The Antique Wireless Association Review

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The AWA Review

Cover Images: The cover page of Marconi's *Ocean Radio News* distributed circa 1914 appears on the front cover of this issue (courtesy of Joe Knight), and the back page of an edition of the *Wireless News* distributed on the RMS *Makura* appears on the back cover of this issue. Both images are taken from "The Wireless News" by Bart Lee.

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Foreword

This year we celebrate the 30th issue of the *AWA Review* marking thirty years of publishing the most respected journal chronicling the history of electronic communication with a focus on antique wireless. It should be noted that the thirty issues were not published in consecutive years because there were no issues published in the years 1994 and 1997. Robert M. Morris, W2LV, was the editor for the first issue published in 1986, and he was supported by managing editor William B. Fizette, K3ZJW. This issue contained eight articles in 123 pages, and the introductory article by Charles M. Brelsford, K2WW, covered the founding and development of the Antique Wireless Association and the development of the AWA Museum. This issue must have been very popular because it was reprinted in January 1991.

From inception, there have been a total of eight editors and coeditors, all of whom are listed on the masthead of this issue. Robert Murray had the longest run as editor with ten issues (Vols. 19–28), while William Fizette was second with six issues as editor (Vols. 9–13) plus three issues as managing editor (Vols. 1–3). William Fizette's most memorable issue is undoubtedly Vol. 12, published in 1999, with a single article entitled "The Atwater Kent Radios" written by Ralph O. Williams, NV3T. This issue is the only one that was devoted to a single feature article.

The format of the *AWA Review* and the cover created for the first volume endured for the first sixteen issues. The first three issues had a photograph of antique wireless equipment on the front cover that had nothing do with the articles inside. When William Fizette became editor, he started the tradition of placing a photograph on the cover that was associated with one of the articles within. Brian Belanger gave the cover a new look when he became editor of Vol. 17 in 2004 by placing a table of contents on the cover, which was accompanied by a photograph from each of the five papers in the issue. He repeated this cover format on the 2005 issue. When Robert Murray became editor of Vol. 19 in 2006, he instituted many changes over his ten-year tenure that improved the articles and modernized the format. He is credited with expanding the range of content, requiring peer review of all articles, adding full color to selected papers and the cover, and engaging Fiona Raven Book Design to develop creative layouts and unique covers. Bob Murray's wrap-around design on the cover of the 2012 issue depicting the Silent room of the *Titanic* on the front and the Marconi wireless room on the back will long be remembered. That issue, marking the centennial of the sinking of the *Titanic*, quickly sold out and was reprinted the next year.

This year continues the traditions set by Bob Murray with eight high-quality, peer-reviewed articles and another creative cover layout using images appearing in Bart Lee's article, "The Wireless News." All but one of these articles were written by returning authors that have published in the *AWA Review* before. We welcome our new author this year, and hope to have many more new authors in the future. A brief summary of each paper follows in the order they appear.

- **David Wunsch** examines an article written by Nikola Tesla entitled "The True Wireless," which appeared in the *Electrical Experimenter* magazine in May of 1919. He finds that Tesla was unable to assimilate a paradigm shift in the scientific discipline that explained the existence and generation of electromagnetic waves—the basis for wireless telegraphy and eventually radio. He quotes Tesla's classic statement from the article: "The Hertz wave theory of wireless transmission may be kept up for a while, but I do not hesitate to say that in a short time it will be recognized as one of the most remarkable and inexplicable aberrations of the scientific mind which has ever been recorded in history."

- **Robert Rydzewski** writes about Zeh Bouck, born John W. Schmidt (1901–1946), who was an early radio pioneer, engineer, writer, and adventurer. He helped design the Pilot Super Wasp and flew it on the first ever flight to Bermuda, penned stories and radio plays, was an associate editor for Radio Broadcast and CQ, and was also an IRE Fellow and a member of the Radio Club of America. Despite an array of achievements worthy of a real-life Indiana Jones, today Zeh Bouck is an obscure footnote to radio history. Robert revives him and gives him new life with his article.

- **Robert Lozier** continues his tradition of writing about interesting and unusual broadcast receivers manufactured outside the United States. Robert does not disappoint us this year with his description of a unique broadcasting system operated in the former USSR known variously as "radio-diffusion exchanges," "cable radio," or "wired radio." They were centralized receivers with wire lines going to subscriber apartment buildings, factories, public halls, or schools and were operated much like telephone exchanges. Even more unusual were the thermoelectric generators that powered these radios, one of which is chronicled in the article.

- **Mike Molnar** explores the history of consumer radio and television manufacturing at Westinghouse from the late 1910s to the end of the twentieth century. He raises many questions about Westinghouse sets and answers most of them. When was it made? Where was it made? Why are the ID tags on two radios so different? Surprisingly, the collector may have to ask, who really manufactured it? Read on and puzzle through some of these mysteries with the author.

- **Bart Lee** informs us that for well over a century, wireless radio provided ships at sea and their well-off passengers with current news of the world, market data, and sports. The wireless news has been indispensible to voyagers of many sorts, especially on transoceanic routes. We learn about the general content of wireless news publications, the companies who provided the wireless news, and how the news was received, printed and distributed to passengers on the ships. Bart also provides many examples of publications carrying wireless news—many in full color.

- **Eric Wenaas** discovered the previously unknown papers of Henry K. Huppert, which he recently found in the possession of his granddaughter, Claudia M. Benish, who inherited them from her father, Ralph M. Huppert. These papers chronicled in his article contain technical notes, photographs, and other memorabilia of Henry Huppert, who designed the Solenoid tube, the Two-in-One tube, the Quadrotron tube, a unique thermionic X-ray tube with a control grid but with no trade name, and a diathermy machine with the trade name "American Radio-Thermy."

- **David and Julia Bart** tell us about the contributions of the U.S. Naval Radio School that was established at Harvard University in 1917 to train naval personnel to operate and repair radio equipment used in WWI. They explain how, in only eighteen months, the Navy came to train nine of every ten naval radio operators who served in the war. The article is filled with historic photographs taken at Harvard as well as photographs of associated memorabilia from the authors' collection.

- **Mike Adams** recently discovered the unchronicled story of early radio broadcasting at Denison University while researching at the Denison University Library. This library holds papers of Richard Howe, the prescient professor that instituted radio broadcasting at Denison in the early 1920s. The Denison story is so compelling because Howe kept detailed records and memorabilia of his radio broadcasting activities, which included correspondence with the Department of Commerce, early broadcast and experimental licenses, listener verification cards, photos of equipment, and much more.

We extend our sincere thanks to the authors for their excellent articles and to the reviewers for their able assistance in reviewing the articles and making suggestions that improved the manuscripts. I also thank the two associate editors, Bill Burns and Joe Knight, who assisted me this year. Their contributions were considerable. The *AWA Review* used the services of book designer Fiona Raven once again to prepare the *AWA Review*. Her help this year was invaluable, as it has been in the past. We thank Fiona again this year for her contributions and creative spirit.

The word-searchable cumulative Table of Contents has been updated this year and is now current though Vol. 30. This index can be accessed on the AWA website at http://www.antiquewireless.org/awa-review.html.

I have enjoyed serving as editor of the *AWA Review* this year and working closely with each and every author. I will continue to serve as editor of the *AWA Review* for at least one more year. I look forward to receiving manuscripts for your articles next year. Tips for authors who intend to submit articles follow.

Eric Wenaas, Ph.D.
Editor
San Diego, California

Tips for Authors

The *AWA Review* invites previously unpublished papers on electronic communication history and associated artifacts with a focus on antique wireless. Papers will be peer reviewed to verify factual content by reviewers whose identity will remain anonymous. This process gives the *AWA Review* credibility as a source of correct historical information. The papers will be edited to provide uniformity in style and layout among the articles. In general, shorter articles of six to eight pages (3,000 to 4,000 words) or less should be submitted to the *AWA Journal*, which is published quarterly. The *AWA Review* is intended for longer articles on the order of 6,000–8,000 words. Longer articles may be accepted with preapproval by the editor.

The *AWA Review* will also publish Letters to the Editor as deemed appropriate. The letters should comment on articles published in the previous issue of the *AWA Review* or make brief comments on wireless history as it relates to one of the articles. Letters will not be peer reviewed, but they may be edited. Text is limited to 400 words and no more than 10 references. The editor reserves the right to publish responses to letters.

It is strongly recommended that authors planning to prepare an article for the *AWA Review* send an abstract of approximately 200 words to the editor describing the subject and scope of the paper before writing the article, including an estimate of the number of words. It is never too early to submit an abstract. Space in the *AWA Review* is not unlimited, so it is important for both editors and authors alike to have an estimate of the expected number of articles and number of pages for each article as soon as possible. The deadline for submissions of manuscripts in 2018 is January 1. Papers will be accepted after January 1, but papers submitted and accepted for publication before January 1 will have priority in the event that there is not space for all papers submitted.

Authors with an interesting story to tell should not be discouraged by a lack of writing experience or lack of knowledge about writing styles. The *AWA Review* will accept manuscripts in any clearly prepared writing style. Editors will help inexperienced authors with paper organization, writing style, reference citations and improving image quality. Edited manuscripts will be returned to the author along with comments from the editor and anonymous reviewers for the author's review and comment. The manuscript will then be set in its final form and sent back for one final review by the author. Normally, only one review of the layout will be accommodated.

To summarize, please submit completed manuscripts by January 1, 2018 (or earlier if possible) in three separate files:

1) A manuscript file *without* embedded figures or figure captions using Microsoft Word or other software that is compatible with Word. The manuscript should have a 200-word abstract, a main body with endnote citations and endnotes, acknowledgements, and several paragraphs summarizing the author's background.

2) A figure file with numbered figures that match the figure call-outs that *must* appear in a sentence of the manuscript text.

3) A figure caption file with a short description of each figure and an attribution for each figure identifying its source.

You may use the articles in this issue as a template for the style and format of your paper. For more information, consult the AWA website at http://www.antiquewireless.org/awa-review-submissions.html. Please feel free to contact me for any questions:

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Paradigm Lost: Nikola Tesla's True Wireless

We examine an article written by Nikola Tesla entitled "The True Wireless," which appeared in the *Electrical Experimenter* magazine in May of 1919. His essay is analyzed as an example of the inability of a scientist or inventor to assimilate a paradigm shift in his discipline, and we use the language and thought of Thomas Kuhn in this discussion. The paradigm shift in question was created by Maxwell and Hertz in the latter third of the 19th century, a shift that explained the existence and generation of electromagnetic waves—the basis for wireless telegraphy and eventually radio. We also focus on the magazine in which Tesla's piece appeared and consider why the article might have been written and accepted for publication.

"The Hertz wave theory of wireless transmission may be kept up for a while, but I do not hesitate to say that in a short time it will be recognized as one of the most remarkable and inexplicable aberrations of the scientific mind which has ever been recorded in history."

—Nikola Tesla, "The True Wireless" 1919

"… the man who continues to resist after his whole profession has been converted has ipso facto ceased to be a scientist."

—Thomas Kuhn, *The Structure of Scientific Revolutions* 1962

The Paradigm

For historians of radio and the wireless telegraph, one of the strangest documents they are apt to encounter is an article entitled "The True Wireless" that was published in the May 1919 issue of the popular magazine, the *Electrical Experimenter*. The author was the renowned Serbian-born inventor, Nikola Tesla (1856–1943). Tesla spent most of his professional life in the United States, and by 1919 he was just past the peak of his fame—a man as nearly well known to the general public as Edison. He was a contributor to the Sunday supplements of newspapers, where he described his latest proposed inventions such as a weapon that would make war obsolete by creating an enormous tidal wave.[1]

Although his reputation as an inventor may have faded, he persists today as a cult figure. A web search will lead to sites proclaiming that he invented radio, radar, x-rays, alternating current, the laser, the transistor, and limitless free energy. His name also endures as the brand of a pioneering high-priced electrical automobile.

There is some irony in this—the car is powered by batteries that supply direct current (DC), while Tesla's great accomplishment resides in his contribution to the generation and distribution of polyphase alternating current (AC). He developed an ingenious device, the induction motor, that is ideally suited to polyphase AC because of the ease with which such current creates the rotating magnetic field required by many motors.

Readers of this paper should have at their disposal a copy of "The True Wireless," which can be found on the Internet.[2] Note that the insert appearing in the article was written by the magazine's editor, Hugo Gernsback, who asserted, "Dr. Tesla shows us that he is indeed the 'Father of wireless.'" Tesla is referred to variously as an engineer, physicist, scientist, and inventor on many websites, including the Wikipedia, which contain his biography. Historically, this blurring of occupations has a distinguished lineage: Galileo, for example, invented telescopes and other instruments and was also an astronomer, and the transistor was invented by men trained as scientists, not engineers.

A Paradigm Missed

Had Tesla's paper appeared fifteen years before—*circa* 1904—its content would be unremarkable. Coming as it does in 1919, just before the era of broadcast radio, it becomes useful as a notable example, in the field of science and technology, of an inventor's failure to grasp what the distinguished historian of science Thomas Kuhn has described as a "paradigm shift."

This term first appears in Kuhn's book *The Structure of Scientific Revolutions* published in 1962. The work is among the most cited scholarly books produced in the last half of the 20th century and has been in print in various editions for over 50 years. We refer here to the 3rd edition of 1996.[3] The expression *paradigm shift* has entered everyday language, and its use has steadily increased since Kuhn coined the phrase. The concept will be employed here in the discussion of Tesla's paper.

What does Kuhn mean by this term? In the sciences, he asserts that a *paradigm* derives from "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners." The word "*model*" is key here. The Greek-Egyptian astronomer Ptolemy (100–170 AD) had a model of what we now call our solar system: his earth was at its center, and the sun revolved around the earth. The concept has a limited use—it does explain sunrise and sunset, but as mankind's knowledge of the planets and stars increased, it became unworkable. Copernicus, Galileo, Kepler, and Newton killed the old model—their work, which began *circa* 1540 and occupied nearly two centuries, led to a classic paradigm shift. The shift describes the discarding of an old model whose use is unfruitful and untenable in favor of a new paradigm that more gracefully and convincingly describes recent experimental evidence.

For our present discussion, the important paradigm shift began with the Scotsman James Clerk Maxwell (1831–1879). Consider what Nobel Laureate Richard Feynman said about Maxwell's work of the period 1860–1873: "From a long view of the history of mankind—seen from, say, ten thousand years from now—there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics."[4]

Maxwell produced a paradigm, or a model, for light: it was an electromagnetic wave having transverse electric and magnetic fields. The theory described a wave moving at the speed of light that could be generated by electrical means, and it did not specify a wavelength—it could be, for example, 700 nanometers (like visible light, whose wavelengths were known in Maxwell's era), or around 300 meters (like broadcast AM radio of our time).

In the late 17th century, Newton had maintained that light consisted of streams of particles, which he named *corpuscles*; his prestige was such that his model still had some adherents as late as Maxwell's era, although there was much evidence favoring a wave theory. To further complicate matters, others analyzed light as a *ray* that describes the path of the light energy.[5]

We now come to a narrative familiar to many readers. In the period 1886–1889, the German physicist Heinrich Hertz carried out a series of experiments in which he generated a wave that exhibited wavelengths on the order of meters, possessed a measurable electromagnetic field, and to a fair approximation moved at the known speed of light.[6] These waves could be reflected, polarized, and diffracted—just as visible light, whose properties had been studied for several centuries. Had the Nobel Prize been awarded in the lifetimes of Maxwell and Hertz, they would surely have been winners. Hertz's work was published in the period 1887–1891 and served as a stimulus to such people as Guglielmo Marconi, Oliver Lodge, and Karl F. Braun, who sought to employ Hertz's discovery in the field of wireless telegraphy. The story is well told in the book by Aitken.[7]

Tesla recounts a meeting with Hertz in the document we are studying: he traveled to Hertz's laboratory in Bonn, Germany, in 1892 and describes in "The True Wireless" an unfruitful encounter where he informs Hertz that he had been unable to reproduce his results. If we believe Tesla, the two parted "sorrowfully" with our narrator subsequently regretting his trip.[8] He also informs us that later, even having developed a "wireless transmitter which enabled me to obtain electromagnetic activities of many millions [sic] of horse-power," he was unable to "prove that the disturbances emanating from the oscillator were ether vibrations akin to those of light…" Unable to generate what soon became known as Hertzian waves, and having read articles describing such waves over the eighteen-year period preceding this article, he remarks, "The Hertz-wave theory, by its fascinating hold on the imagination, has stifled creative effort in the wireless art and retarded it for twenty-five years."

By the time Tesla wrote his article, wireless telegraphy had been a business for nearly 20 years—and had grown into a very big one at that. When the United States entered World War I in 1917, the Marconi Wireless Telegraphy Company of America (American Marconi) had outfitted 582 wireless stations on ships and possessed 45 coastal stations for ship-to-shore and international communication.[9] The Navy took these over at the beginning of the war. At the cessation of the war, British Marconi was eager to buy exclusive rights to the Alexanderson alternators from General Electric; these were powerful and efficient successors to the spark gap and arc transmitters used earlier in wireless telegraphy. Initially, they planned to spend over $3M on 24 alternators and employ them both in their own corporation and in American Marconi.[10] If, as Tesla alleges, the big business of wireless telegraphy did not employ Hertzian waves, how did it operate? He specifically denies that the "disturbances" (a name he uses in lieu of Hertz's waves) emanating from an oscillator "were ether vibrations akin to that of light."

It is interesting to examine the language of his paper. He speaks of "some kind of space waves" and "transversal vibrations in the ether," and except to disparage them, he does not refer to Hertz's (or Hertzian) waves. By 1919, his words and thinking were archaic. The terminology in the discourse of radio and wireless telegraphy engineering had evolved since Hertz's work and the growth of international wireless telegraphy.

We now employ the Google Book's Ngram Viewer, a piece of free Internet software that quantifies how frequently a word turns up in a large number of books during a specified time period. The output of this software is a graph showing the number of mentions in books versus time (in years) for a word or phrase supplied. The frequency of use of the term *Hertzian waves* over more than a century is shown in Fig. 1. We see the term gaining currency beginning with Hertz's famous experiments and reaching a peak at about the time of Tesla's paper. It is not hard to understand that it subsequently lost popularity. A search of the term *electromagnetic waves*, which ultimately replaced *Hertzian waves*, is shown in Fig. 2.

As it became clear to the engineering community that the waves generated by Hertz were merely a part of the electromagnetic spectrum—one which was to become increasingly exploited by broadcast AM radio, television, and FM broadcasting—the locution *Hertzian waves* would have seemed anachronistic. It is evident that at the time of Tesla's writing, the term "Hertzian waves" had already been eclipsed by "electromagnetic waves." Incidentally, an Ngram of the term "radio waves" displays a curve much like that for electromagnetic waves. Both gained favor at the same time.

