of that year the station was moved over to Berkeley, where it was maintained in operation for perhaps a year." (52) In 1929 de Forest remembered the day that the radio inspector first shut down his post-war New York operation: "Then the Federal inspector (Arthur Batcheller) in New York, taking advantage of the technical fault that I had moved my station from High bridge downtown, peremptorily closed the service after a few weeks, with the definite statement that program broadcasting for entertainment had no place, no legitimate place, in the ether, and should be terminated, and he terminated it." (53) Beginning with his arc telephone experiments for the Navy and his transmissions of opera music, and ending with his radio stations at High Bridge in 1916 and San Francisco in 1920, the evidence strongly suggests that Lee de Forest, more than any other individual entered in the race for radiotelephone, saw a potential for voice transmission beyond just a wireless replacement for two-way communication.



90 MILES WITH AN E. I. Co. COIL

WORLD'S RECORD BROKEN
SPECIAL AEROGRAM SENT AS TEST OF NEW AERIAL

On the 17th of April, 1910 at 5:35 P. M., Ray Newby operating for the school of Wireless, broke all previous records for the most efficient transmission, sending to Mare Island a distance of nearly **90 MILES** from San Jose, with an expenditure of not more than **15 WATTS OF ENERGY.** Further tests were carried on the following day the Farallon Island registering interference showing that the earth's potential had been disturbed at this distance ABOUT 90 MILES.

The current was supplied by a small storage battery actuating a **1 INCH E. I. CO. COIL.** The spark gap used was a small E. I. Co. Zinc gap set at about 3 millimeters. The (apparent) wave length was about 500 meters, the frequency 600,000 cycles per second. Following is a copy of the message sent at that time:

1 FN RA CK DG Fu

REAR ADMIRAL H. OSTERHAUS,
Mare Island, Calif.

Congratulations from the Soldier boy whose gun your honored Father shot in rifle pits at Spanish Forts.

W. G. HAWLEY, Postmaster.

3/26/10

SCHOOL OF WIRELESS

Garden City Bank Building
San Jose, Calif., June 23, 1910.

The Electro Importing Co.,
233 Fulton st., New York City.

Gentlemen:—

We have transmitted messages from our station to the Government Stations at Mare Island and the Farallon Island, A DISTANCE OF 90 MILES, and also to the U. W. T. Co. Station in the Crocker Tract, San Francisco, USING ONE OF YOUR ONE INCH (1") coils and a small portable storage battery. We have made some of our best of the above tests **at midday** USING THE SAME ONE INCH COIL. We have given wireless phone concerts to amateur wireless men throughout the Santa Clara Valley, USING THE SAME ONE INCH COIL and an Ericsson Dust Transmitter.

(Signed) CHAS. D. HERROLD.

STATE OF CALIFORNIA,
ss.:
COUNTY OF SANTA CLARA.

I, Chas. D. Herrold, being duly sworn deposes and says that the above matter to which my signature is attached is true to my best knowledge and belief.

CHAS. D. HERROLD.

Subscribed and sworn to before me this 24th day of June, 1910.

WESLEY PIAPA,
Notary Public in and for County of Santa Clara, State of California.

San Jose, Calif., June 23, 1910.

TO WHOM IT MAY CONCERN:

Mr. Raymond Newby and I USING AN E. I. CO.'S ONE INCH COIL, and E. I. Co.'s zinc gap set at about 1/16 inch, and the antenna of the School of Wireless in the Garden City Bank Bldg. called up operator RH of Mare Island Station getting an immediate response. He gave us time from the standard clock and told us that we came in strong.

I have also heard Operator Newby talk to PH, the big U. W. T. Co.'s Station in the Crocker Tract, San Francisco, and also heard the Farallon Island Station tell us "Keep out." In every case we used the **SAME ONE INCH COIL.** I have also, using the same set, talked with PH myself two different times.

(Signed) THAD STEVENS.

STATE OF CALIFORNIA,
ss.:
SANTA CLARA CO.

I, THAD STEVENS, being duly sworn, deposes and says that the above facts as therein set forth are true to my best knowledge and belief.

THAD STEVENS.

Subscribed and sworn to before me this 25th day of June, 1910.

WESLEY PIAPA,
Notary Public in and for County of Santa Clara, State of California.

San Jose, Calif., June 23, 1910.

TO WHOM IT MAY CONCERN:

I transmitted the message from Major Hawley to Admiral Osterhaus using a one inch E. I. Co.'s (1") COIL actuated by a small portable storage battery. The energy used was LESS THAN 15 WATTS, the distance covered being that between San Jose, Calif., and Mare Island. I used the system of the School of Wireless, designed and built by Chas. D. Herrold, the Electrical Engineer for the Company. I also talked with Operator Ludwig of the Farallon Islands and PH United Wireless Station in San Francisco using the same hook-up and using the same one inch coil. Mr. Thad Stevens was present at several of the tests and himself talked with the last named station.

(Signed) RAY NEWBY.

STATE OF CALIFORNIA,
ss.:
COUNTY OF SANTA CLARA.

I, Ray Newby, being duly sworn deposes and says that the above is true to my best knowledge and belief.

(Signed) RAY NEWBY.

Subscribed and sworn to before me this 24th day of June, 1910.

WESLEY PIAPA,
Notary Public in and for County of Santa Clara, State of California.

Figure 33. *Ad from Electro-Importing Catalogue, 1910 telling of Herrold's "wireless phone concerts for amateur men throught the Santa Clara Valley." (EI)*

CHARLES HERROLD BROADCASTS ENTERTAINMENT PROGRAMMING

"By modern broadcasting is understood a radio intelligence that is sent out at a certain pre-determined schedule or program," so wrote radio publications pioneer Hugo Gernsback in *Radio for All*. (54) Later, RCA historian George Clark suggested that in order to qualify as a broadcaster you had to have scheduled, pre-announced, publicly advertised programs, but you also had to reach a "citizen audience," which he defined as people who were not experimenters or hobbyists. (55) By 1912 Charles Herrold of San Jose, California was announcing his regularly-scheduled programs in the local newspapers and while important, these announcements were actually preceded by several years by one of the few very early printed

Figure 34. *Young Charles and his telescope. (Herrold Papers)*

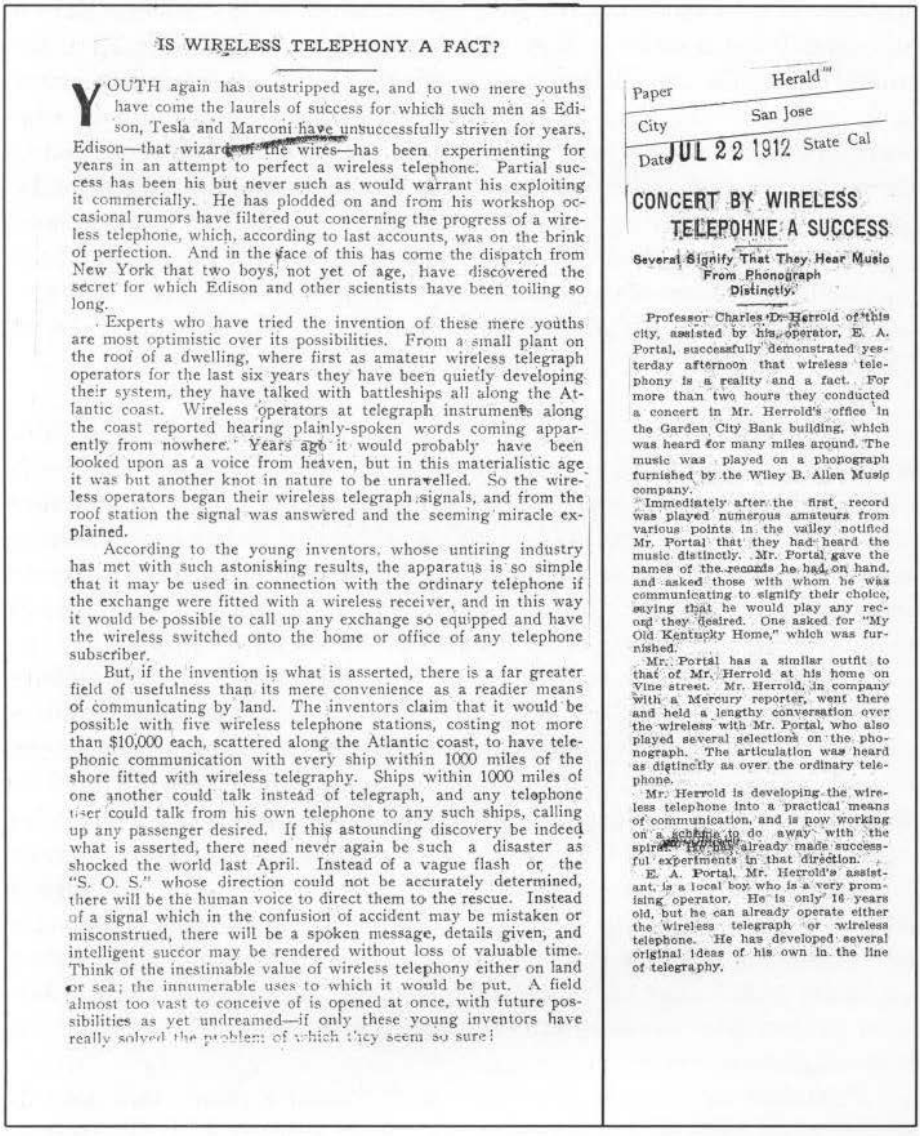
references to the activities of broadcasting to an audience. Likely an important "smoking gun" of intentional broadcasting, it was this 1910 notarized statement by Herrold, "We have been giving wireless phonograph concerts to amateur men in the Santa Clara Valley" that appeared in an early 1910 New York publication of the Electro-Importing Company. (56) To this researcher, it qualifies as the earliest and most prophetic statement in the national public record descriptive of what broadcasting was to become. Not Fessenden, not de Forest, not anyone else engaged in wireless telephony was saying about their work anything close to what Herrold was saying. And while Herrold's 1910 listeners could hardly be considered a citizen audience, he changed all that when he broadcast daily to audiences at the 1915 San Francisco World's Fair. (Figure 33)

Charles Herrold's contributions to the technology of the radiotelephone years and the art of what was to be broadcasting were in the beginning derivative and accidental and finally, purposeful. As an inventor of a transmitting system he called an "arc fone," he spent years attempting to differentiate his system from that of Poulsen's. Herrold received a total of six U.S. patents for his devices, patents that certainly would have been challenged by the Poulsen people were it not for the fact that by 1917 the perfection of the vacuum tube as the basis of all future radiotelephones

made such arc-based devices obsolete. Nevertheless, by 1912 Charles Herrold had established a radio station. He was programming information and entertainment for an audience on a regular schedule, often pre-announced in the newspapers. That he may have accidentally stumbled onto what was certainly radio broadcasting might have been a function of his role as the proprietor and headmaster of a wireless trade school. Given the responsibility of providing daily technical activities for hundreds of eager young boys, it is my belief that the broadcasting of the popular music of the day by his students to an audience of their friends, families and possible future students was the cauldron from which broadcasting emerged, Charles Herrold style.

Charles David Herrold was born in 1875 in Fulton, Illinois on the Mississippi River. In 1888 the family moved to rural San Jose, California where William Herrold became a successful farmer. Charles attended high school between 1891 and 1894 and it was there that he began to be recognized by his teachers and classmates for his superior grasp of mechanical and scientific subjects. He constructed telescopes and microscopes and excelled in photography. After graduation he attended Stanford University in nearby Palo Alto, but after three years he dropped out for unidentified health reasons. In 1900 Herrold set up an electrical manufacturing company in San Francisco, and when the 1906 Great Earthquake destroyed his work and possessions, he moved to the Central California town of Stockton to teach at a small college that specialized in electricity. (57) Both his work as an inventor and his experience with students led Herrold to return to his family in San Jose and open his own school. The Herrold College of Wireless and Engineering was to be a way to provide an income and at the same time provide him with the classroom and laboratory environment necessary to continue his inventing. This was in 1909 and Herrold was most interested in inventing a radiotelephone system that would make him rich and famous.