Fig. 1. Frequency of use of the term "Hertzian waves." (Google Ngram)

Fig. 2. Frequency of use of the term "electromagnetic waves." (Google Ngram)

Tesla "Disproves" Hertzian Theory

Electricity and Hydraulic Analogies

How did Tesla explain wireless communication without Hertzian waves or its synonyms? The answer is fascinating. He used a fishy version of alternating circuit theory. A close reading of "The True Wireless" reveals that he promoted a form of circuit theory employing but a single wire—in other words, there is no real circuit such as those who understood the subject are accustomed to. He also maintains that the earth itself can function—*must* function—as this lone wire. He seeks to explain this with a labored hydraulic (fluid) analogy that is illustrated in Fig. 4 of his paper, which is reproduced here as Fig. 3.

Of course, you can send a disturbance down a water filled pipe without employing a return circuit—just strike one end with a hammer. His analogy proves nothing, but its use is understandable. When Tesla was in college in the late 1870's and early 1880's, alternating current theory was a new and difficult subject.[11] If he learned

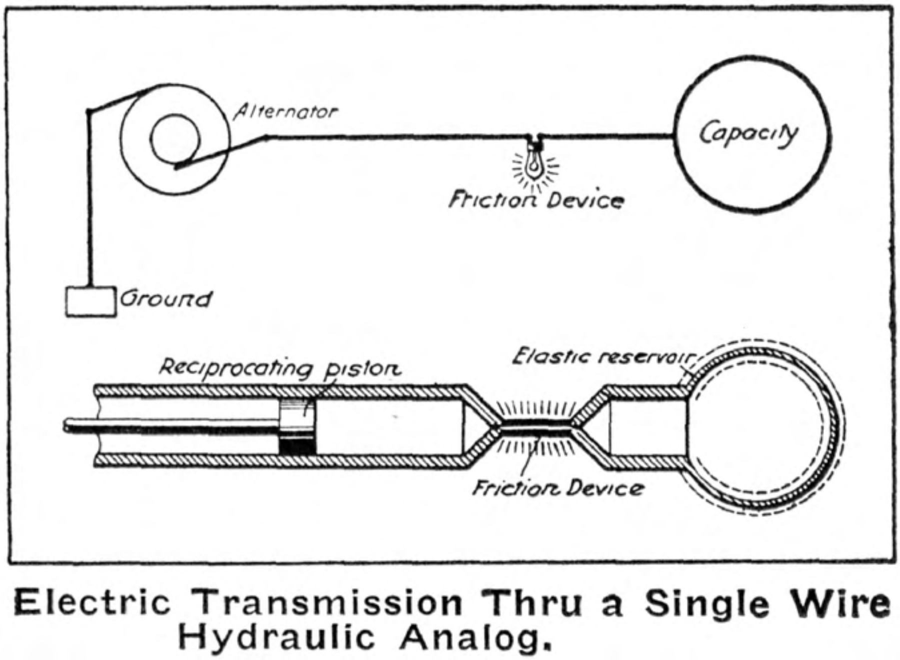


Fig. 3. Tesla's fluid "circuit." (*True Wireless*, Fig. 4)

it there, or, as seems likely, on his own after college, he would have encountered textbooks that sought to treat this discipline using analogies drawn from hydraulics—a much older and better-understood subject.[12] It was not uncommon then to use the word "pressure," taken from fluid mechanics, where we now use "voltage" or "electrical potential." Such analogies, which might employ water wheels to represent inductors and elastic diaphragms as proxies for capacitors, convey only an intuitive feeling for AC circuits and are of no use for communication systems employing electromagnetic waves.[13]

Thus, Tesla attempted to apply a dubious electric circuit approach where it had no validity. In fact, one wonders why no one asked him if the return wire in the circuit could be eliminated, then why not also the wire that carries the current that is outgoing from the generator. Had he taken that radical step, he might have been on his way to understanding communication between two antennas in the absence of any earth.[14]

In criticizing Tesla for his wrong-headed model, are we in fact guilty of what has become known as Whig history? The term Whig history was introduced by the distinguished English historian Sir Herbert Butterfield in 1931. It can refer to an unfair judgment of historical figures and their actions that are based on our present knowledge of what is humane and progressive and acceptable. For example, to condemn Thomas Jefferson for writing in the Declaration of Independence "All men are created equal" (where are the women?) would be to engage in Whig history. In the sciences, Whig history has a similar meaning: it would be to criticize a scientist or inventor of the past for failing to use concepts that we now take for granted.[15]

From our present perspective, Tesla's not using a wave model to explain radio seems bizarre, but given what was known in 1919, are we being unfair and leaving ourselves open to the accusation of Whiggishness? An example of Whig history of science would be to condemn Ptolemy for his earth centered view of astronomy. Given the tools at his disposal, his mistake is understandable. And to disparage Maxwell for his frequent use of the term ether—when we know that the concept is not valid—would be Whig history. I will seek to explain in what follows that I have not fallen into the trap of Whig history in discussing Tesla.

Influence of Mountains or Obstacles

Tesla seeks to disprove Hertzian wave theory as a means of communication with several examples. Consider his Fig. 17, reproduced here as Fig. 4. Tesla claims that "unless the receiver is within the *electrostatic* influence of the mountain range"—in what we would now call "the near field of the antenna"—the signals at the receiver "are not appreciably weakened by the presence of the latter because the signal passes *under it* [italics added]

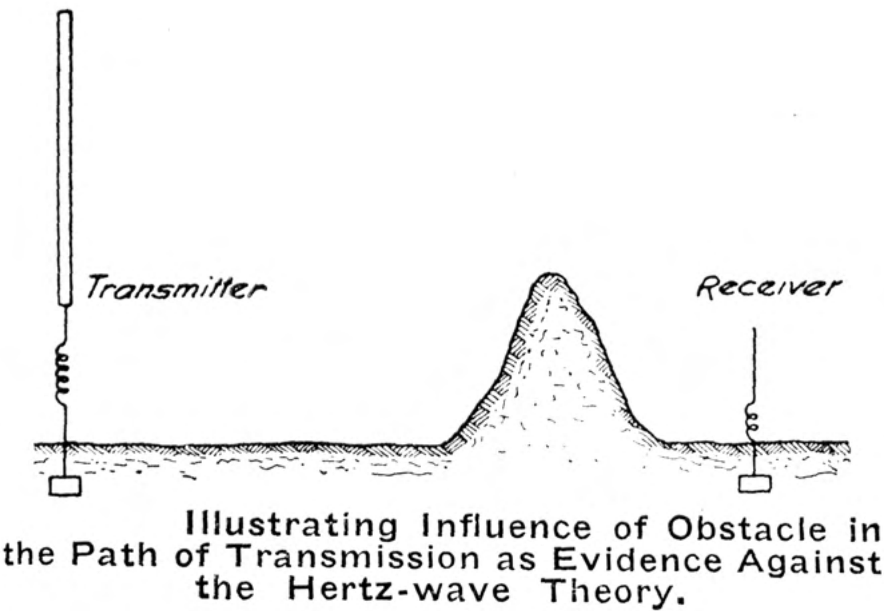


Fig. 4. Tesla analyzes the effect of an obstacle. (*True Wireless*, Fig. 17)

and excites the [receiving] circuit in the same way as if it is attached to an energized wire." No radio propagation engineer would have accepted such an argument in 1919. Indeed, the receiver might well detect the transmitted signal, but not for the reasons stated by Tesla. No model of wave propagation asserts that the signal goes *under* the mountain.[16]

Following the work of Hertz, it was apparent that laws of optics could be applied to electrically generated waves. There would have been no problem in explaining the reception of waves by a detector lying on the shaded side of the mountain—it would be described as Fresnel diffraction, a theory put forth by the eponymous French physicist in the period 1815–1818.[17] The theory asserts, in part, that the greater the wavelength used, the stronger the signal that makes its way into the optical "dark side," provided the distance from the diffracting edge (here, the mountain top) is small measured in wavelengths.[18] Given the long wavelengths employed by Tesla (10 kHz => 30 km. => 18 miles), a number taken from Fig. 1 in his article, there is no trouble in explaining wireless reception on the far side of the mountain. By the time Tesla published this piece, the subject of diffraction of electromagnetic waves had become sophisticated and had engaged the attention of a number of distinguished mathematicians.

If the mountain is modeled as a hemispherical impediment to the wave, and if the earth is a good conductor, then the problem of scattering by the mountain can be attacked using the method of images. The problem becomes that of a plane wave incident upon a sphere. This problem had been solved in the period 1908–9 by Debye and Mie and would also show a signal in the optical shadow cast by the hemispherical mountain.[19]

In the period beginning in 1889 and ending in the era of Tesla's writing, the Scottish mathematician H. M. Macdonald had treated waves from a Hertzian dipole diffracted from the earth, which he modeled as a perfectly conducting sphere.[20] His work was improved by the great French scientist and philosopher, Henri Poincaré, who in the period 1909–1912 converted Macdonald's series of Bessel functions into a definite integral that could be better evaluated. The German mathematical physicist Arnold Sommerfeld, unlike his predecessors, treated the earth as an imperfectly conducting surface, although he simplified matters by making the earth flat. He placed a vertical, electrically short dipole above the earth and derived an expression for the resulting electric and magnetic fields. His results of 1909 were expressed in terms of an integral that he evaluated asymptotically for an observer far from the antenna. He found that a surface wave had been generated, and his theory nicely supported that of another German, Jonathan Zenneck, whose less rigorous work had led to what became known as the Zenneck wave, which existed on the ground at some distance from the antenna. The latter turned out to be the asymptotic solution of Sommerfeld's theory. In 1919, the German mathematician Herman Weyl solved Sommerfeld's configuration and ended up with a different approach that did not contain Zenneck's wave. This result caused Sommerfeld to rework his solution, and his new findings did not agree with Zenneck.

In short, the first two decades of the 20th century was a lively and sometimes contentious period in the theory of radio wave propagation, but there is no hint of this in Tesla's paper. Nor is there any indication in anything he wrote that he had the sophisticated mathematical skills to comprehend what was being written by the people cited above. There were, of course, great inventors with minimal knowledge of higher mathematics (think of Edison, Morse, Bell) but these largely belonged to the 19th century, and one does see Tesla as part of that tradition. His clinging to a sketchy circuit theory explanation seems pathetic. Incidentally, as early as 1904, a textbook of Henri Poincaré had addressed the primacy given to currents flowing through the earth in Tesla's model of wireless telegraphy. He points out that if a coherer is placed in a hole in the ground "it will operate [as a detector of wireless telegraphy] when uncovered; if the hole be filled with earth, the oscillations produce no effect. We must look for something more than earth currents to explain the phenomena."[21] Recall that the most common detector in use at that time was the Branly coherer.

Putting aside theoretical considerations, Tesla's paper is notable for the omission of major empirical findings contained in the famous and practical Austin-Cohen formula, a concise expression that describes the strength of the electric field experienced by a receiving antenna when both receiver and transmitter are over the ocean. Louis Winslow Austin and Louis Cohen had worked for the U.S. Navy in the early 1910's, making shipboard electrical measurements of the field radiated from various transmitters manufactured by Reginald Fessenden's company, the National Electric Signaling Company, or NESCO. By 1911, the two men had devised a successful empirical formula that gives the received field.[22]

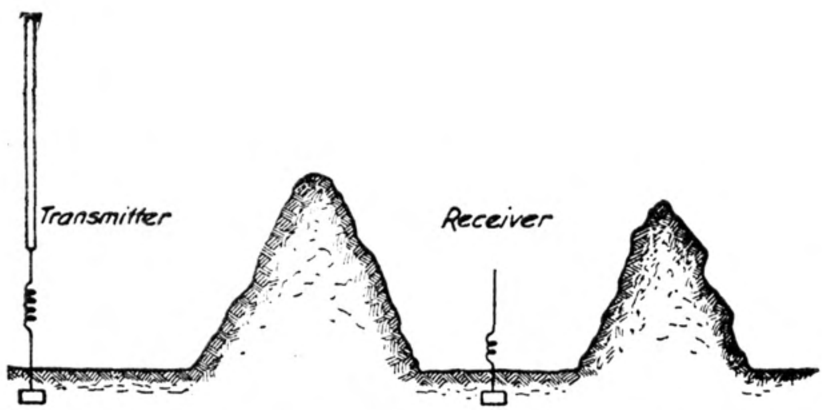
$$I_r = 4.25 \frac{I_s h_1 h_2}{d\lambda} e^{-ad/\sqrt{\lambda}}.$$

Here I_r is the current received by an antenna driving an impedance of 25 ohms, I_s is the transmitting antenna's current, h_1 and h_2 are the lengths of the two vertical antennas, λ is the wavelength, d is the distance separating the antennas, and $\alpha = .0015$. Lengths are in kilometers and currents in amperes. The formula was effective only during the day and was so useful that it became the basis for testing new theoretical predictions of received fields. The presence of the square root of the wavelength in the exponent was later derived theoretically by the English mathematician G. N. Watson and published in 1919, only a few months after Tesla's paper.[23] Interestingly, Tesla, speaking of the formula, states unequivocally "… the actions at a distance cannot be proportionate to the height [length] of the antenna and the current in the same," which is in direct contradiction to what the much-used equation asserts. Tesla's statement "the current in the same" is especially puzzling, not only because it had been established experimentally but also because he has essentially been using alternating circuit theory, in a strange form, and the device he is employing—an antenna, and a conducting earth—are mathematically linear and should, according to linear circuit analysis, create a response in linear proportion to the current exciting the antenna.

Strange to say, Tesla then uses Austin-Cohen to reject Hertzian waves, saying that, "…I cannot agree with him [Austin] on this subject. I do not think that if his receiver was affected by Hertz waves he could ever establish such relations as he has found." So, on the one hand, he rejects the famous formula but then embraces it as a means to argue against Hertzian wave theory.

Let us now study Fig. 18, in Tesla's paper, reproduced here in Fig. 5. He has now introduced a second mountain that is further from the transmitter than the one in the previous figure. He argues that if Hertzian wave theory were true, then the second mountain "could only strengthen the Hertz wave [at the receiver] by reflection, but as a matter of fact it detracts greatly from the received impulses because the electrical *niveau* between the mountains is raised…" [*niveau* is a French word for level surface].

What Tesla fails to understand here is that without knowing the wavelength of the radiation, the separation of the two mountains, and the position of the antenna between them, we can make



Showing Effect of Two Hills as Further Proof Against the Hertz-wave Theory.

Fig. 5. Tesla considers the effect of two hills. (*True Wireless*, Fig. 18)

no statement about the enhancement or reduction of the signal at the receiver caused by the presence of the second mountain. In fact, using elementary wave theory or a transmission line analog, we can argue that if the two mountains are separated by half a wavelength and if the receiver is midway between them, and if the soil is of reasonably high conductivity, then we have what is called a standing wave between the mountains. In this case, the effect of the more distant mountain is to enhance the signal at the receiver. There are waves moving from right to left and vice-versa between the mountains. Such an arrangement, when set up in a room, as Hertz did in his famous experiment published in 1888, is known as an interferometer.[24]

Kuhn tells us that if we want to see what constitutes "normal science" and the paradigms it embraces, we should look at the textbooks of that era.[25] By 1904, we can say confidently that the paradigm shift created by Maxwell and Hertz had taken hold and was part of normal science. This was the date of publication of Poincaré's book, whose chapters 7, 8 and 9 are devoted to the propagation of waves along wires, dielectrics, and air. It seems evident that Tesla was not reading the textbooks of his epoch.

Tesla and Antenna Theory

Another puzzling segment of Tesla's anti-Hertz diatribe is his Fig. 16, shown below as Fig. 6. Tesla would have us believe that the antenna on the right

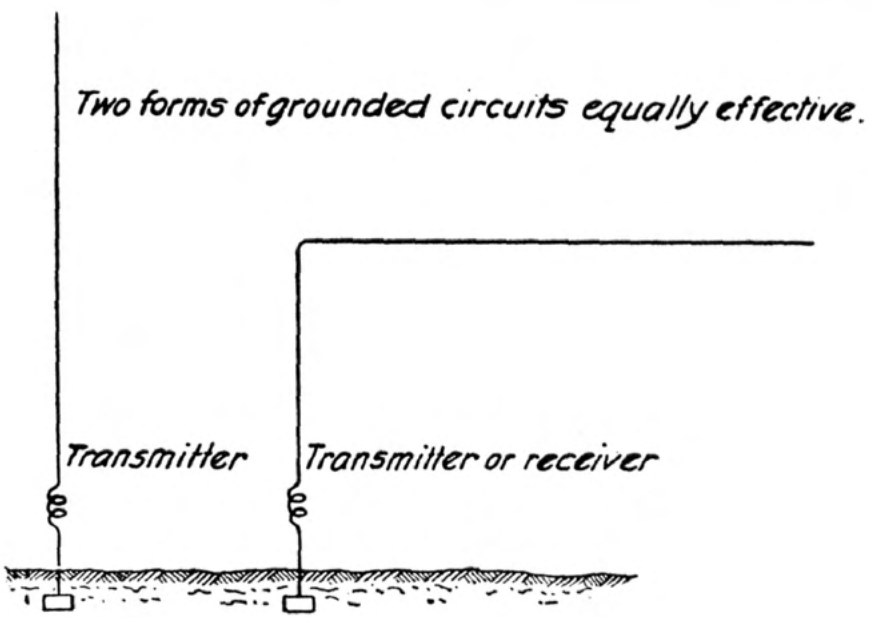


Fig. 6. Tesla considers a straight and bent antenna. (*True Wireless*, Fig. 16)

(which nowadays is called "an inverted L") is just as effective as a receiver or transmitter as the straight antenna on the left. He claims that he has performed an experiment that supports this conclusion. He also asserts that the experiment proves that "currents propagated through the ground, and not … space waves" is the reason for true wireless telegraphy.

In 1919, an understanding of the theory of receiving antennas was still fairly primitive.[26] And it was only in 1924, with the work on reciprocity of John R. Carson at Bell Labs, that the tools that had been developed to analyze transmitting antennas could be brought to bear on receiving antennas.[27] So, we must not be harsh in condemning Tesla for his wrongful assertion. However, it was known as early as 1898 that if antennas are placed above a flat highly conducting earth, one can invoke the method of images for analyzing them.[28] It was well known before 1919 that if the earth is a good conductor, the electric field of a propagating radio wave would be primarily perpendicular to the earth, and the field strength would be proportional to an integral of the current along the vertical portion of the antenna.