Published reports and interviews with former students indicate that beginning in 1909 there was music and voice coming from the Herrold College daily. As the earlier reference in the 1910 Electro Importing Catalogue suggests, "wireless concerts for amateur men" were an accomplished fact. By 1912 Charles Herrold was broadcasting to a sizeable audience: "It was a religion for 'Prof' Herrold to have his equipment ready every Wednesday night at nine o'clock. He would have his records ready, all laid out, and what he wanted to say. And the public or listeners, it became a habit for them to wait for it." (58) Herrold's assistant Ray Newby remembered what contemporary historians now believe to be the first regularly scheduled radio broadcasts of entertainment programming for an audience. (59, 60, 61, 62, 63) Said Newby, "We even had a San Jose music store that



IS WIRELESS TELEPHONY A FACT?

YOUTH again has outstripped age, and to two mere youths have come the laurels of success for which such men as Edison, Tesla and Marconi have unsuccessfully striven for years. Edison—that wizard of the wires—has been experimenting for years in an attempt to perfect a wireless telephone. Partial success has been his but never such as would warrant his exploiting it commercially. He has plodded on and from his workshop occasional rumors have filtered out concerning the progress of a wireless telephone, which, according to last accounts, was on the brink of perfection. And in the face of this has come the dispatch from New York that two boys, not yet of age, have discovered the secret for which Edison and other scientists have been toiling so long.

Experts who have tried the invention of these mere youths are most optimistic over its possibilities. From a small plant on the roof of a dwelling, where first as amateur wireless telegraph operators for the last six years they have been quietly developing their system, they have talked with battleships all along the Atlantic coast. Wireless operators at telegraph instruments along the coast reported hearing plainly-spoken words coming apparently from nowhere. Years ago it would probably have been looked upon as a voice from heaven, but in this materialistic age it was but another knot in nature to be unravelled. So the wireless operators began their wireless telegraph signals, and from the roof station the signal was answered and the seeming miracle explained.

According to the young inventors, whose untiring industry has met with such astonishing results, the apparatus is so simple that it may be used in connection with the ordinary telephone if the exchange were fitted with a wireless receiver, and in this way it would be possible to call up any exchange so equipped and have the wireless switched onto the home or office of any telephone subscriber.

But, if the invention is what is asserted, there is a far greater field of usefulness than its mere convenience as a readier means of communicating by land. The inventors claim that it would be possible with five wireless telephone stations, costing not more than $10,000 each, scattered along the Atlantic coast, to have telephonic communication with every ship within 1000 miles of the shore fitted with wireless telegraphy. Ships within 1000 miles of one another could talk instead of telegraph, and any telephone user could talk from his own telephone to any such ships, calling up any passenger desired. If this astounding discovery be indeed what is asserted, there need never again be such a disaster as shocked the world last April. Instead of a vague flash or the "S. O. S." whose direction could not be accurately determined, there will be the human voice to direct them to the rescue. Instead of a signal which in the confusion of accident may be mistaken or misconstrued, there will be a spoken message, details given, and intelligent succor may be rendered without loss of valuable time. Think of the inestimable value of wireless telephony either on land or sea; the innumerable uses to which it would be put. A field almost too vast to conceive of is opened at once, with future possibilities as yet undreamed—if only these young inventors have really solved the problem of which they seem so sure!

Paper Herald
City San Jose
Date JUL 22 1912 State Cal

CONCERT BY WIRELESS TELEPHONE A SUCCESS

Several Signify That They Hear Music From Phonograph Distinctly.

Professor Charles D. Herrold of this city, assisted by his operator, E. A. Portal, successfully demonstrated yesterday afternoon that wireless telephony is a reality and a fact. For more than two hours they conducted a concert in Mr. Herrold's office in the Garden City Bank building, which was heard for many miles around. The music was played on a phonograph furnished by the Wiley B. Allen Music company.

Immediately after the first record was played numerous amateurs from various points in the valley notified Mr. Portal that they had heard the music distinctly. Mr. Portal gave the names of the records he had on hand, and asked those with whom he was communicating to signify their choice, saying that he would play any record they desired. One asked for "My Old Kentucky Home," which was furnished.

Mr. Portal has a similar outfit to that of Mr. Herrold at his home on Vine street. Mr. Herrold, in company with a Mercury reporter, went there and held a lengthy conversation over the wireless with Mr. Portal, who also played several selections on the phonograph. The articulation was heard as distinctly as over the ordinary telephone.

Mr. Herrold is developing the wireless telephone into a practical means of communication, and is now working on a scheme to do away with the spirals. He has already made successful experiments in that direction.

E. A. Portal, Mr. Herrold's assistant, is a local boy who is a very promising operator. He is only 16 years old, but he can already operate either the wireless telegraph or wireless telephone. He has developed several original ideas of his own in the line of telegraphy.

Figure 35. *A July 8, 1912 editorial from the* San Jose Mercury- Herald.
Figure 36. *A July 22, 1912 story from the* San Jose Mercury-Herald *"Concert by Wireless Telephone a Success" tells of a Herrold broadcast.*

supplied us records, of course free of charge, and I think we played them all. We would take the *Mercury*, I believe it was the *Mercury-Herald* in San Jose, and we would read headlines and discuss them a little bit, just something to yak about and make it interesting at the same time, to develop an audience, I would say." (64) The major significance of Herrold is that he, before anyone else, began the transmission of regularly scheduled

programs of entertainment and information for an audience. He started a radio station.

But no one, not even Herrold, simply woke up one morning in 1912 and said: "Let's broadcast to the public." It happened much more gradually than that, so slowly that even a major San Jose newspaper failed to see its significance. The press, like most of the public, still saw the radiotelephone's importance as that of a replacement for the wired telephone. Two July, 1912 stories in the local *San Jose Mercury-Herald* illustrated both the public's confusion and perception of "broadcasting," and demonstrated why most at that time didn't see the future of the wireless telephone in the way that Charles Herrold did. In a July 8, 1912 editorial, the subject was the potential commercial use of the wireless telephone for two-way communication: "It would be possible with five wireless telephone stations, costing not more than $10,000 each, scattered along the Atlantic coast, to have telephone communication with every ship within 1000 miles of the shore. If this astounding discovery be indeed what is asserted, there need never again be such a disaster as shocked the world last April" (65) Obviously, it was the sinking of the *Titanic*, with its great loss of life, that set the immediate agenda for the new invention.

But it was in another article in the same daily paper two weeks later (66) where you can see that Charles Herrold saw his wireless telephone in a different light. Herrold and assistant Emil Portal demonstrated for the reporter: "For more than two hours they conducted a concert in Mr. Herrold's office in the Garden City Bank building, which was heard for many miles around. The music was played on a phonograph furnished by the Wiley B. Allen Music company. Immediately after the first record was played numerous amateurs from various points in the valley notified Mr. Portal that they had heard the music distinctly. Mr. Portal gave the names of the records he had on hand and asked those listening to signify their choice. One asked for 'My Old Kentucky Home,' which was furnished." (67) It was broadcasting, much in the same way Herrold had been describing it since 1910. Sure, there was no doubt that Herrold's main motive paralleled that described in the earlier editorial; to invent a successful system of two-way radiotelephony and thereby profit from its manufacture. As an inventor that was Herrold's business, and the regular broadcast of music and talk was a way to test his system. Years later, Herrold said that it was from those daily experiments that regular broadcasts designed to entertain rather than test evolved: "Broadcasting was an obsession with us and certainly, the entire Pacific Coast looked upon the radio broadcasts from San Jose as an established institution." (68)

Closer to the action was Ray Newby. Appearing as a guest on the 1950s television show, "What's My Line," he signed in as the "World's First Disc Jockey." Later he described for Herrold biographer Gordon

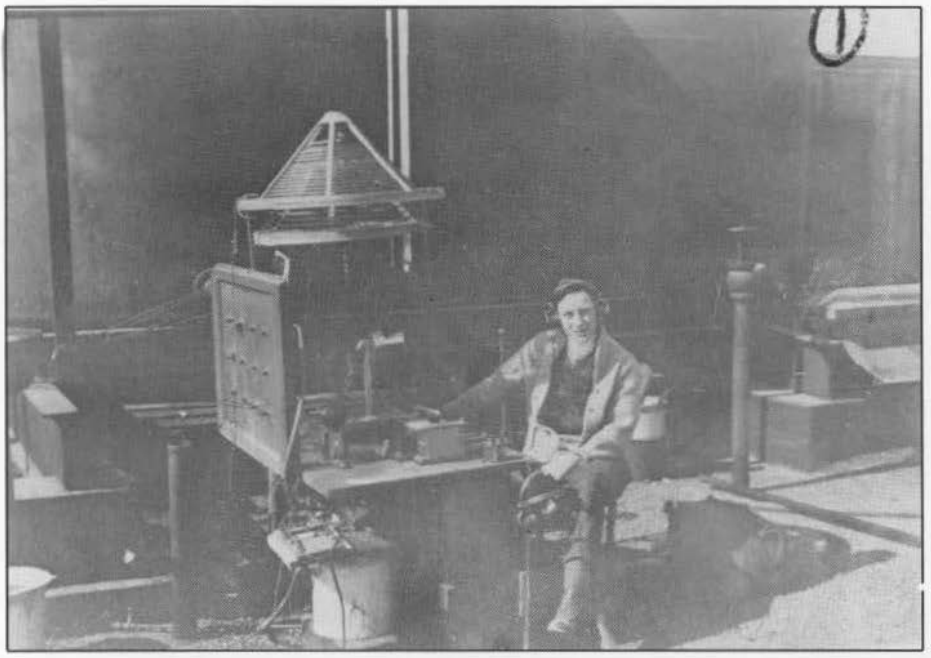


Figure 37. *Herrold assistant Emil Portal at an early arc radiotelephone at the Herrold College. (Perham Foundation)*

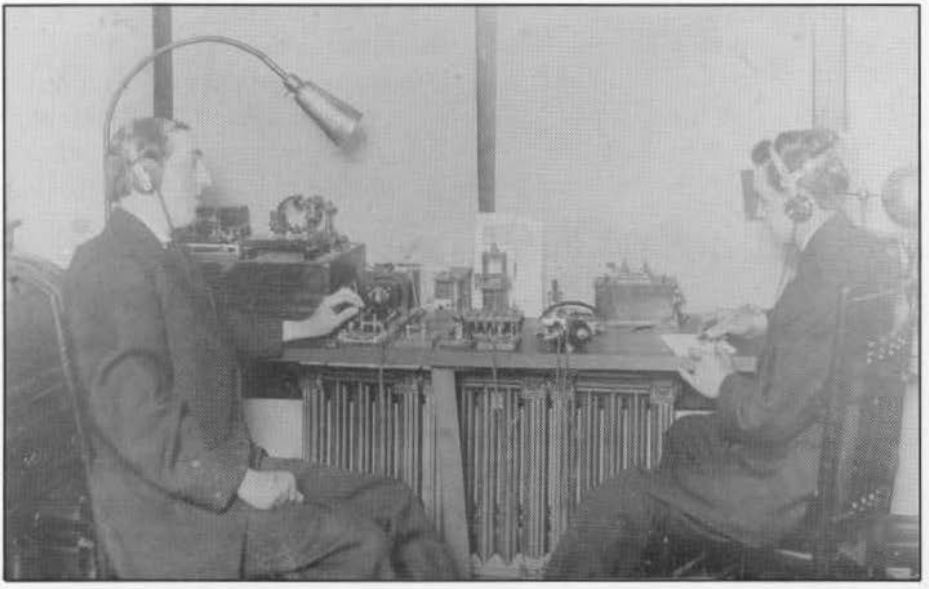


Figure 38. *Herrold and Newby, 1909, with early spark apparatus. (Herrold Papers)*