It should have been apparent to Tesla that if a transmitting vertical wire antenna is small, measured in wavelengths, and has the shape of the antenna on the left of Fig. 6, and if it is now bent into the shape shown on the right, then the electric field normal to a flat highly conducting earth is reduced.[29] However, the situation here is potentially quite complicated. The difficulty occurs with an *imperfectly* conducting earth. Marconi, in 1906, described to the Royal Society an array he built consisting of inverted L antennas and observed that the array broadcasts most effectively in the direction of the arrow shown below, i.e., *away from* the horizontal element.[30] Fig. 7 is taken from *Principles* of *Wireless Telegraphy* by G. W. Pierce, published in 1910.[31]

Jonathan Zenneck, in the same era as Pierce, describes the work of H. von Hoerschelmann, a student of Arnold Sommerfeld, who apparently was the first to explain the directive properties of Marconi's antenna. His earth is assumed to be imperfectly conducting. He includes the vertical portions of the current induced in the earth directly under the horizontal wires of the array.[32] The upshot is that whether one assumes a highly conducting earth or one of imperfect conductivity (as is required for Marconi's antenna), Tesla's assertion "that the antennas can be put out of parallelism without noticeable change in action on the receiver" is utterly wrong. Marconi's inverted L was constructed in the year 1905, and the explanation by Hoerschelmann was

Fig. 7. Marconi's directional inverted L antenna. (G. W. Pierce, *Principles* of *Wireless Telegraphy*, 1910, p. 298)

published in Zenneck's book, which came out in German in 1912, both well before Tesla's paper.[33]

Skin Effect

Tesla repeatedly speaks of his system of wireless telegraphy implemented by sending messages *through* the earth. Here he displays his ignorance of what is now referred to as "skin effect": that alternating currents have a marked tendency to cling to the outside (skin) of conductors. Knowledge of this goes back to the work of the Englishman, Sir Horace Lamb, in 1883 and was advanced further by his countryman, Oliver Heaviside, in 1885.[34] The results showed that the higher the frequency in use, the greater the tendency for the current to adhere to the outside of the conductor.

It is especially puzzling that Tesla does not mention this phenomenon as he took advantage of it in arranging for photographs of himself enveloped by sparks.[35] The frequency of the generator he was using was such that the energy would not penetrate deeply into his body, which meant that although he might have been burnt, he would not have been electrocuted. In an 1893 lecture before the Franklin Institute in Philadelphia, he sought to explain his not being shocked with a confused discussion.[36]

By 1919, skin effect and the concept of skin depth (the depth of penetration of the current) would have been in the better electrical engineering textbooks.[37] We can calculate how far a wave might penetrate into a mountain in the United States where typical soil conductivity, $\sigma = .005$ mhos/meter and the relative permittivity, $\varepsilon_r = 10$.[38] We will assume a frequency $f = 100$ kHz. Using the standard formula for skin depth that applies when conduction current greatly exceeds displacement current,[39] we have

$$\delta = \sqrt{\frac{1}{\pi f \mu \sigma}}$$

Here δ is the skin depth and μ is the permeability of the soil, assumed here to be nonmagnetic. The skin depth for the numbers chosen here is about 22 meters. It is virtually impossible for the signal that Tesla imagines to penetrate a mountain having these typical parameters.

Dismissal of Gliding Waves

Let us now focus on Tesla's Fig. 13 (shown here as Fig. 8) and his accompanying discussion. At the very top of his figure Tesla has the caption, "Hertz's waves passing off into space through the earth's atmosphere." To someone acquainted with even elementary antenna theory, the picture is a puzzle. It depicts what appears to be a vertical antenna fed by a generator connected between the base of the antenna and the earth. In 1919, such an antenna would likely be of small height when measured in the wavelengths in use. Using the method of images and antenna analysis dating from the turn of that century, it should have been apparent that no radiation propagates along the axis of the antenna; instead, the radiation

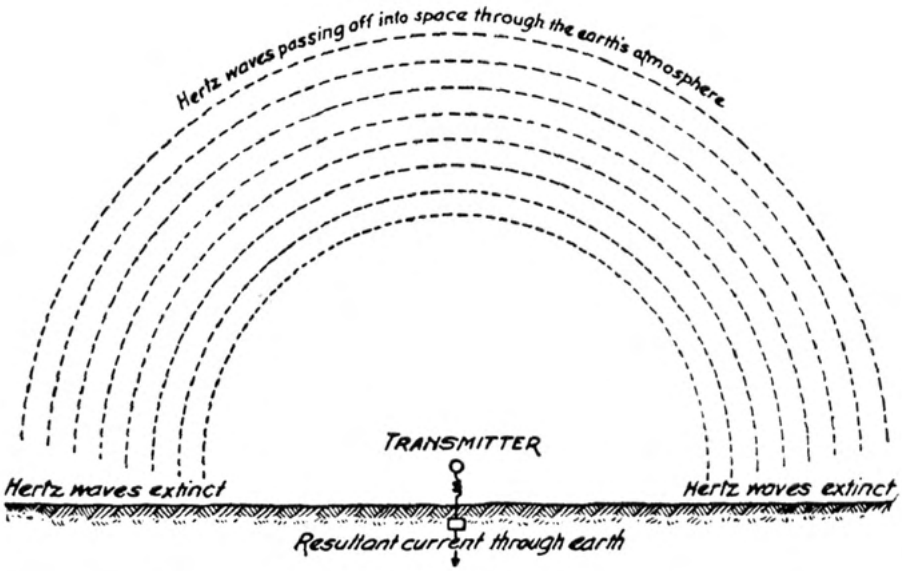


Fig. 8. Tesla condemns the "Gliding Wave." (*True Wireless*, Fig. 13)

tends to be focused along the ground. In fact, if the current in amperes along the antenna is I_0, then elementary antenna theory establishes that the strength of the electric field is at a distance *r* from the antenna, above the earth, is given by

$$E_\theta = \frac{I_0 120\pi h}{\lambda r}\sin\theta \text{ for } 0 \le \theta \le \pi / 2\,,$$

where *h* is the length of the antenna, *l* is the wavelength in use and *r* is the distance of the observer from the antenna.[40] All the distances are in meters. The meanings θ and E_θ should be evident from Fig. 9.

Observe that directly above the antenna corresponds to θ =0, so that sinθ = 0, which indicates there is no radiation normal to the earth, while along the earth θ = 90 degrees, and the radiation is maximum, which might suggest a wave gliding along the surface of the earth, provided we are close enough to the antenna to neglect the earth's curvature. This result would have certainly been known well before 1919. The book *Robison's Manual of Radio Telegraphy and Telephony for*

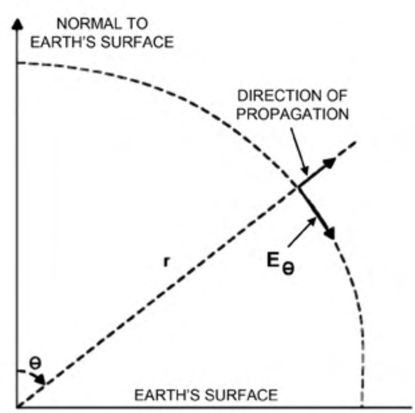


Fig. 9. Electric field and spherical coordinates.

the use of Naval Electricians, published in 1918, contains the following diagram showing the direction of electric lines (see Fig. 10).[41] It illustrates that a monopole antenna radiating above a flat perfectly conducting ground tends to radiate in a direction parallel to the ground and not in a direction along the axis of the antenna. This is not a polar plot of the field strength *vs.* angle but a picture showing the direction of the electric field at various locations. Incidentally, one can argue that there is no radiation along the axis of the antenna even if the ground has imperfect conductivity.[42]

Tesla specifically condemns any theory that claims "[space waves] pass along the earth's surface and thus affect the receivers. I can't think of anything more improbable than this 'gliding wave' theory which… [is] contrary to all laws of action and reaction." Of course, this gliding wave concept that we would now call a "surface wave" did describe daytime radio propagation and was central to the work of such theorists as Sommerfeld, Zenneck, and Watson.[43]

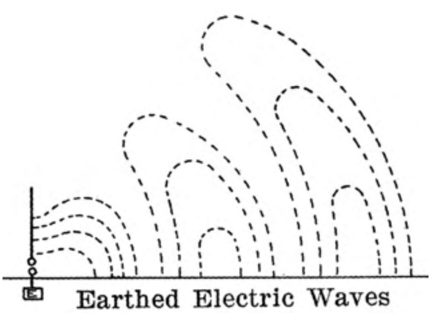


Fig. 10. Electric field lines of a short monopole antenna. (*Manual for U.S. Navy Electricians,* 1918)

Tesla Debunks the Ionosphere

Warming to the task of diminishing other theorists, Tesla then damns what was then only a conjecture: the belief in what was then known as the Kennelly-Heaviside layer. We now call this the ionosphere—a set of layers of three or more ionized gases in the earth's upper atmosphere. It was first postulated, as a single layer, in 1902 by Arthur Kennelly and Oliver Heaviside, working independently, as a way of explaining how radio waves propagate beyond the horizon.[44] Although its existence and height were not verified experimentally until 1924 by the Englishman Edward Appleton, for which he was later awarded the Nobel Prize, its presence was generally accepted in 1919, especially as a means to explain the long distances that radio waves would propagate at night.[45] Tesla tells us, "I have noted conclusively that there is no Heaviside layer, or if it exists it is of no effect." One wonders if he recanted this statement after Appleton's experiment.

Communication with Airplanes

Among the more perplexing aspects of Tesla's article is his discussion tied to his Fig. 15. He is showing here in Fig. 11 a "Hertz oscillator" suspended in the air, and uses this arrangement to explicate something that became well known during World War I: an airplane could communicate with a wireless receiver on the ground. Also known, but not discussed by Tesla, was that two airplanes in the air might experience radio contact with each other.

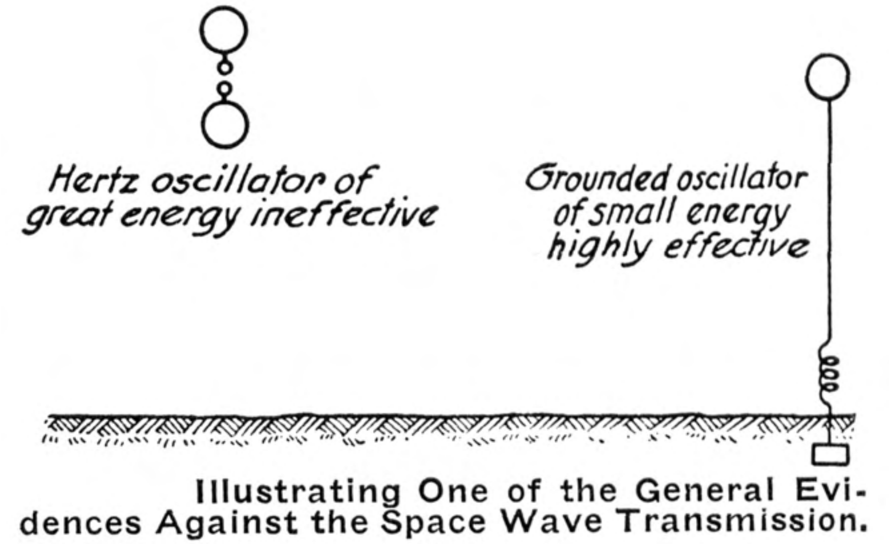


Fig. 11. Tesla denies there is "Space Wave" transmission in wireless telegraphy. (*True Wireless*, Fig. 15)

What Tesla must explain is how his transmitter in the air might communicate with the receiver on the ground in spite of its not having a direct connection to the earth that would be capable of effectively launching his crucial earth currents. His explanation is that "we are merely working through a condenser." Stating incorrectly there is a capacity that "is a function of a logarithmic ratio between the length of the conductor and the distance from the ground," he says the receiver is affected in the same manner as with an ordinary transmitter. Evidently, we are to believe that the capacitance between earth and ground makes possible the earth currents crucial to his argument.

The formula for the capacity of a wire that he is most likely referring to would have been well known by the 1910s when it already had appeared in textbooks and handbooks:[46]

$$C = \frac{1.111\ L}{2\ \ln\left(\frac{2h}{r}\right)} \text{ picofarads.}$$

This expression is the capacity of a wire of length L above, and parallel to, the earth's surface, which is assumed to be highly conducting. An airplane in flight dragging a wire antenna behind itself would create this situation. The wire is at height h above the earth, and its radius is r. All dimensions are in centimeters, and the logarithm is base e. Note that the capacity is proportional to the wire length L, not to the logarithm of L as Tesla asserted.[47] Using the well-known formula for capacitive reactance $X = 1/(2\pi f C)$, where f is the operating frequency, we could in principle obtain the impedance between the wire and earth. Dividing the voltage of the antenna, with respect to the earth, by this impedance, we might think we have obtained the current on the earth.

But what voltage are we to use? Because the antenna illuminates the earth with an electromagnetic wave, the concept of voltage difference or potential difference cannot be applied. It was known in the late 19th century that electric potential difference between two points is calculated by the line integral of the electric field along a path between those points. When there is a time varying electromagnetic field between these points the result will depend on the path taken and so the concept of voltage difference ceases to be of use.[48]

Note that Tesla skirts entirely the phenomenon of airplane-to-airplane wireless communication, which had been observed during the war.[49] Such communication could not possibly involve earth currents if the transmission took place over a desert or dry sandy soil.

The Hertzian Wave Discourse

The publication of Maxwell's *Treatise on Electricity and Magnetism* in 1873, which described his work of the previous decade, together with Hertz's experiments of 1886–9, created the paradigm shift which Tesla was unable to accept. We might be a little indulgent here—the new paradigm was slow to be accepted—consider Marconi for example.

By the late 19th century Marconi was being lionized in the British press because of his demonstrations of wireless telegraphy, but an interview in McClure's magazine from 1899 has him declining to say what sort of waves he was using: "What kind of waves they were Marconi did not pretend to say; it was enough for him that they did their business well."[50] When asked about the difference between his waves and those used by Hertz he replied "I don't know. I am not a scientist, but I doubt if any scientist can tell you..."[51] What seemed to impede the connection of Marconi's waves to those of Hertz's was that it was known by 1897 that the former's radiation could pass through the walls of a building while Hertz's, which was based on a model of radiation as visible light, would apparently not perform such a feat.[52]

Marconi's first British patent, number 12039, which was filed in 1896, speaks of an arrangement that he calls "a Hertz radiator" producing effects "which propagate through space [as] Hertzian rays." But he also talks of electrical actions or manifestations "…transmitted through the air, earth, or water by means of electrical oscillations of high frequency." For a while, Marconi's manifestations in the ether were known in some circles as Marconi waves, but the term soon died. Some further indication of the confusion, *circa* 1900, is a question raised by the historian of early wireless, J. J. Fahie, in his publication of 1901, "… is the Marconi effect under all circumstances truly Hertzian…?"[53]

After 1899, we find that Marconi began to refer more frequently in his work to "Hertzian waves." In a speech given before the Institution of Electrical Engineers (now the IET) in

England on March 2, 1899, he says, "I think it desirable to bring before you some observations and results I have obtained with a system of Hertzian wave telegraphy, which was the first with which I worked…."[54] His U.S. patent 676,332 of 1901 refers to "a transmitter producing Hertz oscillations." And, following Kuhn, we can say that Hertzian waves entered the discourse of "normal science" because we find extensive references to them in a textbook, e.g., Poincaré, cited above. In fact, studying the index of Poincaré, we find that he uses Hertzian waves and electromagnetic waves as synonyms. John Ambrose Fleming, who was the first Professor of Electrical Engineering at University College, London, and who did major work for Marconi beginning in 1899, published a textbook titled *Hertzian Wave Wireless Telegraphy* in 1903, in which there is not the slightest doubt that wireless telegraphy relies on the waves of the title.

Interestingly, Tesla, in certain of his turn-of-the-century U.S. wireless patents, refers to Hertzian waves, or "radiations," being "brought into prominence" by Heinrich Hertz.[55] In all of these instances, such waves are disparaged as being of an outmoded or less desirable way of transmitting signals, or energy, which should be discarded in favor of one that either uses extremely strong electric fields and high antennas to ionize a layer of the earth's atmosphere which is to then act as a conductor of a transmission system (which includes the earth's crust)—or of another that uses wavelengths so long as to make the earth into a conducting sphere that has been brought to a resonant condition. In the later case, he recommends using frequencies lower than 20,000 cycles per second (cps) and asserts one might go as low as 6 cps (patent 787,412, lines 260–270).

Maxwell and Einstein: Difficulties for Tesla

When Tesla wrote his True Wireless paper he was not a young man—he was 63. Male life expectancy in the United States was then 54. His formal education in science and engineering had taken place many years before. He had studied for somewhat less than three years at the Austrian Polytech in Graz Austria in the late 1870's. In 1880 he audited courses at Charles Ferdinand University in Prague but was not enrolled. His course work should have given him a solid grounding in electric circuit theory, and it was in school that he developed a great interest in alternating currents, especially for motors.[56] It is highly unlikely that Tesla would have studied Maxwell's theory while at school. As first presented in 1873, it was so difficult that few could understand it; nowhere will you find in Maxwell's treatise the four succinct equations studied today by all electrical engineering and physics students. His analysis is based entirely on potentials, not the electric and magnetic fields used now. He used 20 equations and 20 variables, and it was only through the efforts of such people as Hertz, Heaviside, and Willard Gibbs in the late nineteenth century that the equations were to assume the form we find them in today.[57] Even with their simplifications, we know that Maxwell's theory was not systematically taught at Cambridge University until after around 1900.[58] Because Hertz's famous experiment was inspired by Maxwell's work, which Tesla most likely did not understand, it seems plausible that Tesla might cling to an electric circuit theory paradigm in explaining what was called wireless communication. Note however, this was not canonical circuit theory—Tesla had added some bizarre features of his own to force it to explain wireless telegraphy.

Maxwell's theory and its experimental verification by Hertz is not the only paradigm shift in Tesla's era that he was unwilling to accept and understand. Throughout his life, he spoke often of particles that moved faster than light—a direct contradiction of Einstein's theory of relativity.[59] In an interview with *Time* magazine on the occasion of his 75th birthday in 1931, he claimed to have "split atoms" with *no release* of energy—again a contradiction of relativity. He also asserted that he had, using "pure mathematics," come up with a theory that "tend[s] to disprove the Einstein theory." There is no indication that Tesla ever had the knowledge to derive a competing theory.

Circa 1930, Tesla wrote a poem for his friend George Sylvester Viereck in which he muses about science.[60] One stanza addresses Newton and contains these lines:

"Too bad, Sir Isaac, they dimmed your renown
And turned your great science upside down.
Now a long haired crank, Einstein by name,
Puts on your high teaching all the blame.
Says: matter and force are transmutable
And wrong the laws you thought immutable."

Note the "long haired crank"—Tesla's name for the man who overthrew the Newtonian paradigm of mechanics.

Much has been written about opposition to Einstein's theory of relativity; this hostility reached its peak in the two decades following the confirmation of the general theory of relativity via the measurement of the bending of starlight by the sun's gravitational field in 1919.[61] Some of this opposition was rooted in anti-Semitism, as the preceding reference shows, and we do know that Tesla had anti-Jewish tendencies.[62] In addition, Hertz, whom he diminishes, was, like Einstein, of Jewish origin,—only partly in Hertz's case—but it seems more likely that the statement to *Time* magazine derives more from an almost pathological narcissism that compelled him to be in the public eye.