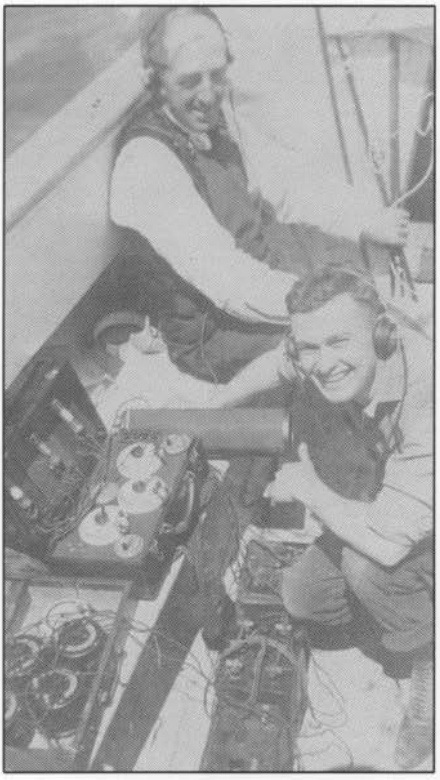


Figure 39. *Herrold and a student experiment with wireless, 1910.*

Greb a typical 1912 broadcast: "In general we would just ad lib and play a record like you would today, more or less. We would read the newspaper headlines and carry on with whatever came into the mind that you would think would be important. We had the old Caruso records. We did use an Edison once but it didn't have a hard needle. Many a time we'd sing with the records at the old bank building. We had musical instruments come in, such as a harp, we had a lady play a harp one time and she was a little disturbed by the proximity of the microphone. She was afraid of the thing." (69)

And who did Newby understand his early audience to be? "The listeners were all amateurs who had crystal detectors listening to ships or codes or whatever they could learn and read and find and they were startled to find music coming in on their ears. Oh, they'd call us right up and say put on such and such a record, or play it over and over, certain ones they liked better. And we had callers coming in from around San Jose, even as far as San Francisco. We had listeners within, I'd say, at that time, even in the earliest arc days, it was heard as far away as 900 miles but under very favorable conditions. We had listeners all over the Bay Area." (70)

Obscured by his broadcasting claims is the fact that Herrold received a half dozen patents for his arc transmitter. Like most radiotelephone inventors between 1910 and 1916, Herrold and his attorneys, in an attempt to get around the American Poulsen arc system patents, had designed a system just different enough to get government recognition. It is believed that if the arc had become <u>the</u> technology of the radiotelephone, Herrold and other arc experimenters would have certainly met the Poulsen forces in court. And lost. One area in Herrold's patent applications in which he was trying to differentiate his system from that of Poulsen was in the elimination of the magnetic field. Poulsen's arc needed to operate in such a field so that high-power, long-distance wireless telephone could be possible. Arc

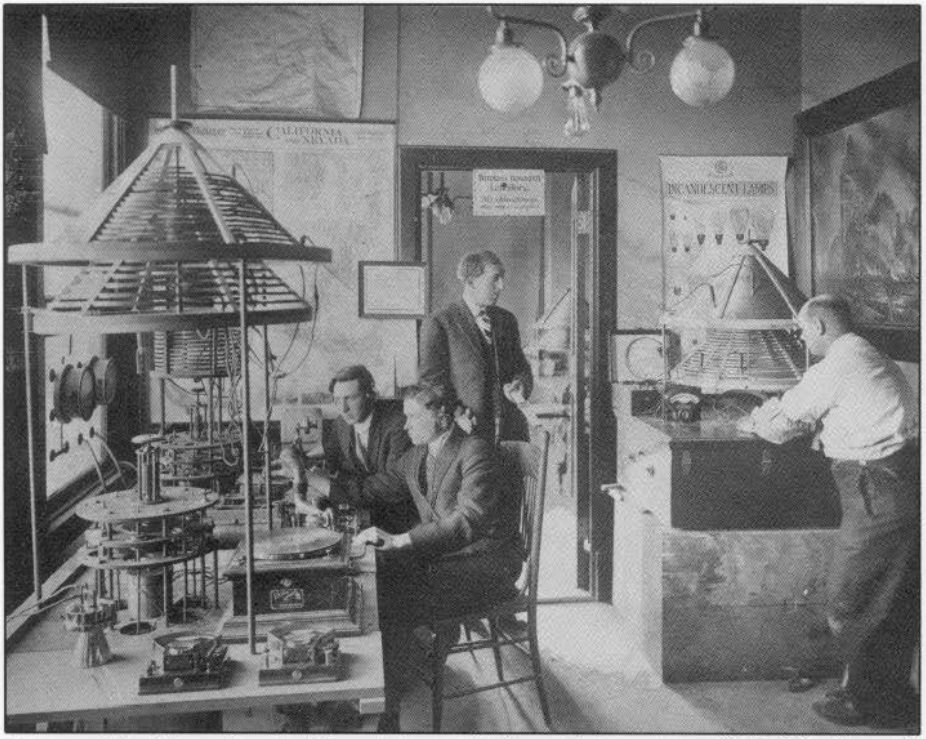


Figure 40. *The classic Herrold arc station photo, circa 1912-14; Herrold standing in the doorway; at right is "mechanician" Frank Schmidt; at microphone, left, Emil Portal; right, Ken Sanders. Portal and Sanders began as Herrold's students.*

technology expert William J. Byron was asked to examine Herrold patents and documents: "Herrold uses no magnetic field, but he does use alcohol in the arc chamber. They will operate at low powers (no more than 10 or 20 watts) without the field, and that's one of the reasons Herrold's arc worked . . . I suspect that Herrold was trying to avoid the difficulties of providing a field in the area of the arc – not to mention infringement of innumerable patents covering the field; the era virtually exploded with patent suits, involving everyone, including Marconi." (71) And the Herrold patent for his distinctively-shaped conical helix coils would have likely been in trouble: "If Herrold were to try to manufacture and sell his system he would have come face-to-face with Marconi's patent on the secondary coupling system; Herrold's 'Conical" coils. It was patented in 1898, British patent number 7777, hence the description 'the four-sevens patent.' The conical shape really had nothing to do with the physics of the device. Marconi's patent would have put him out of business." (72)

The Herrold technology is best seen rather than described. Both the patents and the pieces that made up his "arc fone" are presented here in this series of photographs and drawings. Nearly all radiotelephone inventors,

de Forest included, used some form of an arc fired by 200-500 volts DC, in series with inductors. A water-cooled microphone was typically in the ground circuit of the secondary of the antenna coupling coils. Here is the entire Herrold system, the patents and the actual devices, a system representative of the type of arc systems used by practically every inventor during the two decades of radiotelephone development. (Figures 40-55)

Having invented, tested and improved his "arc fone" between 1912 and 1917, Herrold began to patent the various versions of the pieces that made up his system of radiotelephony.

Science and invention was not Herrold's legacy. It was the sending of regularly-scheduled entertainment programs designed specifically for a public audience that defined Herrold. There were two events, the 1912-1917 weekly "Little Hams Program," and the 1915 daily broadcasts to the public receiving stations at the Panama Pacific International Exhibition in San Francisco. According to former students, Herrold believed that after a week of hard work spent on invention and study, both the students and the audience were entitled to some fun: "Every Wednesday night at nine o'clock he would be on because he knew he had fifty or more listeners with crystal detectors to report to him. They'd call up on the phone and ask for records. They'd request or call in or ask what records we had and also we'd yakity yak and sing. I used to sing on it myself. (chuckle) And news. We'd give out news from the *Mercury-Herald*." (73) Eventually, Herrold, Newby and the students were joined by Herrold's young wife Sybil: "I really believe that I was the first woman to ever broadcast a program. We used to get cards from the little hams asking us to play after we started playing the records for their little programs on Wednesday nights. And I went to Sherman-Clay (a San Jose music store) and arranged to borrow records from them at no cost but just for the sake of advertising these records to these young operators with their little galena sets. And we would play the up-to-date young people's records and they would run down the next day and be sure to buy the one they heard on the radio the night before." (74) (Figure 56)

While the Wednesday night programs were true "local radio," with an audience of mostly young experimenters, it was at another event, known the world over, that the Herrold broadcasting apparatus was placed into service to entertain what probably was their largest audience ever. The 1915 Panama Pacific International Exhibition (PPIE), held in San Francisco, was designed to celebrate the opening of the Panama Canal. Billed as a "World's Fair," the PPIE featured the very latest technology. Newspapers from all over the country began announcing in 1914 some of the big names in wireless expected to attend and present at the event: "William Marconi, the wireless inventor, announced today that he had decided to participate in the Italian section of the Panama Pacific International

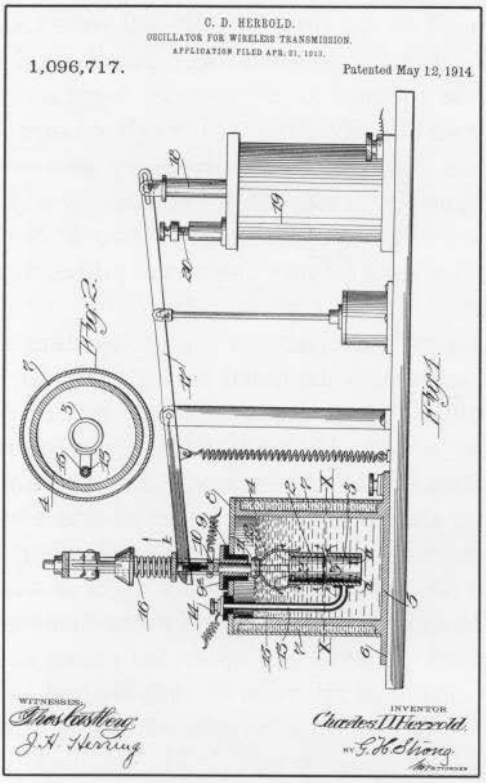


Figure 41. *"Oscillator for Wireless Telephone," filed April 1913, patented May 1914.*

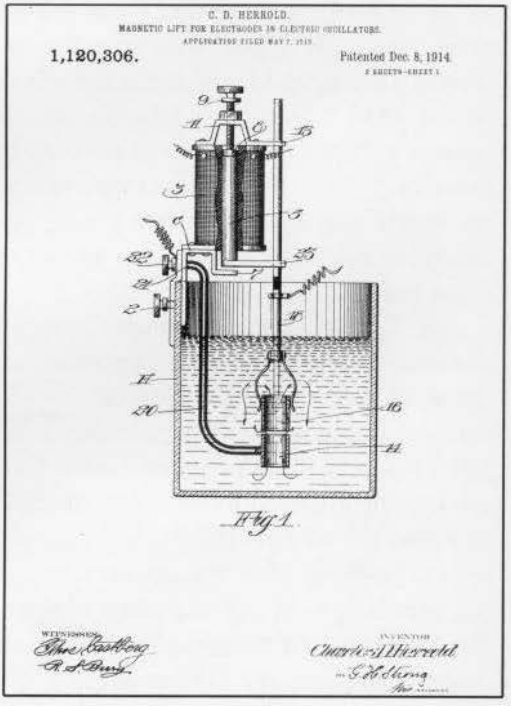


Figure 42. *"Magnetic Lift for Electrodes in Electric Oscillators," filed May 1913, patented December 1914.*