Tesla has been called a scientist, engineer, and inventor. While the confusion and angst that can befall a scientific community having difficulty in adapting to a paradigm shift has been much written about, especially after Kuhn's seminal publication, the effect of a scientific paradigm shift on inventors, as opposed to scientists, has been less explored.[63] When we study the lives of individual inventors or engineers we can find failure to adapt to a paradigm change.

Shifting Paradigms in Invention

Besides Tesla, whose inability to absorb a new paradigm should be evident, we have the example of yet another great inventor, Thomas A. Edison. Edison had little formal teaching in schools and was largely educated by his mother and by his own readings. His first important work experiences and inventions were in the field of the [wired] telegraph, which operates using direct currents, and it is clear that he obtained a strong intuitive grasp of DC theory. It is understandable that his subsequent system of generating and distributing electric power was all based on DC. Paul Israel, the esteemed biographer of Edison and editor of the Thomas Edison papers, remarks, "While experimenting with generators, Edison again relied on his experience with telegraph technology to provide a useful analogy that guided laboratory research." Israel points out how Edison and his workers sometimes envisioned direct current generators as "carbon battery elements."[64]

Historians have written about Edison's unwillingness to adapt to the newly introduced system of AC electric power, which posed a direct economic threat to his own DC system.[65] We will probably never know for sure if his objection to AC was truly based on his concern that it was more lethal than DC, or whether he was acting out of pride, inertia, economic self-interest, or an inability to grasp a phenomenon requiring some mathematical sophistication that eluded him. His statement in 1891 to Henry Villard, President of Edison GE, "The use of alternating current instead of direct current is unworthy of practical men," has proved to be as fatuous as Tesla's notion that Hertzian wave theory is "an aberration of the scientific mind."[66]

Age and Vanity

We are left to wonder why Tesla wrote this long paper displaying a wealth of ignorance. One clue might come from an article about him that appeared in the *New York Times* of January 9, 1943, a few days after the inventor's death. The generally admiring piece observes, "His practical achievements were limited to the short period that began in 1886 and ended in 1903. And what achievements they were." By 1919, Tesla's last important work had taken place more than half a generation before. Studying a list of Tesla's patents, we find that about 90% of them were filed on or before 1903, and all of his important ones were granted before this date.[67]

Resurrecting Tesla's Reputation

His *Electrical Experimenter* piece can be read as a rather sad effort to resurrect his reputation. Moreover, his denigration of Hertzian waves and promotion of the primacy of earth currents may be seen as an attempt to preserve respect for his construction of a 187-foot tower (capped with a sphere) in 1901–1903 on

Shoreham, Long Island, whose purpose was to produce a "World Wireless System" that would radiate "several thousands of horsepower" and permit the connectedness of all the telephone and telegraph exchanges in the world by wireless means. The system was to use currents in the earth but was never demonstrated.[68]

Consider his allusion in "The True Wireless" to a speech he gave in 1893 at the Franklin Institute where there is a portion entitled "Electrical Resonance." He remarks in 1919, "This little salvage from the wreck has earned me the title of 'Father of Wireless' from many well-disposed workers …" Perusing the speech, we wonder who these well-disposed workers are.

In his Institute lecture he asserted, "I do firmly believe that it is practicable to disturb by means of powerful machines the *electrostatic* condition of the earth and thus transmit intelligible signals and perhaps power… We know now that electrical vibration may be transmitted through a single conductor. Why then not try to avail ourselves of the earth for this purpose [italics added]?"[69] Notice the use of the word *electrostatic*. His proposal is not based on any use or understanding of electromagnetic waves. As further proof of this, he goes on to wonder what the electrical capacitance of the earth might be and "the quantity of electricity the earth contains." None of this thinking proved germane to communication by wireless telegraphy nor is his obsession in the article with determining the period of oscillation of currents that might be induced in a resonant earth.

Strengthening Tesla's Claims

In a further attempt to strengthen his claims to invention in wireless, Tesla lays claim to discovering the forerunner of the Audion in the caption to his Fig. 9 (reproduced here as Fig. 12). The captions reads, "The Forerunner of the Audion—the Most Sensitive Wireless Detector Known, as described by Tesla in His Lectures Before the Institution of Electrical Engineers, London, February, 1892." It is instructive to read the text of the talk where he discusses his "forerunner."[70] He begins by paying homage to Professor Crookes and his invention, the Crookes tube. Like Crookes, Tesla is not using thermionic emission. He employs a cold evacuated glass bulb, like a lamp bulb, but with no filament. The bulb, which has a "high vacuum," contains some conducting powder, which in turn is connected by a wire to one terminal of a high frequency, high voltage induction coil. The bulb has a sheet of metal foil on its surface that is also connected to the coil for some experiments, but not others. The

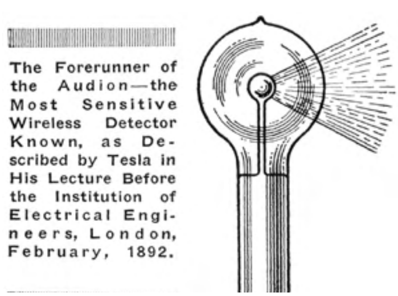


Fig. 12. Tesla's "Forerunner of the Audion." (*True Wireless*, Fig. 9)

straight lines that you see in the figure he calls a "brush"; it gives off a glow that he calls luminosity—whose shape and form he reports is very sensitive to the presence of objects or nearby electric or magnetic fields.

However fascinating his demonstration, Tesla still has not produced the forerunner of the Audion. The latter, we recall, was invented by Lee de Forest, and was the first working three-element vacuum tube. His patent application is dated January 29, 1907, and it issued on February 18, 1908. Despite de Forest's confused understanding of his invention, within the next half dozen years it was proving its worth as both an amplifier and an oscillator. If we want to see the forerunner of the Audion we must look to the work of Fleming and Edison, whose devices, like de Forest's, relied on *thermionic emission*. The distinguished historian of the vacuum tube, Gerald Tyne, makes no mention of Tesla in his well-regarded opus.[71] This is not surprising—Tesla's bulbs responded by glowing only in the presence of strong, quasi-electrostatic fields produced by his machines.

It is regrettable that Tesla's narcissism caused him to write this paper—it can only provide difficulty for his acolytes and apologists. The ignorance he displays of classical electromagnetic theory, which by 1919 was a mature subject, can only diminish his reputation.

Gernsback and His Magazine

If Tesla's True Wireless is so utterly wrong, and if it conflicts with the paradigms used by engineers and scientists of 1919, how did he get his article published? To answer this, we must focus on the magazine where it appeared and its editor/publisher Hugo Gernsback (1884–1967).[72] Almost a generation younger than Tesla, Gernsback had certain things in common with him: they were both inventors with substantial lists of patents—Gernsback had 22, Tesla 112; both came from groups that placed them in small minorities in the United States (Gernsback was a Jew from Luxemburg); both studied science and engineering on the European continent; and both occupied a kind of nether world bridging science and fantasy.[73] They apparently had a lasting friendship that would tend to counter suspicions that Tesla was an anti-Semite. Gernsback pressured the Westinghouse Company, which had benefited greatly from Tesla's work in three phase power and induction motors, to give the near destitute inventor a pension in 1934.[74]

Gernsback's Electrical Experimenter

The *Electrical Experimenter,* started by Gernsback in 1913, is where we find Tesla's article six years later.[75] Although the term "science fiction" did not exist until coined by Gernsback in 1929, his magazine *Modern Electrics* carried a serialized story of that genre in 1911–12, written by Gernsback—something to keep in mind when we look at the *Electrical Experimenter,* where Tesla was to publish abundantly in the 7-year life of that magazine.[76]

What sort of magazine was the *Electrical Experimenter*? It was dense with ads for radio hardware, e.g., Murdock headphones and audio interstage transformers as well as Grebe and De Forest radios. Mainly, it carried stories of new inventions, especially those with an electrical basis, such as a new radio compass, a method of abolishing smoke electrically, new electric stoves, and quack medicine—anesthesia via electricity and an electrical cure for tuberculosis using the Tesla coil.[77] Much of the magazine was given over to what we would now call "techno-euphoria"—a belief that technology would bring us wonderful things in the not-too-distant future. One example was the Thought Recorder, shown in Fig. 13.

The author of the article is none other than Gernsback himself. He imagines a man in an office who is connected to a halo on his forehead. The halo is supporting an Audion amplifier tube that detects and amplifies the man's thoughts. They are then sent to an instrument on his desk that converts his thoughts to an inscription on a moving tape. The latter is supplied to the man's secretary who is capable of reading the information on the tape and who can now write letters or memos based on what the boss has been thinking. The article appears in the same issue as Tesla's, and Tesla, in an introduction, gives some measured support to the idea. Interestingly, Greenleaf Whittier Pickard, a distinguished electrical engineer who helped develop what we would now call the crystal radio, *circa* 1904, also comments and employs the term "Hertzian waves," illustrating how commonly the phrase was used.

The *Electrical Experimenter* does seek to explain legitimate recent advances in the sciences. For example, Einstein's special and general theory of relativity and the general theory's

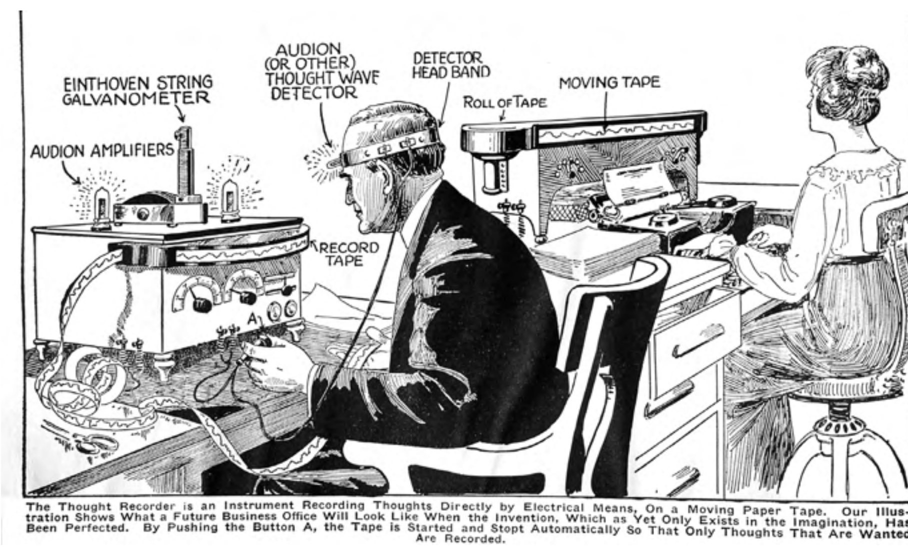


Fig. 13. The "Thought Recorder." (*Electrical Experimenter*, May 1919)

confirmation by the observed bending of light are carefully described in the January 1920 issue by an unusual person for the era: a female astronomer, Isabel M. Lewis, M.A, who was a regular contributor and the first woman astronomer to be hired at the U.S. Naval Observatory.[78] The magazine also published pure science fiction stories, such as "At War with the Invisible" appearing in the March and April 1918 issues, which described a war between the planets Mars and Earth in the 21st century.[79]

Science Fiction, Nostalgia for the Future

Unfortunately, a magazine mixing techno-euphoria, future studies, science fiction and real science is playing dangerous games: the boundaries became diffuse. The March 1918 *Electrical Experimenter* has an article by Gernsback starting on page 743 entitled "Can Electricity Destroy Gravitation?" The author asserts it can, and describes the work of a Prof. Francis E. Nipher of the Saint Louis Academy of Science. The professor's experiment is described thusly: He suspends a small lead ball from a string. It is placed in proximity to a very heavy lead ball that rests on a bench. The small ball and string are seen to be deflected toward the heavy ball because of the force of gravitational attraction—a straightforward replication of the famed Cavendish experiment of 1797–8.[80] The professor then passes a direct current through the large ball. Nothing has changed. But then he applies an AC current, *et voilà,* the small ball moves away from the large one, thereby proving that gravity has been weakened by electricity.

Anyone with a modicum of knowledge of electromagnetic theory would see what was happening here. The AC creates a time varying magnetic field that induces eddy currents in the small ball. These currents interact with the magnetic field to push the small ball away from the large one. The clue that Faraday's law of induction and the induced current serve as the explanation should have been the failure of the experiment to work with a direct current. The gravitational field, like DC and its resulting fields, is static. A direct current cannot induce a voltage or current in a neighboring circuit, while alternating currents have that ability. Eddy currents were well understood by 1919. One wonders how much real science Gernsback knew; it is no surprise that he permitted another paper based on dubious physics to be published the next year: Tesla's "The True Wireless."

The *Electrical Experimenter* morphed into another Gernsback magazine: *Science and Invention,* in 1920.[81] This publication, although it did in some ways live up to its title, increasingly carried science fiction and proved so successful that Gernsback was able to introduce more magazines (e.g., *Amazing Stories, Wonder Stories*) that were wholly devoted to the science fiction genre, and he is best known as a publisher of science fiction. At least one historian has suggested that many of the ideas in Gernsback's science-fiction stories promoted Tesla's "still unrealized ideas" for inventions.[82]

Endnotes

1. Nicholson Baker and Margaret Brentano, *"The World on Sunday: Graphic Art and Joseph Pulitzer's Newspaper (1898–1911),"* (Bullfinch Press, Boston, 2005) pp. 102–103.
2. Nikola Tesla, "The True Wireless," *Electrical Experimenter*, vol. 7, no. 3, May 1919, pp.22–23, 61–63, 87. The following website has images of the original pages: http://www.free-energy-nfo.com/Tesla TrueWireless.pdf. Other sources of the paper can be found by Googling the search term *"Tesla True Wireless."* Vendors of CD's having a complete run of the issues of *the Electrical Experimenter* can be found on eBay.
3. Thomas Kuhn, *The Structure of Scientific Revolutions, 3rd ed.*, (University of Chicago Press, Chicago, 1996).
4. R.P. Feynman, R. B. Leighton, and M. Sands, "The Feynman Lectures on Physics, vol. 2," (Addison-Wesley, Reading, MA, 1964) pp. 1–6.
5. Jed Buchwald, *The Rise of the Wave Theory of Light,* (University of Chicago Press, Chicago, 1989); With the birth of quantum theory *circa* 1900–26, a particle theory of light based on photons was to reemerge, but it did not undermine Maxwell's work thanks to the concept of the wave-particle duality. See for example Ian Walmsley, *Light: A Very Short Introduction,* (Oxford University Press, Oxford, 2015).
6. Hugh Aitken, *Syntony and Spark: The Origins of Radio*, (Princeton University Press, Princeton, 1985), Chapter 3.
7. Hugh Aitken, *Syntony and Spark.*
8. Interestingly, we have only Tesla's word that this meeting took place. There is no supporting entry in *Heinrich Hertz: Memoirs, Letters, Diaries* by Mathilde Hertz and Charles Süsskind, 2nd edition (San Francisco Press, San Francisco, 1977). As Tesla was a famous inventor by the time of the meeting, it is puzzling that he was not mentioned by Hertz. Also, no meeting is described by Bernard W. Carlson in his definitive biography of Tesla: *Tesla: Inventor of the Electrical Age*, (Princeton University Press, Princeton, 2013).
9. Tom Lewis, *Empire of the Air: The Men Who Made Radio*, (Harper-Collins, New York, 1991), p 136.
10. Paul Schubert, *The Electric Word: The Rise of Radio,* (Macmillan, London, 1928) pp. 166–168.
11. It was not until 1893, well after Tesla had completed his education, that the great simplification in AC circuit analysis made possible by the use of complex quantities began to be adopted, thanks to the work of C. P. Steinmetz. See, for example, Charles Proteus Steinmetz, "Complex Quantities and their Use in Electrical Engineering," *AIEE Proceedings of International Electrical Congress*, July 1893, pp. 33–74.
12. Alfred Hay, *The Principles of Alternate Current Working,* (Biggs and Co, Boston, 1897) pp. 137–148. Available at Google Books; for other 19th century engineers who used fluid analogies—or rejected them—see Paul J. Nahin. *Oliver Heaviside: Sage in Solitude,* (IEEE Press, Hoboken, NJ) *1988, p.* 59 (note his footnote 3 and the derisive comment "drainpipe theory").
13. There is a stern critique of using mechanical explanations for explaining electrical phenomena in Henri Poincaré, *Maxwell's Theory and Electrical Oscillations, (*McGraw-Hill, NY, 1904) Chapter 1, pp. 1–2. This book is available at Google Books. Tesla was so committed to hydraulic analogies that he supplied one for his high voltage, high frequency invention, the Tesla coil. See N. Tesla, *My Inventions*. This series of articles originally appeared in the *Electrical Experimenter* in 1919. They have been republished in his book *My Inventions (*Barnes and Noble, NY, 1995). See especially pp. 76–77. The analogy is so complicated that one is better served by studying the original electrical device and applying the laws of AC circuit theory and resonance.
14. Interestingly, in U.S. patent 645,576, Tesla has not yet discarded the return wire in a communication/power distribution system he is proposing. Part of his circuit consists of a path through an atmospheric layer that his powerful transmitter will, he asserts, succeed in ionizing. The earth is also employed in the circuit. The patent was granted in 1900, but by 1919 he has dispensed with the return part of the circuit.
15. For an explanation of the concept of Whig history, as it applies to the history of science, see Steven Weinberg, "Eye on the Present, The Whig History of Science," *New York Review of Books,* vol. 62, no. 20, Dec. 17, 2015.
16. J. Zenneck and A. E. Seelig (translation), *Wireless Telegraphy*, (McGraw-Hill, NY 1915)