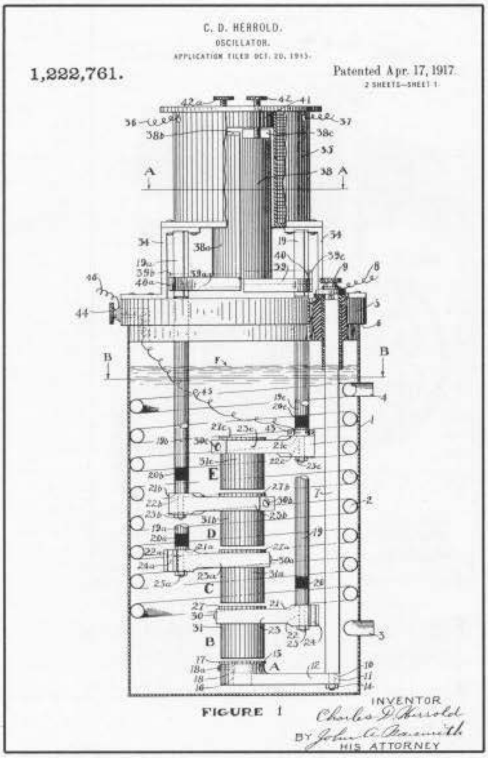


Figure 43. *"Oscillator," filed October 1915, patented April 1917.*

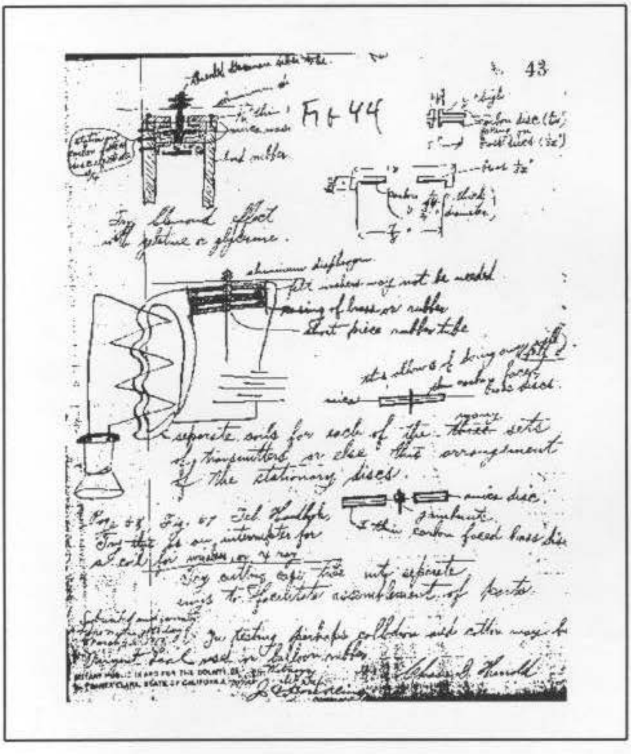
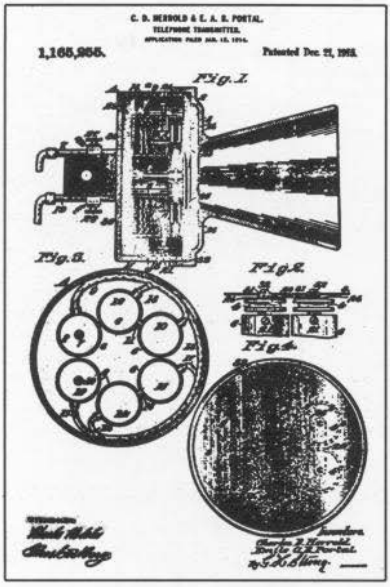


Figure 44. *Original notarized drawings for Herrold "Telephone Transmitter" microphone, 1913.*



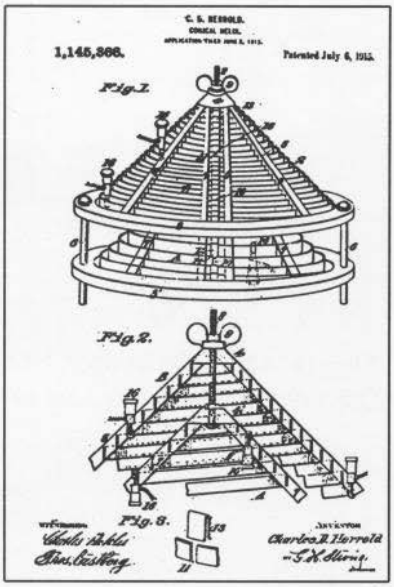
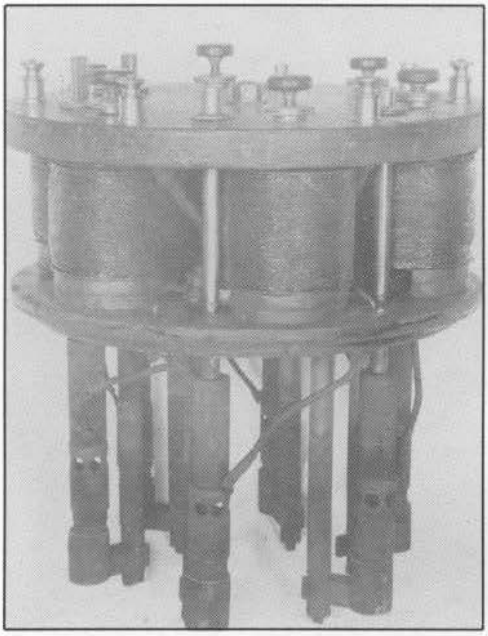


Figure 45. *"Telephone Transmitter," filed January 1914, patented December 1915.*
Figure 46. *"Conical Helix," filed June 1913, patented July 1915.*



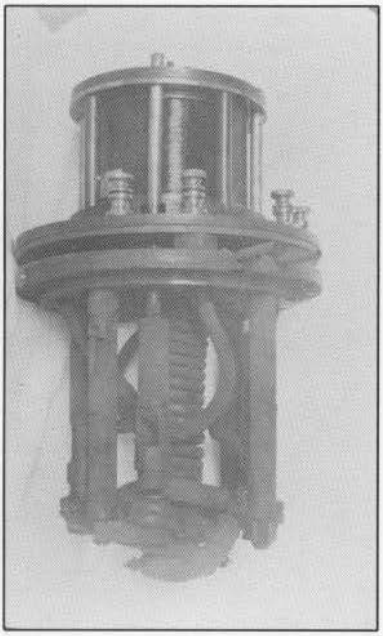
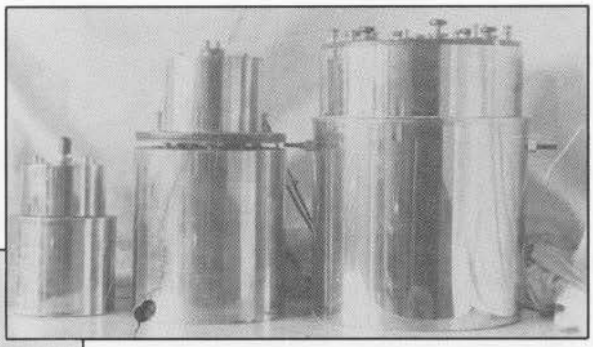


Figure 47. *Oscillator with six arcs and magnetic lift, version 1.*
Figure 48. *Oscillator with six arcs and magnetic lift, version 2.*



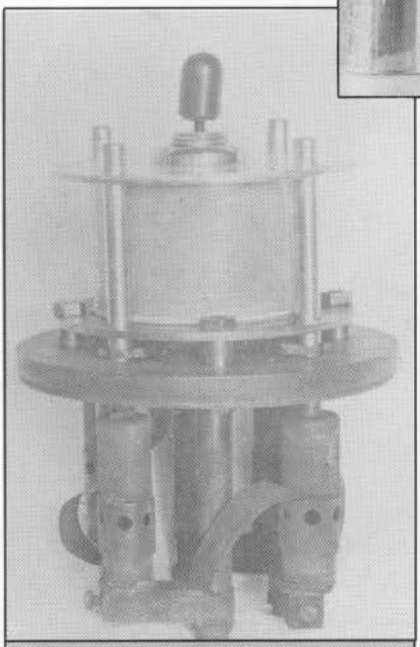


Figure 49. *(left) Oscillator with four arcs and magnetic lift.*
Figure 50. *(above) The above arcs in metal cans for submersion under alcohol, three sizes/versions.*

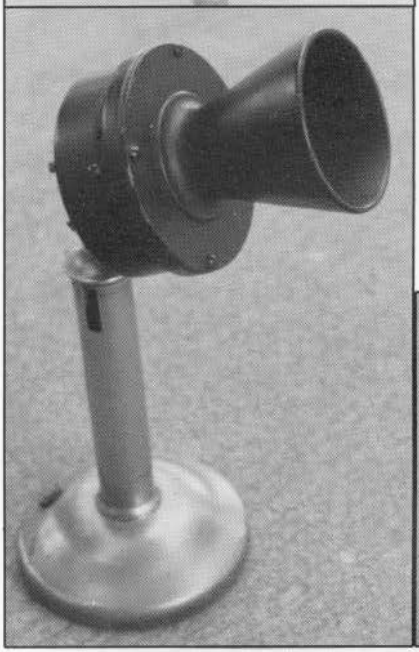
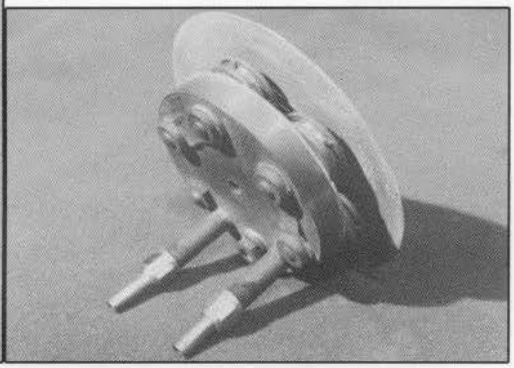


Figure 51. *(left) Water-cooled microphone mounted on telephone base.*
Figure 52. *(below) Water cooling chamber from microphone showing water connections.*



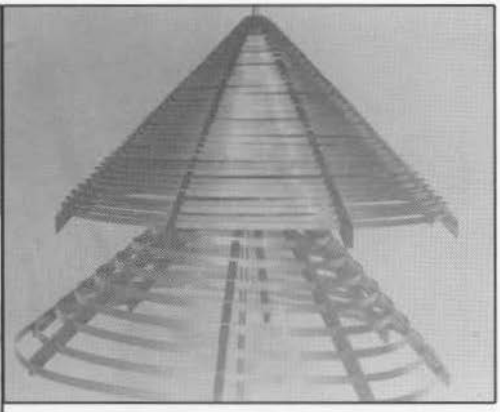
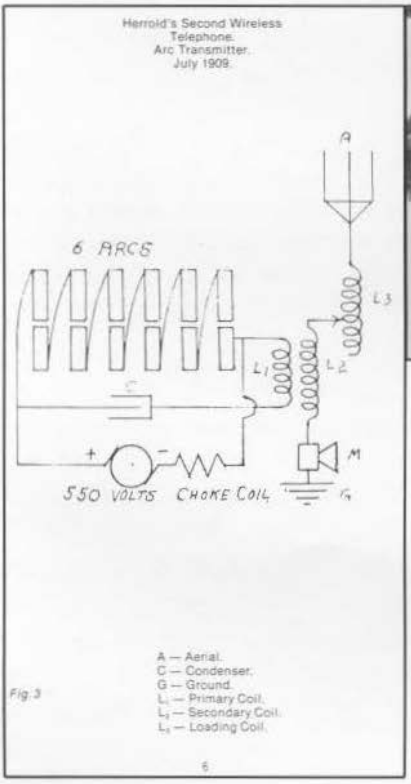


Figure 53. *(left) Attached to water cooling chamber are six carbon buttons in series.*
Figure 54. *(above) The Herrold conical helix.*



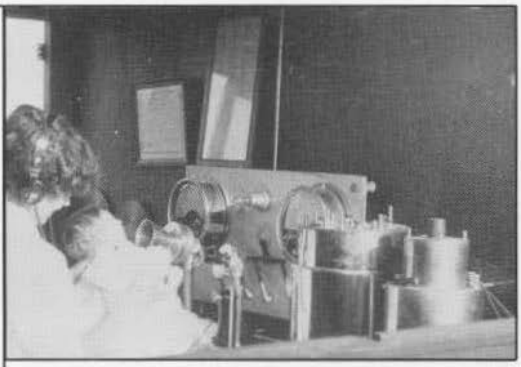


Figure 55. *(left) Possible schematic of basic Herrold arc system as drawn by Thorn Mayes.*
Figure 56. *(above) Sybil Herrold with son Robert, "on the air," 1913.*

Exhibition at San Francisco. He said he hoped to be able to communicate from the exposition by radio-telephony with all of the states and Canada." (75)

Another of the radiotelephone pioneers profiled in this article had also made plans for San Francisco. Lee de Forest, working nearby in Palo Alto, had an exhibit in the fair's Liberal Arts building, one dedicated to a major advance in long distance wired telephony. Sure, it had been rumored that he would also demonstrate at his booth how he had been able to make his audion oscillate at the radio frequencies necessary for the transmission of voice and music. The real purpose, however, of the de Forest exhibit had been to demonstrate the "de Forest Audion amplifier licensed to the American Telephone and Telegraph Company as a telephone relay that made the transcontinental service possible." (76) De Forest's audion transmitter failed to work and that allowed Herrold to participate as a broadcaster at the PPIE: "At the personal suggestion of Lieutenant Ellery Stone, U.S. Radio Inspector, I carried on a special daily schedule of radiocast music from 6 to 8 hours per day for the World's Fair at San Francisco, California, in 1915. This was received at the radio inspector's booth, also at that of Dr. Lee de Forest, in the Liberal Arts building." (77) That first PPIE broadcast was heard at the foot of the Tower of Jewels on the exposition grounds by Herrold and his wife: "I was at the fair with him when he received the programs that our station was putting on here in San Jose. He was anxious to see what the reception was like there. We'd been sending out these things but this was the one time when we got to hear it ourselves." (78)

Apart from that important year of daily broadcasting to the World's Fair, between 1912 and 1917 Herrold was continuously trying to build the most difficult part, the final piece of the radio puzzle. How do you create an audience? Herrold believed that the publicity surrounding the PPIE was one way to gain listeners. He knew that if he was on every day, more and more young men, even commercial operators would tune in. Wrote a former Herrold student: "A Marconi operator stated that he had danced to our 'wireless' music from San Jose on the deck of a trans-Pacific liner, using a long extension cord on his fones." (79) Later Herrold recalled his audience in a letter to Lee de Forest: "My audience was <u>not</u> always made up of amateur wireless telegraph operators. During the period of 1909 to 1917 I trained over 1200 students in the theory and practice of wireless telegraph and telephone. The interesting part is that these students built apparatus and installed sets with which people could listen to the telephone music. It was a beginning, and my students were building my audience, and incidentally they were publicizing my school." (80) He also told his story to the local newspapers: "If any boys in the neighborhood possess a wireless telegraph outfit ask them to permit you to listen any

night between 9 and 9:30 o'clock and you can hear my station experiment with the wireless telephone. Phonograph concerts over the wireless telephone are not all uncommon. You can hear the phonograph as distinctly as if it were placed in the next room to you." (81)

Did Charles Herrold really understand the difference between broadcasting and what he termed narrowcasting? Years later in a radio interview he explained it this way to a reporter: "The word 'broadcast' is an old word used by the Marconi telegraph operators to designate a message 'to all ships and stations.' When Valdemar Poulsen talked from his laboratory at Lyngby, Denmark to a test receiving station, that was a narrowcast. Count Arco, Professor Slaby, and many other Europeans did the same thing. When Lee de Forest in this country had a singer from the Metropolitan Opera sing in his laboratory and he himself talked, this was intended for reception by a group of newspapermen located on a ship in the harbor equipped with receiving instruments. There is not the slightest evidence to show that Collins, McCarty, de Forest, Poulsen, or any of these early experimenters had in mind the use of their experimental radio telephones for entertainment purposes" (82) Conversely, he believed many of his own early transmissions to be true broadcasts: "Certainly the thousands of amateurs who made it a religion to listen every day to our dance music and the thousands of records we played, certainly the hundreds of homes who connected a dozen pairs of telephone receivers to their receiving sets and invited the neighbors to listen – certainly they knew what I was doing." (83)

FRANK CONRAD, THE FIRST LICENSED BROADCASTER

Frank Conrad was a Westinghouse engineer who has been widely credited with being the first person to receive an actual government broadcasting license. The station, of course, was KDKA. According to Conrad researcher David Kraeuter: "Born in Pittsburgh on May 4, 1874, by age 16 Frank Conrad had quit school to work as a bench hand with the Westinghouse Electric and Manufacturing Company, his life-long employer. Between 1898 and 1942 (the year after his death) Conrad received over 200 American, English and German Patents on mechanical and electrical devices such as grenades, refrigerators, carburetors, radio transmitters and receivers, televisions, clocks, arc lamps, gear shifts, air conditioners, insulators, vacuum tubes, and electric meters. His experimentation with radio transmitting in 1919 and earlier helped Westinghouse found pioneer radio station KDKA. In the 1920s Conrad also did pioneering work which helped establish worldwide communications via short wave." (84) A self-made man, in 1928 Conrad was awarded an honorary Doctor of Science from the University of Pittsburgh.

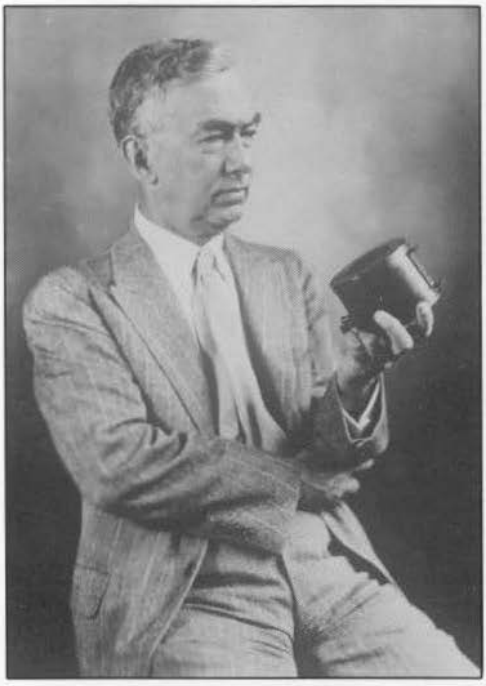


Figure 57. *Frank Conrad. (Westinghouse History Collection)*

Prior to Conrad and KDKA, amateurs and experimenters like Lee de Forest had just "gone on the air" with music and talk, often without any license. Charles Herrold, using the experimental radiotelephone call sign 6XE, had been allowed to "experiment" until the World War I ban beginning in April, 1917. And while de Forest, Herrold and others had probably been "broadcasting" as defined by their programming content and audiences, they were not official in the eyes of the government or the communications industry. To commercial operators they were misplaced, they interfered with legitimate "traffic," and even as late as 1920 there was hope in Federal Government circles that in the future all wireless would be controlled by the Navy. The historic metamorphoses of Conrad's experimental radiotelephone known as 8XK into KDKA almost did not happen!

Nevertheless, it was two years following the April, 1917 ban on amateur radio sending and receiving that stations were allowed to pick up where they left off, and so many continued with their earlier pre-war radiotelephone experimentation. In the June, 1921 publication by the Radio Service, Bureau of Navigation, Department of Commerce called *Commercial and Government Radio Stations of the United States*, a small group of radiotelephone stations were listed as "Special Land Stations, Alphabetically by Names of Stations [Additions to the List of Radio Stations of the United States, edition of June 15, 1919 only]." (85) These three were listed: "Pittsburgh, Pa, 8XK, variable wave length, Frank Conrad; Madison, Wi, 9XM, University of Wisconsin; San Jose, Ca, 6XE, Charles D.

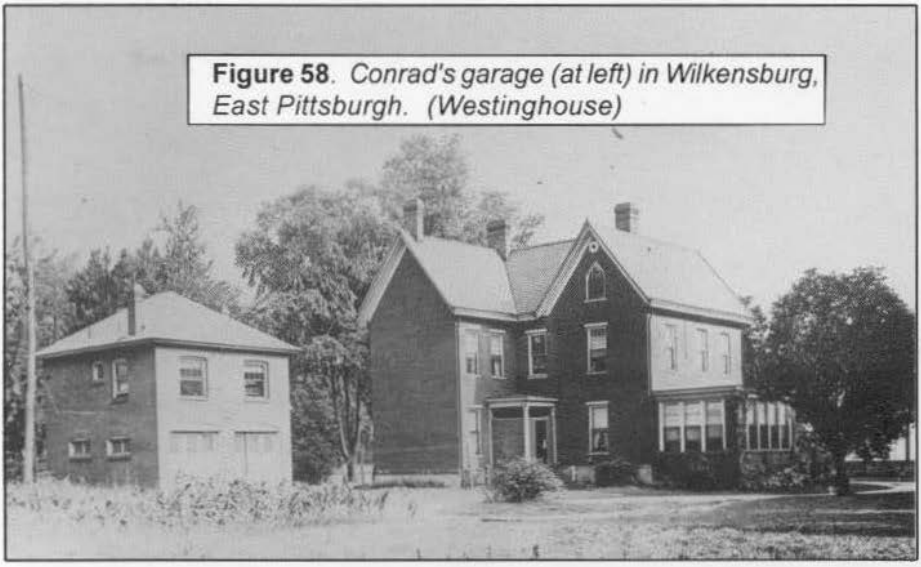


Figure 58. *Conrad's garage (at left) in Wilkensburg, East Pittsburgh. (Westinghouse)*

Herrold." Later each of those experimental radiotelephone licensees went on the air as broadcasters; Conrad in late 1920 became KDKA, the University of Wisconsin (Earle Terry) as WHA, and Herrold as KQW (now KCBS), both in 1921. All three stations operate today.

Unlike others during the war Conrad had been in a unique position, that of being allowed by the Signal Corps to experiment with a vacuum tube radiotelephone. Often he accomplished this by using his voice and a phonograph as an audio source: "During the War, the Navy gave him (Conrad) permission to carry on with his experimental work, for they wanted him to solve some problems, such as an airplane transmitter. His call then was 3WE, the "3" meant that the station was in the third Naval district." (86) After the war ended Conrad continued to experiment, and by mid-1920 his Saturday night phonograph concerts had caught on in an interesting way with a small audience in (Wilkensburg) East Pittsburgh, Pennsylvania. Said Conrad in 1940: "People within radio distance had bootleg receivers, and soon they began picking up (my) transmissions. Then they began to telephone and say, 'We have some friends in this evening. They do not believe us when we tell them that we can pick up music out of the air. Won't you please play some selections for them?" (87) This clandestine receiving and audience activity (Conrad's transmissions were legal) had been building during the wartime ban on amateur activity. After the ban was lifted he continued and he got the attention of his bosses.