pp. 258–259. This book provides an idea of how textbooks, *circa* 1910–1920, explained waves received on the far side of the mountain.
17. See the article on diffraction in the 11th edition of the *Encyclopedia-Britannica, vol. 8, 1911.* https://en.wikisource.org/wiki/1911_Encyclop%C3%A6dia_Britannica/Diffraction_of_Light/11. Also, for a modern treatment see Y. T. Lo, Y. T and S. W. Lee, *Antenna Handbook*, (Van Nostrand-Reinhold, NY, 1988) sec. 29.
18. R. W. P King and S. Prasad, *Fundamental Electromagnetic Theory and Applications,* (Prentice Hall, Upper Saddle River, New Jersey 1986) chapter 7.
19. Jules Stratton, *Electromagnetic Theory,* (McGraw-Hill, New York. 1941), secs. 9.22–9.24.
20. Chen-Pang Yeang, *Probing the Sky with Radio Waves* (University of Chicago Press, Chicago. 2013). I am greatly indebted to this source.
21. Henri Poincaré and F. King Vreeland (translation), *Maxwell's Theory and Wireless Telegraphy*, (McGraw-Hill, New York, 1904) p. 161. Tesla might have countered by asserting that the Branly coherer responds to the electric field—not the magnetic field—and the earth weakens the former.
22. L. W. Austin, "Some Quantitative Experiments in Long Distance Radio Telegraph," Reprint No. 159, *Bulletin of Bureau of Standards*, vol. 7, no. 3, Feb. 1, 1911; see also Robison, 1918, p. 228.
23. Watson, G. N. "The Transmission of Electric Waves Around the Earth," *Proc Royal Society (London) Series A*, vol. 95, July 15, 1919, pp. 546–553.
24. Heinrich Hertz, *Electric Waves*, (Dover Books, Mineola NY, reprint of Macmillan book 1893) chapter 8 (dating from 1888, especially Fig. 26).
25. Kuhn, page 43.
26. Samuel Robison, *Robison's Manual of Radio Telegraphy and Telephony for Naval Electricians* (U.S. Naval Institute, Annapolis, MD, 1918) p.131. He asserts that the directivity behavior of the "flat top antenna" attributed to Marconi, which involves a long piece of wire or wires parallel to the ground, is still not understood.
27. L. J. Chu, "Growth of the Antennas and Propagation Field Between World War 1 and World War 2. Part 1, Antennas," *Proceedings of the IRE,* vol. 50, no. 5, May 1962, pp. 685–7.
28. Charles Burrows, "The History of Radio Propagation up to the End of World War I," *Proceedings of the IRE*, vol. 50, no. 5, May 1962, pp. 682–684.
29. Note that Marconi had described arrays formed from inverted L antennas as early as 1906, as noted in G. W. Pierce below. The horizontal elements were much longer than the vertical ones, a configuration not suggested in Tesla's Fig. 16. G. W. Pierce, *Principles of Wireless Telegraphy*, (McGraw-Hill, New York, 1910) Chapter 25. See also *Practical Wireless Telegraphy*, Elmer Bucher, Wireless Press, 1917, sec. 233. Here, the horizontal portion of the antenna is nearly a mile long.
30. See G. Marconi, "On Methods Whereby the Radiation of Electric Waves May Be Mainly Confined to Certain Directions, and Whereby the Receptivity of a Receiver May Be Restricted to Electric Waves Emanating from Certain Directions," *Proceedings of the Royal Society of London. Series A,* Containing Papers of a Mathematical and Physical Character 77.518 (1906): 413–21; *Electrician*, vol. 60, 1908, p. 883.
31. Pierce, p. 298.
32. Zenneck and Seelig, Sec. 202–204. The book contains the reference to Von Hoerschelmann, which was published in German as a dissertation in 1911.
33. Aitken, p. 267.
34. Nahin, pp. 142–143.
35. Bernard Carlson, *Tesla: Inventor of the Electrical Age*, (Princeton U. Press, Princeton NJ, 2013) p. 200–202; note that some images were the result of multiple exposures where Tesla was not present when the sparks were being generated, see pp. 297–299.
36. T. C. Martin, editor, *The Inventions, Researches and Writings of Nikola Tesla*, 1893; republished by (Barnes and Noble, NY, 1992) Chapter 6. From the lecture: "The reason why no pain in the body is felt, and no injurious effect noted, is that everywhere, if a current be imagined to flow through the body, the direction of its flow would be at right angles to the surface; hence the body of the experimenter offers an enormous section to the current, and the density is very small, with the exception of the arm, perhaps, where the density may be considerable…The expression of these views, which are the result of long continued experiment and observation, both with steady and

varying currents, is elicited by the interest which is at present taken in this subject, and by the manifestly erroneous ideas which are daily propounded in journals on this subject." Tesla misses the essential point here—the very shallow depth of penetration of the energy. The arm plays no special role. Notice that he takes a swipe at other workers' "erroneous ideas."

37. Indeed, it was in Poincaré's book of 1904 (see above).
38. E. C. Jordan and K. Balmain, *Electromagnetic Waves and Radiating Systems*, 2nd ed., (Prentice-Hall. NJ, 1968) p. 655.
39. Note that this is a simplification of a formula derived by Heaviside in 1888. See Nahin, who also gives the formula we are using here, p. 176
40. King and Prasad, section 5.9. The sinθ variation was derived by Hertz in the 19th century (see Hertz, *Electric Waves,* p. 143 above) and was popularized by Louis Cohen in a paper written for engineers in 1914. See his "Electromagnetic Radiation," *Journal of the Franklin Institute*, April 1914, vol. 177, no. 4, pp. 409–418.
41. Robison, 1918, p. 62. Notice that the same picture appears in an even earlier edition of Robison, dating from 1911, on page 76. This book is available from Google Books.
42. R.W.P King, Theory of Linear Antennas, (Harvard University Press, Cambridge, MA, 1956) chapter 7. Note that this work is based in part on Sommerfeld's work of 1909.
43. Burrows.
44. Ibid.
45. The ionosphere, although not called by that name, could be found in electrical engineering handbooks as early as 1915; see for example W. H. Eccles, *Wireless Telegraphy and Telephony: A Handbook of Formulae, Data and Information.* (*Electrician*, London, 1915), pp. 162–3.
46. Eccles, p. 120.
47. In the unlikely event that the wire hangs straight down from the aircraft, the preceding formula does not apply. However, it would still be incorrect to say that the capacitance varies with the logarithm of the length of wire. The required formula shows a more complicated behavior. See Eccles p. 120.
48. James Clerk Maxwell, *A Treatise on Electricity and Magnetism*, vol. 1.(Clarendon Press, Oxford 1891) p. 76. This has been reprinted by Dover Books, NY, 1954. For a modern treatment that emphasizes the limitations of the concept of voltage difference see Edward.C. Jordan and Kenneth. Balmain, *Electromagnetic Waves and Radiating Systems,* second ed., (Prentice-Hall, New Jersey 1968) p. 36.
49. http://blogs.mhs.ox.ac.uk/innovating incombat/ See also R. W. Burns, *Communications: An International History of the Formative Years,* (IEE Press, UK, 2004) p. 407.
50. http://earlyradiohistory.us/1899marc.htm, *McClure's Magazine*, (London), June 1899, pp. 99–112.
51. Sungook Hong, *Wireless: From Marconi's Black Box to the Audion*, (MIT Press, Cambridge, MA, 2001) p. 205. See Aitken, his footnote 12 page 195. Note (same page) that even Fleming, Marconi's well-regarded consulting engineer, was at first misled by the misuse of analogies drawn from the theory of light.
52. Aitken, pp. 285–286 and Hong p. 42, footnote 48.
53. J. J Fahie, *A History of Wireless Telegraphy*, (Blackwood, Edinburgh, 1901) p. 216.
54. Guglielmo Marconi, "Wireless Telegraphy," *Journal of the Institution of Electrical Engineers,* vol. 28, 1899, pp. 273–291.
55. U.S. Patent 685,955 of 1901, 685,954 of 1901, 685,956 of 1901, 787,412 of 1905.
56. Carlson, chapter 2.
57. Nahin, chapters 7 and 9.
58. Bruce Hunt, The *Maxwellians,* (Cornell U. Press, Ithaca, NY, 1991) p. 202.
59. Marc Seifer, *Wizard: The Life and Times of Nikola Tesla*, (Citadel Press. New York, 1998) p. 423.
60. Margaret Cheney & Robert Uth, *Tesla: Master of Lightning,* (Barnes and Noble/Metro Books, NY, 2001) pp. 138–139.
61. Milena Wazeck , *Einstein's Opponents, The Public Controversy about the Theory of Relativity in the 1920's.* (Cambridge University Press, Cambridge, UK, 2014).
62. Seifer, p. 212.
63. For an example of writing on the subject of paradigm shifts in physics after Kuhn, see Jaume Navarro, "Electron Diffraction Chez Thomson: Early Responses to Quantum Physics in Britain." *The British Journal for the History of Science,* vol. 43, 2010, pp. 245–275.
64. Paul Israel, *Edison: A Life of Invention*, (John Wiley & Sons, New York, 1998) p. 176.
65. Thomas Parke Hughes, *Networks of Power: Electrification in Western Society*, (Johns Hopkins University Press, Baltimore, 1983).

66. Matthew Josephson, *Edison: A Biography,* (Wiley, New York, 1992) p. 359.
67. The web site https://en.wikipedia.org/wiki/List_of_Nikola_Tesla_patents lists 111 or 112 U.S. Tesla patents (depending on how they are counted).
68. Nikola Tesla, "My Inventions," *Electrical Experimenter, 1919,* see chapter 5, available on the Internet http://www.teslasautobiography.com/ See also Carlson, chapter 15.
69. T. C. Martin, pp. 346–7. In the late 19th century, Tesla spoke repeatedly of disturbing the electrostatic condition of the earth as a means of sending intelligence. See also Martin p. 292 for an example used in a speech before the British IEE in 1892.
70. This tube appears in a speech he gave in 1892 to the Institution of Electrical Engineers (London). See T. C. Martin ed. pp. 225–229.
71. Gerald Tyne, *Saga of the Vacuum Tube*, (Antique Electronic Supply, Tempe AZ. 1977).
72. Mike Adams, "Hugo Gernsback: Predicting Radio Broadcasting, 1919–1924," *Antique Wireless Association Review*, vol. 27, August 2014, pp. 165–192.
73. For a listing of the Tesla U.S. patents see http://web.mit.edu/most/Public/Tesla1/alpha_tesla.html. The number for Gernsback was obtained from a search of Google Patents using his name as the inventor. Footnote 64 above also gives a source of Tesla's patents.
74. Carlson, p. 379.
75. K. Massie, and Stephen Perry, "Hugo Gernsback and Radio Magazines: An Influential Intersection in Broadcast History," J*ournal of Radio Studies*, vol. 9, no. 2, 2002. Note that the magazine was originally titled *The Electrical Experimenter.* The title was shortened during 1917.
76. The term was apparently first used in Gernsback's magazine *Wonder Stories* in the issue of June 1929; Gernsback had earlier coined the term "scientifiction." See Leon Stover, *Science Fiction from Wells to Heinlein*, (McFarland Publishers, Jefferson, NC, 2002) p. 9.
77. Frederick Strong, "The Home Treatment of Tuberculosis by High Frequency Currents," *The Electrical Experimenter*, vol. 5, no. 10, Feb. 1918.
78. http://maia.usno.navy.mil/women_history/lewis.html.
79. M Ashley and R. Lowndes, *The Gernsback Days,* (Wildside Press, Rockville, MD, 2004) p. 51–2.
80. https://en.wikipedia.org/wiki/Cavendish_experiment.
81. Ashley, above, p. 53.
82. Stover, p. 175. In 1923 Gernsback produced a book, *Radio for All*, published by Lippincott. The work was designed to introduce people to what was still in many ways a hobby. Thus, there were instructions for building simple radios—crystal and one-or two-tube sets, as well as transmitters. It is puzzling that the book makes no mention of the work of Tesla, given his friendship with Gernsback, although there are numerous allusions to Marconi as well as single references to such inventors as Poulsen, Pickard, Fessenden, and Dunwoody.

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About the Author

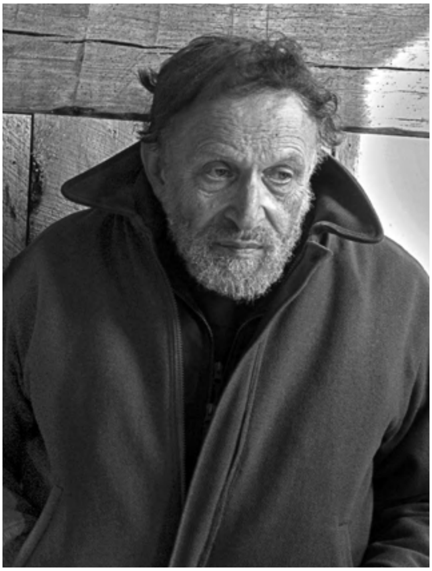
A. David Wunsch was born in Brooklyn, NY, on December 15, 1939. He grew up in the same Flatbush neighborhood of red diaper babies as Bernie Sanders. David studied electrical engineering at Cornell and later earned his Ph.D. at

Harvard where he was a student in the Antenna Group directed by Professor R.W.P. King.

David has spent most of his professional life at the University of Massachusetts, Lowell which is located in Lowell, Massachusetts. He is now Professor of Electrical Engineering *Emeritus*. In 1995 he started the course for liberal arts majors at Lowell, *Principles and History of Radio.* It is described in the article "Electrical engineering for the liberal arts: radio and its history," IEEE Transactions on Education, vol.41, no.4, pp.320–324, Nov 1998.

David is the book review editor of the IEEE Magazine *Technology and Society*. He is the author of two textbooks: *Complex Variables with Applications* (Pearson), currently in its third edition, and the recently published *A MATLAB Companion to Complex Variables* (Taylor and Francis).

David recently rebuilt the Heathkit oscilloscope that he constructed in 1957. He thought it would make him 17 again but his beard remains white.



David Wunsch

Zeh Bouck, Radio Adventurer
Part 1: The Pilot Radio Flight to Bermuda

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Zeh Bouck (2PI, W4FCP, W8QMR), born John W. Schmidt (1901–1946), was an early radio pioneer, engineer, writer, and adventurer who represented amateurs in Washington, D.C. and met with President Hoover. He helped design the Pilot Super Wasp, was one of the first newspaper radio columnists, penned stories and radio plays, and was an associate editor for journals such as *Radio Broadcast* and *CQ: The Radio Amateur's Journal*. An IRE Fellow and member of the Radio Club of America, he was most famous in his day for his role aboard the airplane *Pilot Radio*, a "flying laboratory." In 1930 the plane made two historic journeys: the first flight from the United States to Bermuda and the first flight of any land plane around the South American continent. This article provides a brief biography of Bouck to 1930 and summarizes the history of the Pilot Radio Company of Brooklyn and its interest in aircraft radio. Along the way, other figures such as Reginald Fessenden, Hugo Gernsback, and Milton Sleeper are encountered. A detailed account of Bouck's famous and hazardous Bermuda flight with pilot William Alexander and navigator Lewis Yancey follows, focusing on the role of radio communications. Remarkably, Bouck, who remains largely forgotten today, accomplished all this in spite of a serious disability caused by childhood polio.

Zeh Bouck

Accomplishments

Zeh Bouck visited the White House in 1930 and met with President Hoover, and at one point he represented the Hoover administration, acting as an unofficial U.S. ambassador to foreign nations.[1] Alongside Hiram Percy Maxim and Edwin Howard Armstrong, he advocated for radio amateurs at the Third National Radio Conference in Washington in 1924. He was one of the first radio columnists, writing for the *New York Sun* by 1922, and a newsmaker himself. He wrote hundreds of articles for magazines ranging from *Boys' Life* to *Radio News* to *Cosmopolitan*, plays for the radio, technical pamphlets, and books. Largely self-educated in radio engineering from a childhood spent chasing DX (long-distance communication) in the days of spark, he became a Fellow of and served on committees for the Institute of Radio Engineers and was a Member of the Radio Club of America. He contributed to the design of the Pilot *Super Wasp* and early receivers made by the National Radio Company. He helped edit several journals, including *Radio Broadcast, Aero News & Mechanics*, and the radio amateur's journal *CQ*. He was an aircraft radio pioneer, spending more than a thousand hours in the air and many more in the lab trying to solve the many problems involved in aircraft communications. He served as radioman aboard the *Pilot Radio*, a "flying laboratory," on the very first flight from the U.S. mainland to the speck in the ocean known as Bermuda. Soon after, he served on the first flight of any land plane around the South American continent, surviving a plethora of emergency landings, mishaps, and one hellacious crash landing that took the *Pilot Radio* to its watery grave.

Despite an array of achievements worthy of a real-life Indiana Jones, today Zeh Bouck is an obscure footnote to radio history. One might have read his fate in the tealeaves of his later years. He was no Horatio Alger; if anything he went from riches to rags—not uncommon in those years of the Great Depression. By World War Two, he had seen his fame and fortune rise and fall. Time would not allow him to reach those heights again.

Most people who have seen a picture of Bouck have come across it in the pages of old *Radio News* accounts of his aeronautical adventures. There he is, standing next to that vintage Stinson airplane in some exotic locale, a short,

Fig. 1. From left to right: Emile Burgin, Zeh Bouck, and Lewis Yancey. Photo taken at Roosevelt Field, New York, May 14, 1930. (Author's collection)

pipe-smoking, broad-shouldered man with a boyish face, Harry Potter-like glasses, and upswept dark hair, looking a bit old-fashioned even then with his signature cravat, and perched conspicuously on a pair of crutches (see Fig. 1). Most readers probably assumed he had just been injured in his adventures. Not so. Like a more famous American of the time, Franklin D. Roosevelt, day in and day out Zeh Bouck stared down a major disability that would have left most people satisfied to just be able to get around the house, much less the cockpit of a plane or the jungles of the Amazon. But Bouck was different. His was a spirit and determination that few possess. He didn't try to conceal his handicap, nor did he curse the rotten card that fate had dealt him in the form of childhood polio. In what may have been his greatest achievement of all, he simply ignored it and did what he set out to do, struggling along step by step.

A Short Biography

The story of Zeh Bouck has many chapters, the aerial adventure recounted here being just one of them. He was born John W. Schmidt in New York in 1901, the son of John A. Schmidt, a German dry goods merchant, and Alice White, whose maternal grandparents had the Dutch surnames Zeh and Bouck.[2] The Boucks had produced a governor of New York. His mother's brother had changed his name from Charles White to Bouck White and was famous (or infamous) as a firebrand revolutionary and writer who was, at various times, jailed, tarred and feathered, and driven out of town.[3] The Zeh and Bouck clans hailed from rural Schoharie County in upstate New York, where Zeh Bouck would later live and where Zehs and Boucks still live to this day. By the mid-1920s, his parents had divorced, and he lived with his mother in New York City.

John "Jack" Schmidt wrote under the pen name Zeh Bouck and later legally changed his name to that as well. Possible reasons for the name change could include the anti-German sentiments prevailing in the years around World War One, a preference to be associated with his mother's side of the family, or just the more distinctive sound of the name. Unfortunately, his reasoning on this is unknown. Despite the thousands of available documents by and about Zeh Bouck, many blank spots on the map of his life remain.

Writing about himself in the third person, he said that he had "blossomed forth as an operator in the heyday of the E.I. Co. to the crackling tune of the one-inch spark coil and the rat-tat-tat of the decoherer. His first call was issued by Gernsback in his Wireless League of America, and his first code was Morse."[4] All of this was before he had reached the ripe old age of 11. He attended Townsend Harris High School in New York City and took classes at the City College of New York, although he never received a degree.[5] In 1928 Zeh Bouck married Charlotte Bosse, with whom he would have a daughter who, sadly, lived for only a few weeks, and a son, Paul. A natural born writer as well as a superb radio operator and experimenter, his works began appearing in newspapers and magazines shortly after World War One. His earliest known article is a short story he wrote around the time he graduated high school, which was called "A Ham on the Telephone." This appeared under the pen name of "Tewpieye" (a play on his callsign, 2PI) in the August 1920 issue of *QST*.[6] By early 1922, he was penning a regular radio feature for the Saturday *New York Globe* (which later was merged into the *New York Sun*), thereby becoming one of the world's—not just the *Globe's*—very first newspaper radio columnists.