Said S.M. Kintner of Westinghouse: "On account of the number of requests he received he agreed to undertake this broadcasting at regular intervals. So he agreed to do this every Wednesday and Saturday night at certain times. The number of requests kept growing, till by the summer of

Figure 59. QST, *September 1920.*

1920 some of the department stores of Pittsburgh were carrying radio receiving sets of approved type which were advertised as suitable for listening to Mr. Conrad's concerts." (88) And according to Leroy Williams, special patent counsel to Westinghouse: "As a result of the publicity that Conrad got with his sending out radiotelephone signals, Joseph Horne and Co., a department store of Pittsburgh advertised in September, 1920, that they would sell receiving sets that would pick up Conrad's music. H.P. Davis (Westinghouse president) saw this ad and saw the possibilities of radio broadcasting. He thought it was time for the company to take over the work of Conrad." (89) It was the corporate spin on the work of an inventor who incidentally spent his entire working life at Westinghouse. Was Conrad bitter in later years that his idea had been usurped and the credit taken by boss Davis? The evidence suggests that he never publicly raised the issue. Conrad was a good soldier.

There was national publicity as well. Concurrently with Westinghouse's awareness of the potential of Conrad's work, his experimental station was featured in a cover story in a major national amateur publication. In the September, 1920 issue of QST, Conrad's 8XK was written up in great detail. (90) With photos and descriptions of his low-power tube transmitter with its microphone aimed at the horn of a wind-up phonograph, it was the first up-close look at the technology that several months later in that same year would be licensed as KDKA, just in time for its broadcast of the Harding-Cox presidential election. And unlike the de Forest Wilson-Hughes presidential broadcast of four years earlier, that time the public was more ready for radio. Thanks to the ongoing RCA negotiations and their effect on the supply of legal radio parts, a few ordinary citizens were able to buy receivers with which to hear the KDKA broadcasts. In fact, one of the major benefits hoped for out of the highly publicized Conrad broadcasts was to profit by selling simple consumer versions of the Westinghouse/ RCA RA DA tuner-receiver, a device originally worked on by Conrad and manufactured for the war. (91)

But it was not simply an overnight transition from Conrad's garage experiments to KDKA as a broadcast station. According to Conrad, the

whole idea began as a plan for a two-way service: "(S.M. Kintner of Westinghouse) planned a city service or rather cities service, placing stations at Pittsburgh, Newark, and Cleveland, for code communication, with radiotelephone working as a sideline. These point to point stations were installed. It was for code operation in these stations, incidentally, that the RC receivers were designed. I went to H.P. Davis, big boss of Westinghouse and said, 'Why have this just a point to point affair? Why not let the station talk to everyone, not just to each other?' This was June or July of 1920." (92) Davis agreed and KDKA evolved out of that group of Westinghouse stations originally designed for this commercial operation: "It went on the air, for the first time, on Election Day, 1920. Permission to use the station for broadcasting on that night was granted, the call to be 8ZZ. A few days after the election, permission to add broadcasting to KDKA's license was granted . . . [I] used the calls 8ZZ and KDKA more or less interchangeably during the night." (93)

Frank Conrad described the famous November, 1920 election eve broadcast in a 1937 letter to RCA historian George Clark: "The broadcast was carried out in cooperation with the Pittsburgh Post and the publicity was entirely confined to the Pittsburgh Post circulation. The broadcast was primarily to announce the election returns and the first returns were received about 8pm; however, some preliminary matters, such as talks and music were transmitted from about 6:30pm. The content of the broadcast, other than the news bulletins of the election, consisted of short talks explaining how the broadcast was carried out and interspersed with musical selections. These selections were almost entirely phonograph reproductions. My recollection is that the weather was clear on that day. We had carried out enough preliminary tests to assure ourselves that the service would be reasonably reliable; however, to guard against any general breakdown, such as power or lines, arrangements were made so that (my) private station in the garage (8XK) could be used in place of the station at East Pittsburgh – line facilities being arranged for from the *Pittsburgh Post* building to (my) home. Certain information on the results were known soon after the broadcast started by telephone calls from receiving stations, which previously had been instructed to report on the success of receiving the returns. The broadcast in general was handled by the personnel of our publicity department and the radio engineering department. It would be somewhat difficult to give a complete list of the names of the people taking part in the program. However, so far as the listening audience was concerned, it is probable that only one name appeared, that of L.H. Rosenberg, who did the announcing." (94)

Unlike Lee de Forest and Charles Herrold, Frank Conrad had excellent timing. The nation had put the war behind, the technology had mostly

been sorted out and the patent issues were being resolved. Radio had arrived and people were beginning to embrace its possibilities. And most important, there was big-time corporate support behind the fledgling service.

SOME CONCLUSIONS ABOUT THE RADIOTELEPHONE DECADES

So which of these individuals won this imaginary race for the radiotelephone? Can you now visualize the finish line, the prize? You probably have your own opinions. Before I give you mine I want to summarize the importance of the years 1900 to 1920 to the invention, realization and perfection of the radiotelephone from its communications beginnings into broadcasting for an audience. I offer the following five broad conclusions:

1. BROADCASTING WAS AN ACCIDENTAL BY-PRODUCT OF INVENTION

The first radiotelephone experimenters and inventors probably became broadcasters by accident; they discovered that they had small groups of listeners or audiences in the course of trying to invent a wired replacement for the Bell telephone. Fessenden was a musician, de Forest an opera lover and promoter, Herrold the headmaster of a wireless trade school with a large number of young boys to keep occupied. Conrad used the phonograph as an audio source for his Signal Corps experiments. As you'll read later on in these conclusions, it would be several years into the 1920s before a clear direction for broadcasting was finally realized. (Figure 60)

Figure 60. *The young boys who were the first radio audience.*

2. PUBLIC AWARENESS OF THE POSSIBILITIES OF THE RADIO TELEPHONE BEGAN AS EARLY AS 1912

The years between 1912 and 1915 were important to the future perception of the radiotelephone because they were the first years in which the latest inventing news made its way from the hobby periodicals to the daily newspapers. Beginning in 1912 the general public finally began to hear about the inventors and their experiments, and therefore the editorial comments surrounding that new medium. Those were also the years in which several unrelated events convinced the youth of the day that any place related to wireless was an exciting place to be. Perhaps it began with the publication of exciting reading material aimed at the high school boy. The 1911 book, *Tom Swift and his Wireless Message* (95), was all the impetus many boys needed to sell their parents on the idea that a little "higher education" at a wireless school could translate into a living wage. Certainly the popularity of wireless in general was further helped by the major event of 1912, the sinking of the *Titanic*, the news of which came in the form of a wireless message: "We have struck an iceberg. Badly damaged. Rush aid." According to its survivors: "Seaward and landward, J.G. Phillips, the *Titanic's* wireless man, had hurled the appeal for help. By fits and starts for the wireless was working unevenly and bluringly Phillips reached out to the world, crying the *Titanic's* peril." (96) To many newspaper readers, the value of wireless had been solidified. (The loss of White Star's *Republic* in 1909 was a significant event in wireless history although it did not have the same public exposure as the *Titanic*.) (Figures 61-63)

Meanwhile, from coast to coast the work of the radiotelephone inventor was being reported in the nation's newspapers. (97) In what were four of the most important years in the slow transition from experimental radiotelephone development to actual programming for an audience, the years between 1912 and 1915 marked the introduction of the radiotelephone to the public. No longer confined to the technical and wireless hobby publications, the radiotelephone was now being discussed on Main Street. As the newspaper stories indicate, dozens of inventors, having constructed their own radiotelephone systems, began working on the next steps: promotion and publicity and marketing and sales. Newspaper reporters during those years seem to be interested in two things: how these inventors planned to replace the wired telephone and the type of audio content they were using to promote, test and demonstrate it. Often it was the inventor himself shouting, "Hello, can you hear me?" Sometimes it was music from a phonograph. Always, the goals were to both augment the wired

Figure 61. *Montage of newspaper stories about radiotelephone, 1912-1914.*

telephone for two-way personal conversation and add a voice to the message handling work of the wireless telegraph business. With the exception of a few speculative editorials, the content of broadcasting was rarely discussed.

3. BROADCASTING WAS READY FOR THE PUBLIC BY 1916

Some members of the public were even ready for broadcasting. That much was obvious from the news reports. The technology and mass manufacturing, however, had not quite caught up. The situation in 1916 was that all the various inventors of the pieces that would make up radio transmitters and receivers had up to this time refused to put their pieces together and so a complete system was legally impossible. Then there was the war. As a result of our entry into WWI in 1917, the holders of various radiotelephone patents were forced to pool their inventions for national security, but it took until after the war for the patents to finally be sorted out and cross-licensed through the 1919 RCA agreements. The manufacture and marketing of radio receivers specifically for the consumer began

Wireless Talk Across the Atlantic

1913

Wireless Telephony Here, Though Its Promoters Still Talk Through Their Hats

By Frederick W. Ford

TALKING across the Atlantic Ocean, from Neustadtam-Roebenberge, Germany, to New Jersey, a distance of four thousand miles, was accomplished by wireless telephony on October 27, according to Rear Admiral Georg August Ennmann. The message was sent and received in the middle of the afternoon, in spite of the daytime being most unfavorable for wireless communic[ation]

Youths Make Phone Calls by Wireless

Work to Perfect Scheme They Stumbled Onto

C. L. Sears, Son of Expert Marksman, Is Reticent About Discovery.

Wireless Telephony an Established Fact

BY GARRETT P. SERVISS.

There is no longer the slightest doubt that the time is coming, and perhaps close at hand, when we shall habitually talk to one another at distances of hundreds, or even, thousands, of miles without the intervention of any wires connecting the speaker with the hearer. Wireless telephony is an established fact, but the apparatus still needs development before it can come into general everyday use and displace the existing telephonic system.

There is something weirdly impressive in the thought of transferring the feeble human voice over mountains and seas, and making it virtually encircle the earth. Man speaks and his planet hears! At his command a little electric device transforms his voice into waves that traverse the ether with the speed of light, carrying the voice with them, locked up in their undulations. In less than one second and a third they could bear it to the moon. In about three minutes they could carry it to the planet Mars.

WIRELESS TELEPHONE NOW.

An Italian Scientist Says He Has Solved the Great Problem.

Dr. Ricardo Moretti of Rome claims to have solved the problem of wireless telephony owing to a special generator of electric oscillations of his invention, which has been successfully experimented with between Rome and Tripoli. This apparatus consists of two poles fixed vertically a small distance apart and through one of which a thin continuous jet of water flows.

The water is evaporated by an electric spark between the ends of the poles, and an alternating current of extraordinary rapidity is consequently generated since the oscillations thus produced are calculated at several hundred thousands *every* second. As the oscillations exceed in number and rapidity the vocal vibrations by means of this generator it is possible to transmit the voice over long distances.

Dr. Moretti has experimented with his invention in connection with the naval wireless installations with the addition of ordinary telephone receivers and transmitters, but he is now working on a hydraulic transmitter, particulars of which are still withheld.

Constructed Most of Plant.