His column reflected radio enthusiast interests of the day, the earlier ones being more technical (like how to build your own resistance-coupled amplifier), while later ones in the 1930s included critiques of popular radio shows, guides to listening in on shortwave bands, and observations on European shortwave propaganda broadcasts.[7] In all, Bouck probably wrote several thousand articles in his short life, many of which can still be found.

He also worked in various capacities for a number of radio parts manufacturers at times including Daven, Amsco, Arcturus, and later, Pilot Radio & Tube Corporation of Brooklyn (see Fig. 2). Ever busier, he wrote some fiction for national magazines including *Cosmopolitan* and *Argosy*, a few radio plays, books (one of them with a chapter on how to write radio plays),[8] and he was a contributor, editor, or associate editor for a number of magazines, including *Radio News*, *All-Wave Radio*, *Boys' Life* (which had some remarkably technical articles for youths), *Radio Broadcast*, and *Aero News & Mechanics*. At one point he even helped organize a radio department for an advertising agency.[9] Looking at his circumstances in those decades, like many another, it is likely that his jobs in the 1920s represented burgeoning opportunities, while those in the 1930s had more to do with keeping the wolves at bay.

Back in the early 1920s, when more radio receivers were "homebrewed" than commercially manufactured, more money could be made selling radio parts than factory-assembled sets. Close ties existed between parts manufacturers, their engineers, salesmen, copywriters, publicity agents (who might all be the same guy), and magazine and newspaper publishers. "Every Saturday, *The New York Sun* published a 32-page supplement on how to build various circuits. Everyone followed the writings of Stuart Blyden, the radio editor at *The Sun*," explained Harry Kalker, an M.I.T. educated engineer. "I was a salesman for Amperite… If I wanted to live well the following week, I regularly called on Thursday to see if Blyden of *The Sun* and Casson of *The Telegram* had specified my Amperite parts by name in the 'Circuit of the Week' for that issue."[10] It wasn't unusual, then, for Bouck to "kill two birds with one stone" and write articles on circuits featuring Daven or Amsco resistors or Arcturus tubes in those years. But from the time he joined Pilot Radio in 1928, his job was different—and considerably more interesting.

Fig. 2. Advertisement for the Pilot Radio & Tube Corporation. (*Radio Design*, Vol. 2, No 4, Winter, 1929, inside back cover)

Pilot Radio of Brooklyn

Management

The Pilot Electric Manufacturing Company made and sold parts as well as complete kits, the latter being something like the Heathkits of their day, if not as easy to assemble. Pilot ran the full gamut of activities, including manufacturing primary parts, designing circuits, publishing schematics, advertising in their house organ, *Radio Design*, and selling by mail order through their distributor, "the fastest radio mail order service in the world," Speed, Inc.[11] "Pilot was one of the very few real fabricators of the radio industry," wrote former Pilot employee Robert Hertzberg. "In a crowded factory in Brooklyn, NY, it made its own tools and dies and manufactured all the bits and pieces of its components and assemblies. It did all its own turning, stamping, winding, plating, forming, etc."[12]

Pilot's pilot, so to speak, was Isidor Goldberg, who was raised in an orphanage on New York's Lower East Side. Goldberg had been exposed to the possibilities of wireless by the age of 16 when he worked at Hugo Gernsback's Electro Importing Company (E.I. Co.) factory.[13] Later, he managed to construct a radio parts empire out of nothing but hard work, savvy, and determination. Goldberg had big ideas and knew how to take chances. His company, Pilot Electric Manufacturing Company, morphed into the Pilot Radio and Television Corporation, and then the Pilot Radio and Tube Corporation in 1929; all will be referred to as "Pilot Radio." Pilot Radio didn't confine itself to just manufacturing parts for homebrew or manufactured radios; the company also explored promising new areas like television and aeronautical radio communication. Much later, it would be a pioneer in the new "high fidelity" audio field.

Pilot Radio and Early TV

Pilot Radio's foray into television, back in those spinning disk days, may have contributed to the forced bankruptcy of former boss Hugo Gernsback's publishing empire early in 1929.[14] The year before, in a U.S. first, Gernsback had collaborated with Pilot Radio and its brilliant young chief engineer, John Geloso, to broadcast televised images for five minutes at the top of each hour (after a much more ambitious schedule had been abandoned) over his New York City radio stations, WRNY (920 kHz) and W2XAL (9700 kHz). One could watch "faces of living people, the WRNY placard… a moving toy monkey, and a moving 'roly poly man.'"[15] The Pilot television receiver used in the first public demonstration of wireless television in the United States is shown in Fig. 3.

What could one see on the television that Pilot developed? According to Bouck, "One gazed hopefully through the window in the upper center and saw all sorts of things with zig-zags of dull red light predominating… Occasionally an image could be seen—the fringy call letters of the broadcasting station, or an equally fringy head and shoulders.

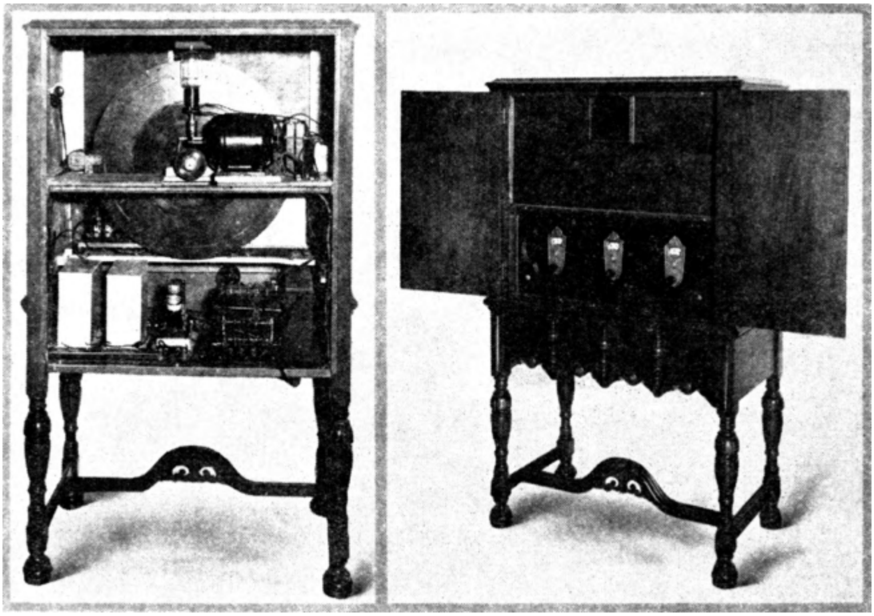

Fig. 3. Rear and front view of the Pilot television receiver used at New York University in the fall of 1928 in a successful demonstration of images broadcast from Hugo Gernsback's radio station, WRNY. Note the motor and large disk. The screen measured 1.5 inches. (*Radio Design*, Vol. 4, No. 1, Fall, 1931, p. 23)

This would float with varying degrees of rapidity across the field of vision and disappear in parts or wholly like the Cheshire cat." There was a control for synchronization, but "this was usually accomplished far more satisfactorily by the rule of thumb—i.e., by placing the thumb against the periphery of the scanning disk as a light brake. You could always tell a television engineer… by the callous on his right thumb."[16] The images, of course, were unaccompanied by sound, except for the drone of the motor.

The equipment and broadcasting costs involved probably helped push Gernsback's own empire into the red at the time. Gernsback wrote in his autobiography, "Indeed, the experiment, the first of its kind, cost a small fortune, with no income whatsoever even contemplated."[17] But mere bankruptcy couldn't keep the futuristic Gernsback down, and a new series of magazines like *Radio-Craft* quickly rose from the ashes to compete with his old ones like *Radio News*. But the television venture hadn't done much good for Pilot either. "I betcha I must have paid to have the darn things [Pilot television sets] thrown away in '29," Goldberg said decades later. "If I'd kept up all those programs, I'd have gone broke."[18] Television back then was definitely not ready for prime time. "After a few rounds," concluded Bouck a while later, “television never even came out of the corner.”[19] When it finally did, after decades had passed and cathode ray tubes had supplanted spinning disks, Pilot Radio would have better luck, if more competition.

Wasps and Super Wasps

In late 1920s, it was in a different arena that Pilot Radio proved to be a quite a contender—that of shortwave receivers. Its introduction of the 3-tube, regenerative Pilot Wasp shortwave receiver in 1928 tapped into the burgeoning shortwave and amateur long-distance reception (DX) markets in a big way. With a $21.75 price in kit form including plug-in coils (around $300 today!), it represented a good balance of economy and performance, and it became a popular choice for young amateurs and DXers. According to *QST*, by 1930 more amateurs were using Pilots than any other receiver. Adding a fourth tube, a screen-grid 224, in a front-end-tuned RF section was expected to improve its performance considerably. To this end, Goldberg assembled an all-star team including Robert Hertzberg, chief engineer John Geloso, Alfred Ghirardi, Zeh Bouck, and Robert S. Kruse. According to Hertzberg, the circuit was designed largely by Kruse (see Fig. 4), and the packaging was done by Geloso, while he himself did the field testing and manual writing. The roles of the others are less

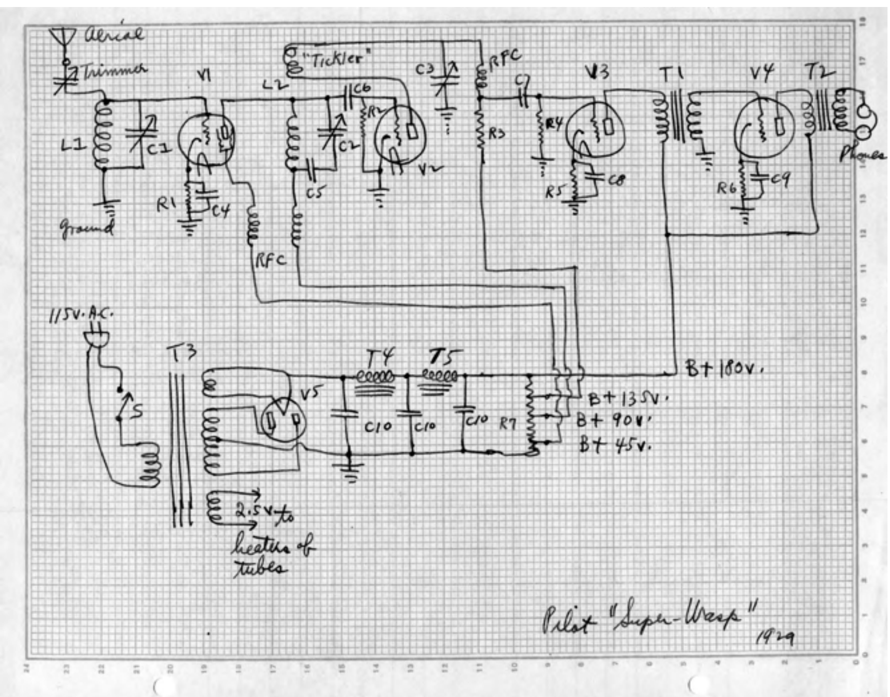

Fig. 4. Pilot Super Wasp original schematic hand drawn by Robert Hertzberg in 1929. (Courtesy of son Paul Hertzberg, K2DUX)

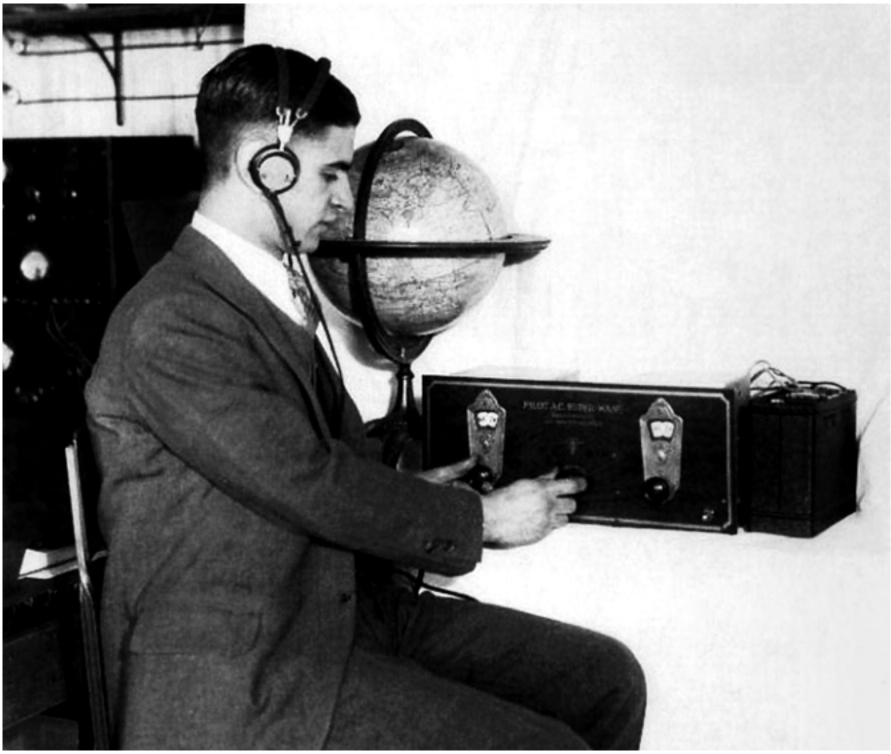

Fig. 5. Robert Hertzberg at the controls of the Pilot AC Super Wasp in 1929. (Courtesy of son Paul Hertzberg)

clear, but Bouck is credited with having an input into the design of the final product, the Pilot Super Wasp (see Fig. 5), which, gratifyingly, ended up living up to everyone's expectations.

It was an instant success, which Hertzberg attributed to its bulletproof design, favorable sunspot conditions, and the growing popularity of programs from the BBC in Chelmsford and PCJ in Eindhoven, Holland, with its star Edward Startz. The set was popular both in America, where one could either order the kit from Pilot Radio or buy it at Kresge's, and abroad, where Pilot did a surprisingly large amount of its business. Hertzberg himself personally installed a set in New York for the King of Siam (and he was).[20] The success of the Super Wasp ensured that the AC Super Wasp, Universal Super Wasp, and eventually a very strange superhet cathedral set called the Super Wasp Allwave would follow.

As for Bouck, he had previously designed circuits published in *Radio Broadcast*, and later he would have a hand in the design of some National shortwave receivers, along with Robert Kruse (again) and David Grimes.[21] Based on his own choice of receivers in later years, Bouck would remain partial to National sets for life. But in 1928, it was Pilot Radio that offered young Zeh Bouck truly soaring career opportunities as it entered a field where "the sky's the limit" and let its Super Wasp fly.

Aircraft Radio

Utility

There were many reasons for airplanes to carry radios. Air-to-ground communications could greatly increase aviation safety. Bad weather might be avoided, flights tracked, emergency messages sent, aerial navigation improved, lives saved. As runways became crowded, hop-offs and landings could be coordinated to avoid accidents. Flight safety was not then what it is now; accidents were appallingly common, especially among small planes with fearless (or clueless) pilots. Improving flight safety was mostly a concern of commercial airlines that conducted regular flights, such as Pan American Airways and United Airlines. They preferred to keep their expensive planes and pilots intact and had to convince potential passengers that buying an airline ticket was not a form of assisted suicide. Manufacturers of small planes were more laissez-faire about it, as they were essentially selling the thrill—not the safety—of flying: "A half hour in flight on a bright sunny day will dispel all those memories of the difficulties of flying in a storm or fog."[22] But only if you made it through the storm or fog.

Improving aerial navigation was another important use of aircraft radio. Early flight navigation relied mostly on visual landmarks. In some states, towns over a certain size (e.g., a population of 4,000 in Maryland) were required to paint their names prominently on a roof or large tank for the benefit of flyers. Amelia Earhart herself wrote, "An arrow pointing the direction to the nearest landing field is also desirable."[23] According to Bouck, "Piloting a plane across country… is a tiresome undertaking, requiring constant vigilance of the man at the controls. Winds move much more rapidly than sluggish ocean currents, and the plane travels so fast that it requires only small errors in compass or judgment to throw the flyer off his course."[24] Worst of all, visual landmarks could not help at night, with low clouds or fog, or at sea. Navigation by radio waves would have no such limits. A. K. Ross noted, "No longer will it be necessary for the long-distance flyer, crossing the trackless ocean or fog-hidden land, to be isolated from those on land and sea as effectively as though he were on a different planet."[25]

Radio beacons would point the way—literally. Using a system developed by the National Bureau of Standards in the mid-to-late 1920s, a central radio tower would support the tops of two large, side-by-side triangular loops, each of which would broadcast an aero band signal (315–350 kHz). Both would use the same frequency, but one would be modulated with a 65-cycle tone and the other at 85 cycles. The setup would allow these signals to propagate in figure-eight patterns at right angles to each other. Using a goniometer (an "overgrown variometer"), the orientations of the two figure eights could be rotated to any desired compass bearing without physically moving the antenna. The 65-cycle and 85-cycle signals would be of equal strength only at the centerlines of the four areas of overlap (see Fig. 6). A plane using a nondirectional antenna (often a 5- or 10-foot vertical rod) would receive the signals, which would be amplified and detected; the signals would ultimately cause two mechanically resonant reeds (one resonating at 65 cycles, the other at 85 cycles) to vibrate up and down rapidly, tracing out apparent white lines side-by-side on a black background. The lines would be of equal length when the signals were of equal strength, indicating an approach (or departure—beacons could be used for both) along the desired course (see Fig. 7). A shorter line on one side meant that the plane was off course in that direction and the pilot would turn in the direction of the longer line until the two were equal.[26]

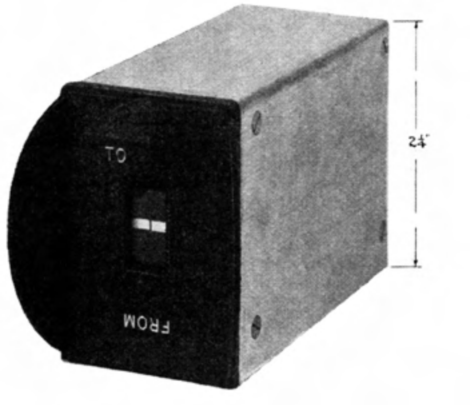

Fig. 7. Radio beacon indicator for panel mounting in plane. The instrument was "about the size of a pack of cigarettes." (*Radio Design*, Vol. 1, No. 4, Fall 1931, p. 125)

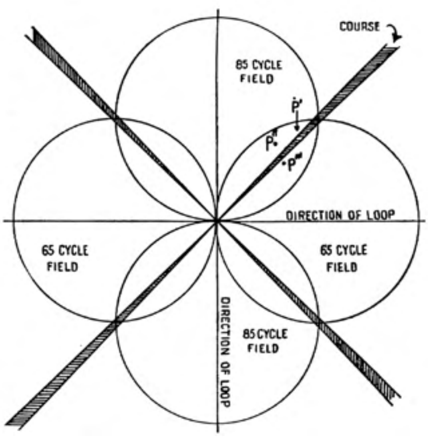

Fig. 6. Field characteristics of radiating loop antenna system for radio beacon. The two signals are of equal strength only along the crosshatched area. (*Radio Design*, Vol. 1, No. 4, Fall 1931, p. 127)

This visual indication enjoyed some advantage over a competing system that had used audio signals sending letters in code (A and N—with the di dah and dah dit starting at the same time so that it came out as a long dah or T, along the centerline). The pilot or navigator would have a hard time hearing these above engine noise (which he would rather listen to for signs of malfunction) and interference, even with the best headphone-equipped helmet.[27] All of which points out just a few of the many problems that needed to be overcome in developing aircraft radio systems.