Sears has attended Manual Training School, but in telegraphy he is entirely self-taught. With the exception of the motor and the receivers, he has made the whole of his complicated plant. He says that with his instruments he has intercepted communications from Hawaii, Cape Hatteras, Cape Cod, Tampa and

Figure 62. *Another montage of the same.*

around 1920. Nevertheless, you can tell from some of the newspaper stories in 1916 that the public was beginning to embrace radio. Most important were the earlier mentioned High Bridge, New York broadcasts by de Forest. (98) Less well known were the 1916 efforts of Charles Herrold. The public record of one such Herrold broadcast illustrated what the public was being told about a new use for the radiotelephone:

First, the broadcast was pre-announced on December 22, 1916: "An extremely novel form of musical entertainment is planned for Christmas morning at 11 o'clock. The place will be anywhere that wireless waves can reach. Ships at sea as well as commercial and government stations within a radius of 1000 miles will be listening to catch the first strains of the opening numbers of the program. Professor Charles Herrold, the well-known radio and electrical engineer, assisted by Emile Portal, well known in wireless circles, will have charge of the concert. A modern talking machine will be placed in front of the transmitter through which flows a stream of cold water to protect against the powerful currents used. This system of wireless voice transmission has been subjected to the severest tests during the past three years and represents the highest development of the art." (99) (Figure 64)

Figure 63. *This Advertisement appeared in the May 1911* Modern Electrics *for a new Gernsback book called* The Wireless Telephone.

News of the concert's apparent success was reported on December 26: "Edward Bellamy's prophecy in '*Looking Backward*' that some day people would turn on a button and listen to music from a central plant came true yesterday in San Jose when the wireless operators of the city and beyond within a radius of 1000 miles listened to a program of Christmas music in their homes. It was made possible by connecting their own wireless apparatuses with the central apparatus of the Herrold-Portal aerial system of telephony." (100) Even the papers didn't really get it, or at least they didn't get it right. There was no connection between the "central plant" and homes. That was the point. Later in the article, a listener gave his impressions: "It was as clear and sweet and beautiful as if it had been played and sung in the next room. The sounds came in distinctly. There was no disturbing noise and we listened to the whole program, which lasted about 20 minutes, without the slightest difficulty." (101) (Figure 65)

And what about the public? What about those in that very early small audience who would wonder themselves about what it all means? A San Jose newspaper editorialized the day of the Christmas morning broadcast. They compared it to other media forms of the day; film, records and the player piano. They were thoughtful. They were impressed. They counseled caution. The entire 1916 editorial is re-printed as an early indicator

Concert by Wireless Heard by 300 People

Music Clear and Distinct, States Man Who Was on "Wireless."

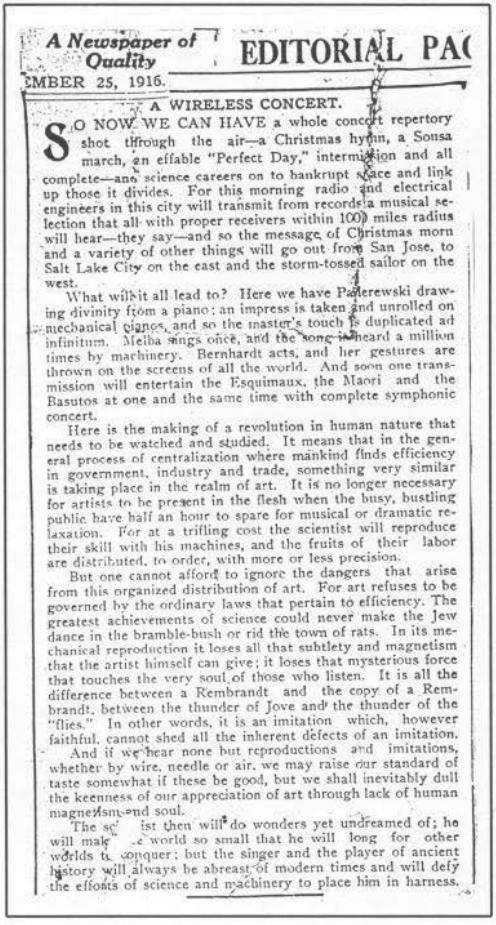
Edward . Bellamy's prophecy in "Looking Backward" that some day people would turn on a button and listen to music played and sung at a central plant, came true yesterday in San Jose when the wireless operators of the city and beyond within a radius of almost 1000 miles listened to a program of Christmas music while sitting in their homes. It was made possible by connecting their own wireless apparatuses with the central apparatus of the Herrold-Portal aerial system of telephony.

One of the local families which had the benefit of listening to this program was that of Mr. J. O. Heatwood, 239 Sixth street.

Mr. Heatwood said in speaking of the program, which was heard through the wireless apparatus of his son, James G. Heatwood: "It was as clear and sweet and beautiful as if it had been played and sung in the next room. The sounds came in distinctly. There was no disturbing noise and we listened to the whole of the program, which lasted about 20 minutes, without the slightest difficulty." Mr. James Heatwood has been working with wireless apparatus for the past five or six years.

Prof. Charles Herrold, who has perfected the system to its present most efficient state, said last night that there were about 300 owners of wireless apparatus within the radius reached by his machine. One of the great advantages of his system as explained by Prof. Herrold was the fact that operators could break into the middle of the word and start again without disarranging the sentences in a tenth of a second. With other systems it takes from two to five minutes to be "on" and "off."

~~12~~=16



A Newspaper of Quality

EDITORIAL PA(

MBER 25, 1916.

A WIRELESS CONCERT.

SO NOW WE CAN HAVE a whole concert repertory shot through the air—a Christmas hymn, a Sousa march, an affable "Perfect Day," intermission and all complete—and science careers on to bankrupt space and link up those it divides. For this morning radio and electrical engineers in this city will transmit from records a musical selection that all with proper receivers within 1000 miles radius will hear—they say—and so the message of Christmas morn and a variety of other things will go out from San Jose, to Salt Lake City on the east and the storm-tossed sailor on the west.

What will it all lead to? Here we have Pasterewski drawing divinity from a piano; an impress is taken and unrolled on mechanical pianos, and so the master's touch is duplicated ad infinitum. Melba sings once, and the song is heard a million times by machinery. Bernhardt acts, and her gestures are thrown on the screens of all the world. And soon one transmission will entertain the Esquimaux, the Maori and the Basutos at one and the same time with complete symphonic concert.

Here is the making of a revolution in human nature that needs to be watched and studied. It means that in the general process of centralization where mankind finds efficiency in government, industry and trade, something very similar is taking place in the realm of art. It is no longer necessary for artists to be present in the flesh when the busy, bustling public have half an hour to spare for musical or dramatic relaxation. For at a trifling cost the scientist will reproduce their skill with his machines, and the fruits of their labor are distributed, to order, with more or less precision.

But one cannot afford to ignore the dangers that arise from this organized distribution of art. For art refuses to be governed by the ordinary laws that pertain to efficiency. The greatest achievements of science could never make the Jew dance in the bramble-bush or rid the town of rats. In its mechanical reproduction it loses all that subtlety and magnetism that the artist himself can give; it loses that mysterious force that touches the very soul of those who listen. It is all the difference between a Rembrandt and the copy of a Rembrandt, between the thunder of Jove and the thunder of the "flies." In other words, it is an imitation which, however faithful, cannot shed all the inherent defects of an imitation.

And if we hear none but reproductions and imitations, whether by wire, needle or air, we may raise our standard of taste somewhat if these be good, but we shall inevitably dull the keenness of our appreciation of art through lack of human magnetism and soul.

The scientist then will do wonders yet undreamed of; he will make the world so small that he will long for other worlds to conquer; but the singer and the player of ancient history will always be abreast of modern times and will defy the efforts of science and machinery to place him in harness.

Figure 64. *An announcement of the success of the December 1916 Herrold broadcast,* San Jose Mercury-Herald, *December 26, 1916.*
Figure 65. *Editorial from the December 1916* San Jose Mercury-Herald *about the Christmas Day, 1916 Herrold broadcast.*

of what radio would become and how the audience might come to view this revolutionary use of the radiotelephone:

> "So now we can have a whole concert repertory shot through the air - a Christmas hymn, a Sousa march, an affable 'Perfect Day,' intermission and all complete and science careens on to bankrupt space and link up those it divides. For this morning radio and electrical engineers in this city will transmit from records a musical selection that all with proper receivers within 1000 miles radius will hear they say and so the message of Christmas morn and a variety of other things will go out from San Jose, to Salt Lake City on the east and the storm-tossed sailor on the west.

"What will it all lead to? Here we have Paderewski drawing divinity from a piano; an impress is taken and unrolled on mechanical pianos, and so the master's touch is duplicated ad infinitum. Melba sings once, and the song is heard a million times by machinery. Bernhardt acts, and her gestures are thrown on the screens of all the world. And soon one transmission will entertain the Esquimaux, the Maori and the Basutos at one and the same time with complete symphonic concert.

"Here is the making of a revolution in human nature that needs to be watched and studied. It means that in the general process of centralization where mankind finds efficiency in government, industry and trade, something very similar is taking place in the realm of art. It is no longer necessary for artists to be present in the flesh when the busy, bustling public have half an hour to spare for musical or dramatic relaxation. For at a trifling cost the scientists will reproduce their skill with his machines, and the fruits of their labor are distributed, to order, with more or less precision.

"But one cannot afford to ignore the dangers that arise from this organized distribution of art. For art refuses to be governed by he ordinary laws that pertain to efficiency. The greatest achievements of science could never make the Jew dance in the bramble-bush or rid the town of rats. In its mechanical reproduction it loses all that subtlety and magnetism that the artist himself can give; it loses that mysterious force that touches the very soul of those who listen. It is all the difference between a Rembrandt and a copy of a Rembrandt, between the thunder of Jove and the thunder of the 'flies.' In other words, it is an imitation which, however faithful, cannot shed all the inherent defects of an imitation.

"And if we hear none but reproductions and imitations, whether by wire, needle or air, we may raise our standard of taste somewhat if these be good, but we shall inevitably dull our keenness of our appreciation of art through the lack of human magnetism and soul.

"The soloist then will do wonders yet undreamed of; will make the world so small that he will long for other worlds to conquer; but the singer and player of ancient history will always be abreast of modern times and will defy the efforts of science and machinery to place him in harness" (102)

Who were the other broadcasters of 1916? By 1917 an inventor named Earl Hanson was broadcasting to his small audience in Los Angeles. According to Hansen: "Municipal wireless phonograph concerts may also soon be a reality. For these a single centrally located sending station would be necessary, the waves from this having a radius of the entire city." (103) And in a Pittsburgh newspaper story from 1915, "Wireless Talkfest Planned," historian George Clark related a story about a Professor Van Dyke of the

Carnegie Institute of Technology who planned and pre-announced a wireless "talk" about general news, politics, etc., aimed at "every amateur wireless operator in the county." Another isolated event, "the test was for the benefit of amateurs within a radius of ten miles." (104) And while impossible to prove but fascinating to think about, consider that another Pittsburgh resident, KDKA's Frank Conrad, might have been in that 1915 Van Dyke audience, and thereupon got an idea or two. Still another local event was happening in New Rochelle, New York: "Station 2ZK, operated by George C. Cannon and Charles V. Logwood, broadcast music between 9 and 10pm daily except Sunday in November, 1916." (105) Logwood earlier had worked in Palo Alto with Lee de Forest during his days at the Federal Telegraph Company. Another set of influences, another connection. Broadcasting, 1916 style. So why didn't it happen? Why would it take four more years to catch on?

It was the Great War. It was in April, 1917 that all licensed amateurs received this letter from the Department of Commerce and the US Navy District Communication Superintendent: "To all Radio Experimenters, Sirs: By virtue of the authority given the President of the United States by an Act of Congress, approved August, 13, 1912, entitled, 'An Act to Regulate Radio Communication,' and of all other authority vested in him, and in pursuance of an order issued by the President of the United States, I hereby direct the immediate closing of all stations for radio communications, both transmitting and receiving, owned or operated by you. In order to fully carry this order into effect, I direct that the antennae and all aerial wires be immediately lowered to the ground, and that all radio apparatus both for transmitting and receiving be disconnected from both the antennae and ground circuits and that it otherwise be rendered inoperative both for transmitting and receiving and radio messages or signals, and so remain until this order is revoked. Immediate compliance with this order is insisted upon and will be strictly enforced. Please report on the enclosed blank your compliance with this order; a failure to return such blanks will lead to a rigid investigation." (106)

Never again would such a sweeping ban on not only transmitting but receiving radio signals be implemented. That was a historic decision. And even more onerous, emboldened by this shut down and with the belief that amateurs have no place in the future of radio communication, the Padgett Bill, known as HR 2773, was introduced on April 9, 1917. It proposed that all American radio communication be turned over to the Navy, forever. And while the bill did not become law, America's involvement in the Great War did portend an uncertain future for wireless and radio.

4. THE SUCCESS OF LICENSED BROADCASTING IN 1920 WAS GREATLY ENHANCED BY THE RCA AGREEMENTS

Licensed broadcasting started in 1920 with KDKA, but it took several years to get off the ground. In a survey of all issues of the periodical *Pacific Radio News* between 1920 and 1923, I noticed how a gradual transition occurred from an audience of mostly amateurs building sets and listening to radio to a non-technical public being able to buy easy-to-tune receivers. As late as 1923, the radio magazines were still using the term, "radiophone concerts." (107) In those three years, programming was being developed, advertising was not yet legally allowed, and all stations were sharing the same frequency (360 meters), with each on for a hour or so a day. It would take a few more years for both audience and government to take broadcasting seriously enough for regulation. That would finally happen in 1927 and by 1930 the radio industry was fully formed. Advertising was its financial basis, networks were formed, programming was in place, the AM broadcast band had been separated into local, regional and clear channels, the public was hooked.

Why did broadcasting catch on in the 1920s in way that it couldn't and didn't in 1916? One answer was the war. On a social level it could be argued that the public, having been freed from the weight of war, death and sacrifice, was ready for some fun, some good times. It was in this context that a device, the radio, was introduced that could bring music into the home, something you didn't have to learn to play like a piano. As believed in 1920 (an almost exact paraphrase of Bellamy's 1888 book): "By using channels of different frequencies, different classes of aural amusement would be simultaneously transmitted, permitting the subscriber to select at will his own type of amusement merely by pushing the proper button which controls the selective circuit employed . . . The amusement might come from stored sources, as from phonograph devices, or might be given directly by a speaker, or a concert." (108)

The other, more objectively explained outcome of the war was the negotiation of a collection of hard-fought technology agreements that made the radio possible. The Radio Corporation of America began forming in 1919 with two companies, GE and AT&T. General Electric had the patents to the Alexanderson Alternator, and AT&T/Western Electric held the all-important de Forest tube patents. Initially, these were the most important companies to sign on to the RCA agreements. Although author Banning (an employee of AT&T during the RCA negotiations with that company) seemed to have viewed the agreements as a way for the telephone company to retain its position in vacuum tube technology, it was really the specter of British control of the Alexanderson Alternator by the Marconi company that added urgency to the formation of RCA and propelled it

toward its conclusion. After the war had ended, many in government and industry had wondered hypothetically what could happen in a future war if the means of international and national communications within our borders were controlled by a hostile power. "Thus in 1919 was created a corporation which, in power, financial and otherwise, was able to cope with any other in existence. General James G. Harbord, a recently returned war hero, representing government influence, was elected president, and a young man of twenty-eight named David Sarnoff, whose first job, nearly fifteen years before, had been that of telegraph messenger boy, was made commercial manager." (109)

Later, Westinghouse, a company that originally believed itself strong enough to go it alone, reluctantly signed with the Radio Corporation. They had obtained the International Radio Telegraph Company and important patents held by Fessenden and Armstrong. So while not a part of the original RCA group, Westinghouse had already owned or quickly obtained enough important exclusives to finally get in. As the final player in the RCA group, Westinghouse signed on June, 30, 1921. The Radio Corporation was now complete. The threat of Navy control, of Government ownership of radio, very real at the conclusion of the Great War, was stopped thanks to the RCA agreements, worked out by a combination of government officials and private companies, but with the control resting with the private companies. RCA was born as a government-sanctioned telecommunications monopoly. It is a truly fascinating and complex story, the most complete and accurate details of which can be found in Hugh Aitken's *The Continuous Wave: Technology and American Radio, 1900-1932.* (110)

RCA was originally formed for commercial communications purposes, not entertainment radio. So how did the RCA agreements affect broadcasting throughout the 1920s? Here is the simple version: Westinghouse and General Electric were allowed to manufacture radio receivers, to be sold to consumers under their name and that of the RCA label. The so-called "telephone companies," Bell, AT&T and Western Electric, were given exclusive rights to manufacture broadcast transmitters. Practically every radio station in the 1920s used a version of the Western Electric transmitter. More important initially, this latter group of companies, because of its ownership of the wired telephone system, were also given the exclusive RCA franchise in two other untried and untested areas: Toll Broadcasting, or the right to charge advertisers money to have their names mentioned on the air as a program sponsor, and Chain Broadcasting, the ability to "network" more than one station to ensure a larger regional or national audience for a single program. And while the AT&T group through station WEAF in New York was the first to try "Toll" and "Chain" broadcasts, they were not really interested in the further exploitation of these RCA granted exclusives. By the mid-1920s networks began to form and

advertising became the basis of support for radio broadcasters.

5. ALWAYS QUESTION HOW HISTORY IS MADE AND PERCEIVED

I have also looked seriously at how the history of the radiotelephone and its transition into broadcasting was created. When, why and by whom was the agenda really set for what we now believe as "the history of broadcasting?" Many of the historians of the 1940s and 1950s had based their knowledge on one important source, Gleason Archer's 1938 book, *History of Radio to 1928*. Archer based some of his work on the collected documents of RCA historian George Clark. Beginning in the early 1920s and continuing until his death in the 1940s, Clark argued for his criteria for what was broadcasting and what was not. According to Clark, to qualify as broadcasting the transmission had to be expressly to entertain, it had to be advertised ahead of time, or pre-announced to the public, it had to adhere to a regular schedule, and it had to be heard by a citizen audience, not just a group of "hams" or professional operators. It was this last criteria that left out Herrold and de Forest. Finally, but no less important, from the late 1930s until the early 1950s, there were published a plethora of popularized broadcast history books, mostly anecdotal in nature. And while many of these books were not accurate or thoughtful, and even written by those with an unspecified commercial or political agenda, their influence lasted far too long. The real story is surely more complex and is always being revised. Always seek primary sources, evaluate carefully and ask plenty of questions.

THE FINISH LINE

And who won my race for radiotelephone? Of the five, some won more than they deserved, some have probably already been given an accurate place in history, while others are still being re-evaluated by scholars. If there is a prize for being remembered as a serious inventor and prestigious scientist of the radiotelephone era, then Valdemar Poulsen and Reginald Fessenden share the honors for their thoughtful technical contributions to the very early technology of the radiotelephone transmitter and receiver. Were it not for the early inventions of the arc radiotelephone and the liquid detector, later experimenters would not have considered wireless as a carrier for voice and music as early as they did. So for most of this century Fessenden and Poulsen have enjoyed a solid, secure place in history. Lee de Forest gets the prize for being the first and most tenacious in his pursuit of the radiotelephone as a device for bringing culture into the homes. Ironically, most of de Forest's early and most important work in this area

was carried out using his version of Poulsen's arc transmitter. It was only later, in 1916, that de Forest used his own invention of the oscillating vacuum tube to broadcast.

Charles Herrold was included in the race for two reasons. First, there is no question that however accidentally, between 1912 and 1917 he started and maintained a radio station designed to entertain an audience of hobbyists, experimenters and friends. And second, Herrold is symbolic, a good example of one of the dozen "every men" in the pre-WWI race toward broadcasting. He began like dozens of others, using arc technology, and while trying to find a replacement for the wired telephone, he affiliated with a company for the purpose of obtaining capital. When license broadcasting began in the 1920s, Herrold set up a station, and like hundreds of others, lost it. The difference between Herrold and the many other minor players, pre-1920, is that he stayed on the air, was reinforced by an audience and received publicity for what he was doing, and therefore was early in the promotion and experimentation of the non-two-way communication uses of wireless telephone transmitting technology. Because of the war Herrold did not finish the race.

Frank Conrad started the race late but finished. He wins the prize for being in the right place at the right time, and for possessing the good sense not to question the wisdom of his employers at Westinghouse. While his radiotelephone experiments were not significantly different, content wise, from those of Herrold or de Forest a decade earlier, Conrad had the right technology, the right company behind him, and most important, the right audience, an American public freed of the darkness of war and ready to be entertained. Unlike the others, Conrad had arrived at the same time and place as his audience. Five individuals all racing toward an imaginary finish line in the race for radiotelephone.

ACKNOWLEDGMENTS

I wish to thank a large group of individuals and organizations for their cooperation during my five year research effort into the pre-history of broadcasting. Beginning initially as a narrow search into the life and work of Charles Herrold and evolving into a need to put the Herrold story into the larger context of the invention of the radiotelephone, I have traveled and interviewed and photocopied and written and concluded, and at times been both excited and baffled by the early history of the radio. First, and most important to this effort has been friend and fellow San Jose State scholar Gordon Greb, whose early research into Charles Herrold inspired my 1995 PBS video production: *Broadcasting's Forgotten Father: The Charles Herrold Story,* as well as a book, *The Accidental Broadcaster*, we are writing on the subject. And in addition to the help provided by several dozen

researchers and biographers of the principles of this article, I have long been helped in my efforts by scholars and broadcast historians Christopher Sterling and John Michael Kittross, whose time and interest on the video and with the book manuscript have been significant. Thanks also to Bruce Kelley who opened the Antique Wireless Association archive and his home to me, to Jim and Felicia Kreuzer who allowed me to search their private library, and Elliot Sivowitch who coordinated my activities at the Smithsonian Institution where along with Gordon Greb I spent a week with the Clark Papers. This *Review* article was reviewed by Gordon Greb, Christopher Sterling of George Washington University, by Barry Mishkind of the valuable Internet broadcast history archive, <www.oldradio.com> and by Donna Halper of Emerson College. And, as always, my sincere thanks to the Perham Foundation for its generous support of my research and publication.

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Mike Adams

Mike Adams remembers a defining moment in his childhood when he first discovered radio. As a young listener, Adams began to poke around behind the little box in an effort to discover where "radio" came from. During his high school years he built several pirate transmitters and entertained his neighbors with music and talk. More than anything, he wanted to be on the air. In 1960 Mike went to Ohio University in Athens where he got involved with the college radio station as an announcer and news reporter. For spending too much time at the station and too little at the books, he flunked out. He spent the rest of the 1960s working in radio where he found modest success as a "top-40" disc jockey during the "golden age" of rock and roll AM radio.

Bored with commercial radio he returned to college and completed his graduate work at Ohio State University. He moved to Los Angeles in the 1970s where he made documentary films and taught at several universities. Currently, he is professor of radio and television at San Jose State University where he is also the coordinator of the radio-TV-film degree program. And yes, he is back in college radio, this time as faculty advisor to the student-run FM station, KSJS. He has authored numerous articles for historical radio journals and periodicals, two books on radio and television production, and a video series for PBS called Radio Collector. Adams is a former president of the Southern California Antique Radio Society, SCARS, and is currently on the boards of the California Historical Radio Society, CHRS, and the Perham Foundation Electronics Museum. His latest works are a book and a television documentary on what else radio broadcasting history. Look for Broadcasting's Forgotten Father: the Charles Herrold Story on PBS. And look for the Herrold book, The Accidental Broadcaster, coming soon. You can learn more about Mike Adams on the World Wide Web. His page is at <http://www.ksjs.org/adams>