Aircraft Radio Challenges

Bouck describes various problems that had to be addressed in the design of radios for aircraft in an article entitled "The Problems of Aircraft Radio" published in *Radio News*. He writes, "A plane is capable of lifting a certain gross weight."[28] After subtracting out the machine itself, pilot, fuel and oil, "what is left is payload, and comprises passengers and express or mail." Every pound added in radio equipment, antenna, and radio operator, including the effective poundage added by wind resistance of externally placed radio accessories like a generator, was one pound less that the plane could carry for profit. Aerial radiotelephony (voice) had an advantage over telegraphy (code) in that the radio operator's weight would be eliminated and the pilot didn't need to transmit and receive code, which required the use of hand and brain. Most pilots were not proficient in code and didn't want to deal with it.[29] But even after adding in the weight of an operator, telegraphy was still more efficient than telephony. As Table 1 shows, after including the operator's weight for telegraphy (assumed to be 150 pounds here), pound-for-pound a readable code signal would still reach further than voice. With either method, making the apparatus as lightweight as possible helped maximize payload, and aircraft radio found extensive use for aluminum in place of iron and steel wherever possible.

Perhaps the biggest problem to confront aircraft radio designers in those days was noise caused by the ignition system with its multitude of spark generators and the audible noise of the engines themselves. Both were much worse than for autos and far harder to deal with. The U.S. Navy as well as many radio companies had found that the entire ignition system including plugs, high-tension wires, magnetos, and even the magneto switches needed to be shielded. This was best done at the time the plane was built, but unfortunately aircraft manufacturers didn't seem too concerned with this. The audio noise generated by aircraft engine was another problem, and vibration of the plane could wreak havoc on vacuum tubes and create loud microphonics. Shock mounting the sets to the rack with just the right degree of rigidity and the use of special tubes helped with the

Table 1. Airplane Radio Ranges at 300 kc. (Z. Bouck, Radio News, July 1929, p. 20)

Power (W)	***Telephone***		***Telegraph***	
(Antenna)	***Weight (lbs)***	***Distance (mi)***	***Weight* (lbs)***	***Distance (mi)***
50	100	50	250	200
100	175	100	300	300
150	200	120	325	350
200	250	135	350	400
250	275	150	375	450

*Including 150 pound weight of operator

latter. According to Bouck, who had worked for Arcturus, the heavy-cathode AC Arcturus tubes were the best. The vibrations also affected variable condenser plates, causing rapid fluctuations in capacitance and therefore wavelength. Larger or more numerous, thicker (0.0025 inch) plates with wider spacing were called for.

For ground-based applications, raising the antenna up high enough is never easy, but getting a good ground usually is. Aloft, the problem is strangely reversed. The metal fuselage (or frame with canvas-covered planes such as the *Pilot Radio*) could be used as a counterpoise surrogate for ground, but that required special preparation. All metallic parts not rigidly fastened together had to be bonded into a single electrical structure to provide a good counterpoise and reduce noise caused by rubbing together and sparking at imperfect contacts.[30] Again, this was something best done during aircraft manufacture, but that often didn't happen. Bouck tells of his own experience where a radio serviceman bonding structural elements accidentally bonded a rudder cable to a flipper control tube putting both rudder and elevator out of commission, which resulted in a narrow escape from what could have been a fatal crash caused by a radio serviceman improperly installing the ignition shielding.[31]

For airborne antennas of the late 1920s, the trailing wire type then in use came with a host of problems. The advantages were that the length of antenna reeled out could be adjusted to resonate at the desired frequency, aerodynamic drag was modest, space and weight allocations were small, and there was no drag when not in use. But there were many disadvantages aside from a flyer forgetting to reel them out (or reel them in before landing). The line was typically terminated with a one or two pound lead "fish" to keep it from flapping around and tearing itself to bits or wrapping itself around the wings. If it were let out too quickly, the wind could take it, causing the whole antenna to snap off. A drag mechanism similar to that used on a fishing reel was called for, and more sophisticated antennas came with a centrifugal clutch to keep the release rate even. Still, things went wrong—farmers complained that their houses or barns were "beaned" by lead weights falling from the sky. Trailing wire antennas weren't much use for planes on the ground. Another problem was the directionality of a relatively long wire antenna. This made it unsuitable for use with directional beacons mentioned previously. Loop antennas could be used and could even provide radio direction finding (RDF) for transmitters like broadcast radio stations, but they had to be mounted externally (that drag factor again), were low gain, and couldn't be used to transmit. Bouck noted that a loop used with a superheterodyne broadcast band receiver was much less perturbed by ignition noise than other arrangements. Various configurations of dipoles strung from wingtips, fuselage, and tail were sometimes used, but were too short to have much gain on a small plane, particularly at the long aero band wavelengths then in use. The best antenna to use seemed to be "up in the air."

The Flying Laboratory

At the time Pilot Radio entered the field, the idea of airborne radio was not new. As noted by Arthur Lynch, radio and aviation grew up at about the same time and even in the same neighborhood. He observed that Professor Fessenden "conducted much of his preliminary work on radio on Roanoke Island, just about three miles from where the Wright brothers were doing their first work with gliders at Kitty Hawk, at the same time."[32] Aircraft wireless telegraphy from the plane to ground by spark transmission predated World War One, primarily due to its "eye in the sky" military potential for aerial reconnaissance and artillery spotting.[33] Airborne wireless equipment had played an important role in the first transatlantic crossing by the U.S. Navy flying boat NC-4 in 1919,[34] and a lesser one in Admiral Richard Byrd's 1926 flight to the North Pole.[35] Although the market for aircraft radio among explorers would always be miniscule, the markets for military aviation, airmail and airfreight, and the expanding passenger air service were huge.

The fact that radio in those days had been tied to exploration and adventure in the public's mind offered a way of increasing sales of whatever the company happened to manufacture. After all, Eugene McDonald hadn't outfitted the MacMillan expedition with his company's equipment with the goal of marketing it to the Inuit peoples—although if anyone could do that *he* could. Instead, he provided a way for ordinary Americans to make a vicarious connection to the thrill of Arctic exploration without risking frostbite or having to eat their dogs—simply by buying a radio marked "Zenith."[36] Others in the radio business had tapped into the romance and adventure of flying for promotional purposes as well, including Powel Crosley, who sometimes supplied his radios to selected dealers in well-publicized flights of his personal plane.[37] His company even manufactured a plane for a while, the Crosley Moonbeam.[38] In short, an association with airplanes or exploration could sell radios—or anything else.

Whether Pilot Radio ever seriously aimed to build and sell receivers and transmitters for the small plane market (where most pilots didn't want to be bothered with what they'd initially see as another complication), or the commercial flight or military aircraft markets (which corporate giants like RCA, GE, and Western Electric had already sunk their talons into) is debatable.[39] More likely, the impetus behind Pilot Radio's efforts had to do with Goldberg's aerial enthusiasm. He had previously sold aeronautical parts and even model planes. In 1909 and 1910 he had worked with Glenn Curtiss at Curtiss Field. As Pilot's president, Goldberg had a landing strip built near his home in Westchester County, and his use of the *Pilot Radio* for business travel no doubt allowed for tax advantages to help defray its expense.[40]

A second and more practical reason for Pilot's involvement in aero communications was to use *Pilot Radio* flights, which involved constant air-to-ground HF contact, to generate publicity and boost sales of their popular shortwave Super Wasp receivers, a Bouck-modified version of which their plane carried. Whatever the reasons, between 1928 and 1930 Pilot Radio acquired, maintained, equipped, and flew a "flying laboratory," a Stinson Detroiter monoplane aptly christened the *Pilot Radio*. Other companies had their own flying laboratories as well, including RCA, which also used a Stinson Detroiter and flew it cross-country, awarding prizes to the amateurs who communicated with it at the greatest distances.[41]

Pilot Radio's interest in airborne radio likely began in 1927, the year of the Lindbergh transatlantic flight. An article in the *Brooklyn Standard Union* on May 15 states that Milton B. Sleeper, a "well known radio engineer and originator of the transatlantic receiving tests in 1919," had joined Pilot as Chief Research Director.[42] Sleeper, who was four years older than Bouck, had also started out in amateur radio before World War One. Soon he was writing about the latest radio circuits and kit building for magazines such as *Everyday Engineering*. He later founded his own magazines, including *Radio and Model Engineering*, and, much later, *High Fidelity*. Like Bouck, he was a prolific writer and a colorful figure in radio history. Although Alan Douglas refers to him as "primarily a writer" in *Radio Manufacturers of the 1920's*,[43] Sleeper's technical abilities must have been considerable as well since he not only had his own radio company in the early 1920s, but he also had been a radio engineer for Western Electric.[44] He would later go on to serve as editor of the *Proceedings of the Radio Club of America*.[45] His plunge into aviation may have begun with his decision to volunteer for the Royal Flying Corps (RFC) during World War One. He had ground training in Toronto and the fascinating accounts he published about it in *Everyday Engineering* may be the only known documentation of that process.[46] Sleeper was discharged from the RFC, which had an overabundance of volunteers, after only five months, and he apparently never flew in combat.[47] A *Popular Aviation* article in early 1929 identified Sleeper as overseeing the flying laboratory.[48] Curiously, although the Pilot Radio name and logo can be seen painted on the plane behind him in an accompanying photo, the article never once mentions Pilot Radio, which could not have pleased Goldberg. It would not be the last time Pilot's pricey sponsorship would be unreported, its public relations and promotional value lost.

How long Sleeper stayed at Pilot Radio is unclear; a month after that article appeared, his primary affiliation was with his own Sleeper Research Laboratories, from which he penned an article deriding the type of spinning disc television that Pilot had worked on.[49] Although correct about the limits of that technology, it seems he chose to rub salt in Goldberg's wound.

Bouck and Sleeper must have known each other, since both were early amateurs, engineers, writers, and members of New York's Radio Club of America, and Bouck had taken over as editor of *Radio Engineering* magazine following Sleeper's departure in 1927. Bouck began his affiliation with Pilot Radio the following year, overlapping with Sleeper for a time. Their hierarchical relationship at that point is not known. *Aviation Week* reported that both Bouck and Sleeper oversaw Pilot's radio engineering.[50] But then again, they also reported that they were working on aero television. After Sleeper's departure from Pilot, however, there is no doubt that Bouck, with the title of Engineer in Charge of Aeronautics, led its aerial efforts.[51]

Aerial Feats

By 1930, many dazzling aerial feats had already been accomplished by death-defying (if they were lucky), leather-helmeted, flying idols—the rock stars of their day. Charles Lindbergh had successfully soloed the 3,500 miles across the Atlantic from New York to Paris three years earlier, becoming a national hero and the most famous man in America overnight. About three months later, pilot Roger Q. Williams and able navigator Lewis "Lon" Yancey attempted the 4,000+ mile transatlantic flight from Maine to Rome.[52] Their first attempt ended in a plane wreck, but some people never learn. They set out again in the Bellanca monoplane *The Pathfinder*, and by flying blind part of the way, they were able to reach that destination after an emergency landing in Spain. Arriving in Rome, they were greeted by Air Marshal Italo Balbo, cheered by admiring throngs, and decorated by *Il Duce* (Mussolini) himself.[53] *New York Times* headlines and a parade down Broadway followed upon their return.

Two weeks earlier, on the opposite side of the United States, two Army Air Corps flyers, Lieutenants Albert Hegenberger and Lester Maitland (in whose honor two streets near the Oakland, California, airport are still named), accomplished the first nonstop "hop" from the U.S. mainland across the Pacific to the Hawaiian Islands. Starting from Oakland, they set down their Fokker C-2 trimotor, *Bird of Paradise*, some 2,400 miles away at Wheeler Field on Oahu the next morning (see Fig. 8).[54] Interestingly, although radio beacons had been installed at both fields, because of spotty reception and limited range at both ends,[55] the old-fashioned, visible beacon of the Kilauea lighthouse proved more useful in guiding the flyers to their destination.[56]

By April of 1930, many of the biggest feats in long distance aviation had already been accomplished. But one peculiar challenge remained: no one had ever flown a plane from the U.S. mainland to the tiny islands of Bermuda, just over 700 miles away. Bermuda had neither runways nor radio beacons, and unlike the European continent (almost 4 million square miles) or the Hawaiian Island chain (4000 square miles), at 20.5 square miles it was truly "a dot in the ocean." In those

Fig. 8. Arrival of the *Bird of Paradise*, the first flight from the United States to Hawaii, at Wheeler Field, Oahu, June 29, 1927. (Photo on display at the Kilauea lighthouse in Hawaii, credited to U.S. Air Force Museum)

days before LORAN, GPS, or Google Maps, when aerial navigation (or "avigation" as it was sometimes called) was via compass, sextant, and other dated methods, a deviation of just a few degrees could mean never seeing land and being stranded at sea, far from help, or worse, as befell Amelia Earhart in the Pacific seven years later. So the challenge remained.

Bermuda was a British dependency, and therefore not subject to U.S. Prohibition, making it a very popular destination for wealthy American tourists in those years. A two-day trip by steamer was the only way to get there. The island's merchants, however, realized the economic opportunities that tourists arriving by air could present, and just getting a plane to reach the islands was the obvious first step.

Armstrong's Seadromes

Interestingly, Armstrong had an idea that would convert that step into two shorter ones—that is, Edward R. Armstrong, an engineer and former aviator. He proposed that a giant (1,100 foot long, 28,000 ton) floating mid-ocean platform be constructed about halfway between Bermuda and the United States.[57] This would ride 80 feet above the surface, anchored to the sea floor with steel cables, and it would come complete with a landing strip, radio and visible light beacons, a weather station, service and refueling facilities, and a hotel equipped with a Prohibition-free bar for nervous passengers and thirsty aviators.[58] Armstrong had met with, and received encouragement from, Bermudian officials. The first seadrome, the *Langley,* was to be anchored 395 miles southeast of New York. Although a concept endorsed by many, including Igor Sikorsky,[59] the Armstrong seadrome fell victim to the unpredictable (poor financial timing) as well as the totally predictable (planes with extended ranges). Armstrong attempted for years to revive the seadrome idea in the interest of patriotism (boosting jobs during the Depression, bringing bits of America closer to Europe whether they wanted them there or not), or in a seedier form, as a tourist destination "beyond the reach of the 18th Amendment,"[60] which would only have to be "free from practices that would shock the conscience of mankind."[61] But the *Langley* and its kin would be at sea only in the figurative sense. The technology Armstrong pioneered, though, would later enable the development of offshore oil rigs.

Bermuda Safety Prize

To encourage efforts to reach it by air, with or without seadromes, the Bermuda Trade Development Board had offered a prize of £2,000 (about $140,000 today) to be awarded to the first flyer to reach it from the United States.[62] Although it was termed the Bermuda Safety Prize (see Fig. 9) and would supposedly be awarded based on the safety measures employed rather than speed, doubts were raised that it might instead only serve to lure reckless flyers to their doom. Lost at sea or crash-and-burn would be bad for business, not to mention the airmen. At the behest of the Director of the National Aeronautical Society in the United States, the prize offer was withdrawn before anyone tried for it.[63] But the lure of being the first remained. Prize or no prize, there was the glory that went along with the risk, and to many flyers that was enough.

On October 28, 1928, the Ireland N-2B Neptune amphibian *Flying Fish*, with pilot W. N. "Bill" Lancaster, navigator Henry W. "Harry" Lyon, and passenger George Palmer Putnam, publisher and future husband of Amelia Earhart, attempted the nonstop flight from Long Island Sound, with Amelia herself waving goodbye from shore. Other than Putnam, this was an experienced crew. Lancaster was a pioneering aviator and Lyon a legendary character who had recently been the navigator on

Fig. 9. Bermuda Safety Prize announcement and map. (*Aero Digest*, September 1927, p. 276)

the first flight from the United States (Oakland) to Australia (via Hawaii and Fiji).[64] But great expectations couldn't lift the ship. Placid waters made for too much surface tension, making it impossible for the heavily laden flying boat to take flight. The ship was later able to hop off from Hampton Roads, Virginia, but various problems including water in the gas were blamed for it ultimately setting down off Atlantic City, New Jersey, rather than Hamilton, Bermuda.[65] The flight of the *Flying Fish* to Bermuda was postponed and later rescheduled, but it never took place.[66]

Among those who thought they could do better was Captain Lewis Yancey (see Fig. 10), the navigator on

Fig. 10. Captain Lewis Alonzo "Lon" Yancey, navigator on the historic flight of the *Pilot Radio* to Bermuda. (*Aero News and Mechanics,* Vol. 2, No. 1, Feb. 1930, p. 9)

the much-publicized Williams flight to Rome. A native Chicagoan, he had enlisted in the U.S. Navy at 16, had been a lieutenant in World War One, received master mariner certification in civilian life, then joined the U.S. Coast Guard, becoming interested in aviation and especially the application of the science of navigation to flying. A true navigator's navigator, Yancey went on to write a book on aerial navigation.[67] He found the challenge of locating that dot in the ocean irresistible, and publicly announced that given just 48 hours' notice he could guide any good plane and pilot to Bermuda.[68]

William H. Alexander was one good pilot. A World War One flyer and flight instructor who had trained at the Wright brothers' aviation school, he held the *Fédération Aéronautique Internationale*, or FAI (an international organization based in Paris), flying license No. 1.[69] But unlike Yancey, Alexander had recently experienced more ignominy than adulation. On Saturday, September 7th of the fateful year 1929, after dropping off six passengers from his Coastal Airways plane at North Beach he took off again but soon ran out of fuel. Taking his seaplane down off Coney Island in the fog, he landed among the shocked bathers at Seventh Street, killing two children and wounding ten other people. Alexander, "haggard and grief-stricken," held that his water landing would have injured no one had not a wing accidentally struck a warning sign, deflecting the plane into the bathers. Nevertheless, his pilot's license was revoked and he was charged with homicide.[70] In what now seems too far-fetched for even a Perry Mason courtroom drama, the judge agreed to fly with Alexander in a reenactment, after which he suggested further safety regulations for aviators and not only cleared him of all charges but noted that it was “a marvelous experience.”[71] Alexander’s license was soon reinstated.

How navigator Yancey, pilot Alexander, and radioman Bouck came together on the *Pilot Radio* for the historic first flight to Bermuda and exactly what their hierarchical relationship was are not exactly clear. Bouck was no stranger to Bermuda; he had already visited the islands ten times,[72] including at least once with his wife Charlotte,[73] and he had friends there. A document providing important clues to the origin of the Bermuda flight can be found in the Bermuda Archives.[74] On January 9, 1930, Zeh Bouck wrote to J. P. Hand, the chairman of the Bermuda Trade Development Board, that a friend, Allan Thompson, suggested that he contact Hand about flying to Bermuda. Bouck said he was “seriously contemplating” flying to Bermuda from New York within the next month “if it is worth while.” “Can you,” he asked, “get the Board of Trade to put up a cash price [sic] for the first flight to the Islands?” He must have been aware of the previously withdrawn prize, and was hoping to get it reinstated. “I should like to know what the Board of Trade can offer me and my co-pilot for the first and necessarily historic flight to your beautiful islands.” This, and a later reference (“I am flying my ship to Miami. . .”) would seem to indicate that Bouck, who needed crutches to walk due to what one newspaper account said was “infantile paralysis” (childhood polio),[75] could still fly a plane. A number of other accounts over the years suggest this as well,[76] and reports of Bouck driving a car can also be found. A recent search was not able to uncover a pilot’s license for Bouck, but these can be hard to find, and in those days some flyers (including Lewis Yancey) apparently considered them optional.[77] So for now, this remains yet another unknown in the story of his life.[78]

Another surprising thing about Bouck’s letter is his affiliation. His letterhead was from Mackinnon Fly Publications, Inc., the publisher of *Aero News & Mechanics*, of which he was the Managing Editor. Neither his employer, the plane’s owner (Pilot Radio), nor radio in general is mentioned at all. In the letter, Bouck noted that his secondary purpose was to arrange for a series of annual air races to Bermuda, to be sponsored “more or less” by *Aero News & Mechanics* (see Fig. 11). Bouck mentioned that manufacturers (aircraft, instrument, or radio?) and pilots were enthusiastic about this, and informed Hand that he was tentatively scheduling the races for May! This letter and a few other available documents on Bouck’s private business dealings give the impression that, rather than being meek and mild as one might expect from his photos, Bouck’s was a hard-nosed, “take-charge” personality that would put Alexander Haig to shame. Being crammed into a confined space

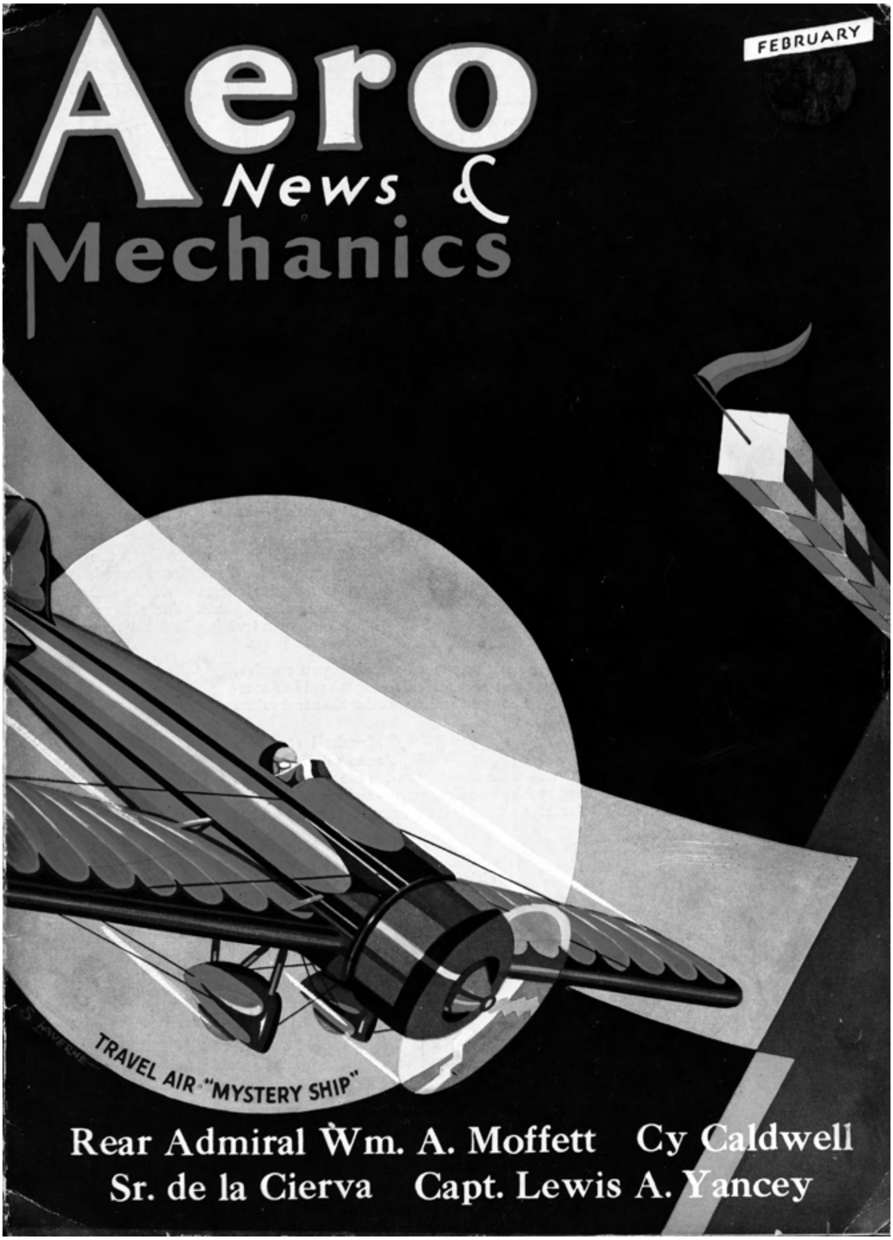

Fig. 11. Cover of *Aero News and Mechanics,* Volume 2, Number 1, Feb. 1930. Zeh Bouck was Managing Editor for this magazine, published by Experimenter Publications, and originally envisioned it sponsoring a first flight to Bermuda followed by annual races to the island.

(the *Pilot Radio*) on stressful missions with two other gentlemen similarly not lacking in ego or self-proclaimed authority surely had interesting consequences, but unfortunately little about this remains in the historical record.

In writing to Hand, Bouck didn't fail to note that "we all appreciate the publicity and trade that would accrue to Bermuda as a result of my primary flight and the subsequent annual races." Bouck did receive a reply to his letter—a negative one. He was advised to "abandon any such idea until proper navigational and meteorological facilities exist."[79] Bermuda had already voted funds for the construction of a meteorological station and planned to eventually install a radio beacon, but the government was slow to act, which may, in fact, have prompted the flyers to hurry up and reach the islands while doing so was still a challenge. Replying to the Bermudian objections, the ever-resourceful Bouck wrote back, suggesting that Bermuda station BZB could be used as a navigational aid (RDF). Permission to land, required by international convention, was never granted,[80] the prize was not reinstated, and the proposed races would never take place, but the proposed first flight to Bermuda did… "more or less."

The Flight to Bermuda

Preparations

Financial support for the flight came from a variety of companies. Isidor Goldberg, provided the lion's share by providing the *Pilot Radio*, the radio equipment, and payments for the crew. Goldberg no doubt anticipated his company's name being featured nationwide in news accounts of the flight. Richfield Oil provided the fuel and oil. The Pioneer Instrument Company was a sponsor. The Edo Corporation, named from the initials of founder Earl Dodd Osborn, fitted the "ship" with the pontoons that would allow for water takeoff and landing. This was carried out in secret lest someone else beat them to the punch. *Aero News & Mechanics* was apparently not involved,[81] but other publications, notably the *New York Times*, were. In fact, Bouck would be pounding out exclusive in-flight dispatches to the *Times* radio station WHD on 43rd Street in Manhattan and its chief engineer and crack operator, R. J. Iverson, thus reducing to practice the idea of constant two-way air-to-ground HF communication. WHD already had an impressive record of DX communications with explorers and flyers (although not necessarily continuous contact) and would build on this in coming years.[82]

The *Pilot Radio* itself was a recently manufactured, modified 6-seat Stinson SM-1FS "Detroiter" high-wing monoplane (NR 487H) powered by a 9-cylinder, 300 horsepower Wright "Whirlwind" (J-6) engine, with brakes by Harley Davidson (see Fig. 12). The ship, acquired in mid-to-late 1929 to replace an earlier Pilot Radio flying lab (a Stinson SM-1B, NC 4876),[83] was specially equipped with extra gas tanks in the wings, for a total fuel capacity of 200 gallons, enough to cruise at 100

Fig. 12. The *Pilot Radio*, Pilot's "flying laboratory," a Stinson SM-1FS Detroiter that made the historic first trip from the U.S. mainland to Bermuda. (*Aero News and Mechanics,* Vol. 2, No. 1, Feb. 1930, p. 52)

mph for 12 hours. Oil could be added from inside the plane. It had a maximum speed of 135 mph and a service ceiling of 17,000 feet.[84] Its rated carrying capacity was 4,700 pounds, but the fully laden plane at takeoff would weigh 5,200 pounds.[85]

The plane would carry two transmitters, one longwave (600–1100 meters) for the old aero beacon/emergency band and the other a shortwave transmitter (35–50 meters) for anticipated in-flight communications. Both were housed in a single unit, and both employed a Hartley oscillator. Communications would be entirely radiotelegraph. All of the radio equipment had been built by Pilot Radio under Bouck's direction. The receiver was a modified AC Super Wasp that used Arcturus AC tubes, which, with heavy cathodes, were less prone to microphonics than DC tubes. Special coils allowed it to be tuned between 14 and 1200 meters. Receiver and transmitters were combined in a single unit suspended from the top of the plane's frame. An Exide "non-spillable," 12-volt, lead-acid aircraft battery supplied filament voltage to both receiver and transmitters and powered an Esco dynamotor that fed 1000 volts at 100 milliamps to the plate of the De Forest 510A transmitting tube. The Exide, in turn, was continuously charged (except when receiving) by a wind-driven generator mounted on the plane. Receiver B and C voltage was supplied by Eveready batteries. A trailing antenna of variable length was used. Communications would be carried out with the antenna spooled out to 90 feet to work the third harmonic on 41 meters. When not in the air, an emergency antenna could be strung up between the wingtips or flown via kite,

Fig. 13. Zeh Bouck at his station aboard the *Pilot Radio. (Radio News*, July 1930, p. 12)

and Bouck estimated there would be enough power to communicate for ten hours without charging.[86] The entire radio setup weighed 140 pounds, and the plane's callsign was W2XBQ (see Fig. 13).

The Bermuda Short Hop

It was April Fool's Day, 1930, but the mission that day was dead serious. The flyers were eager to hop off as soon as possible to forestall possible competition for the title of first to fly from the United States to Bermuda, but weather was a major factor. For advice on weather, they turned to Dr. James H. Kimball, chief meteorologist at the New York Weather Bureau, whom Bouck referred to as "that Palladium of oceanic flyers"[87] (*i.e.*, their protector). He had prognosticated weather conditions for Lindbergh for his famous transatlantic flight and for Byrd on his flight to the North Pole.[88] At 11 p.m. on March 31, Kimball's report had come in: calm weather was predicted the next day for the entire area between New York and Bermuda. The hop was on (see Fig. 14).

In the wee small hours of the morning at Bouck's New York apartment "provisions had to be packed and other domestic arrangements completed, much to the annoyance of the folks living below. They rapped viciously and repeatedly on their ceiling with some variety of battering ram. After eighteen hours of a hard day's work, this was an amusing interlude, and I responded, in my kindly way, by dropping encyclopedias on the floor at judicious intervals."[89]

After just a couple of hours of sleep, Bouck went to pick up the battery that he had left at a battery station for charging after specifically warning the attendant not to top them off. Batteries meant for airplane use were constructed differently from car batteries to compensate for in-flight sloshing; the cells were not meant to be filled completely. Of course, after a

Fig. 14. The *Pilot Radio* being towed from its hangar into the water at College Point, Queens, the morning of April 1, 1930, for its historic first flight from the U.S. to Bermuda. (Author's collection)

shift change the new attendant took a look, saw the low level, and proceeded to top them off. "I discovered this at 6 a.m. with our takeoff scheduled for a half an hour later," wrote Bouck. "There was only one thing to do: empty out most of the electrolyte and add sulfuric acid. Unfortunately, there was no sulfuric acid to be found. I tried frantically for a half hour to locate an open drug store without success." He finally located some at 7:30, dumped the old electrolyte and filled each cell with 24 hydrometers full, one by one. "We blew through the gates at North Beach a quarter hour later, held up for a moment by an importunate member of the press who was clamoring for a story. We explained that we were somewhat busy at the moment, whereupon he sweetly expressed himself with the following sentiment: 'I hope — — — plane sinks!' This didn't bother me at the time, though I did recall this touching farewell that night."[90]

Because of the battery, Bouck was nearly two hours late for the "hop off" and out of contact with Alexander, Yancey, and others who were probably searching for him the whole time. Usable daylight hours, important for this long flight, had burned away. The greeting he received from his fellow crewmembers can only be imagined; about it he wrote nothing. The plane was afloat on Long Island Sound at Clason Point where the takeoff was attempted. Inauspiciously, the takeoff failed four times in a row because the fair weather had left the waters too calm, which made for high surface tension, which produced significant drag on the pontoons of the heavily laden plane. This was the same problem that had beset the earlier Bermuda attempt by Lancaster and Lyon. Even the big 300-horsepower Wright Whirlwind engine struggled with this. Takeoffs in choppy water were easier.

To lighten the load, the weight needed to be reduced, and it wouldn't be surprising if the idea of jettisoning Bouck and his batteries came up. Instead, a sea anchor, spare pontoon plates, and some extra fuel were discarded. The fifth attempt again failed, but the sixth was a charm. This time they took advantage of the wakes created by two ferryboats and some helpful waves created by an assisting Edo seaplane. "Bill Alexander gave her the gun," chronicled Bouck. "In another second the *Pilot Radio* was on the step, the bumps becoming sharper and sharper as the air speed indicator rose from fifty to fifty-five, sixty, sixty-five miles an hour. One more sharp rap on the pontoons and we were off. We gained altitude rapidly and cleared the bridges in good style." Yancey remembered it differently. "I saw the Hells Gate Bridge straight ahead. I pointed it out to Bill. He nodded and said he saw it. Meanwhile, when destruction seemed certain and it appeared we were going to crash into it, Zeh Bouck, calmly oblivious, proceeded to reel out his fishing line antenna . . ."[91]

The oblivious Bouck then began his radiotelegraph dialog with the *New York Times* station WHD. "What provisions were they carrying?" asked the

Times. "Rations on board consist of two broiled chickens, four boxes wholewheat crackers, five pounds of chocolate, twelve oranges, five gallons water, one quart Scotch," he radioed back. In those Prohibition days, the last item seemed to create some excitement, but Bouck noted that it was for medicinal use only—later observing that they were probably the only ones ever *bringing* whiskey *to* Bermuda. Yancey took sightings by sextant after sliding back a plastic (pyralin) window at the top of the cabin, letting in 100 mph winds. Sightings taken through the pyralin would have been more comfortable, but they would have been in error because of its refraction.[92] Yancey carried three Longines chronographs so that if one got out of whack the other two would give a consensus on which one was in error.

The plane sped on its way at an altitude of 2,000 feet. Bouck communicated with WHD regularly the whole way, and the station relayed his messages.[93] At 1:55 p.m. Bouck sent a message, "Greetings from mid-Atlantic to you, mother....JACK." WHD was asked to relay hotel reservations to BZB in Bermuda. Yancey asked Bouck to tap out, "The sky is partly cloudy and we hope it will get no worse, as it might prove hard to find the islands." At 5:20 p.m. the message from the *Pilot Radio* was, "If we don't see the islands pretty soon, we will set her down for the night. If we have to set her down for the night, don't let anyone worry about us. The sea is like a lake." Fifteen minutes later the update was, "we may make it and we may not." It was getting dark and they had been fighting headwinds. The morning's delay loomed larger and larger. Had Yancey really steered them on the correct course? At 5:50 PM a decision was reached: "Setting her down right now. Position sixty miles north of Bermuda. Tell everyone not to worry… Will continue to Bermuda in the morning." GN (good night) followed. The *New York Times* would tell its readers the next morning: "Two-Hour Delay in Taking Off Is Blamed for Failure to Reach Objective."

Bouck decided that after landing on the water, he would let his notorious batteries rest until morning rather than string up an emergency antenna and run them down overnight. Fully charged batteries would be most useful in case of problems taking off in the morning. While the *Pilot Radio* had been fitted out with pontoons for water takeoff and landing, actually being able to land on the open, rolling sea and then take off again the next morning after the engine had potentially been sprayed with brine all night was not assured. And with the sea anchor left behind, there was the possibility of drifting into a coral reef overnight that could sink the plane (after all, there was that reporter's curse). In fact, to that date no plane forced down in the middle of the ocean had ever successfully taken off again. For one thing, as Bouck was to note, "water is a hard thing to hit at 60 miles per hour." But Alexander, an experienced seaplane pilot, managed to set her down and the Edo pontoons held. Seen up close, the sea turned out to be rather unlike a lake. The sea anchor having been jettisoned, a couple of 10-quart pails were strung together to provide some stability, but these proved useless for much of the time. Afloat, the flyers endured swells and pitches. "'Gentlemen, I'm going to be sick,' Alexander said. And he was."

The plane was too far away from Bermuda for it to have been spotted, and the flyers rather conspicuously made no attempt to contact the Bermudian authorities, who had pointedly denied them permission to land there in the first place.[94] Bermudians were therefore unaware of the plane's presence off their shores until a cable from New York reached them after 8 p.m. The sound reasons behind denying landing permission then became apparent. With incomplete information from New York and nothing from the plane, Bermudian authorities had to assume that it was in distress and mobilize their resources for assistance. Much to their credit, this they did, fully and immediately. Bermudian authorities tried to communicate with W2XBQ (the *Pilot Radio*) at the 600 meter (500 kHz) international emergency frequency from their St. George's wireless station, which was kept open all night, but received only silence in return. A little-publicized consequence of the *Pilot Radio*'s silence was that U.S. East Coast radio stations briefly shut down at about 5:52 p.m. Eastern time per protocol to "clear the airwaves" for a possible 500 kHz SOS transmission.[95]

Upon learning that the plane had been working 41 meters, the Bermudians attempted to reach the flyers on that band as well, but the De Forest 510A tube remained unlit, perhaps unlike the flyers with their bottle of Scotch. Searchlights were switched on. A lookout was kept at the Gibb's Hill lighthouse. All ships anywhere in the vicinity were asked to be on the lookout. Arrangements (which included insurance issues and financial considerations) were made to have a steam tender, the *Mid-Ocean*, leave Hamilton at dawn to search for them.[96] In short, the Bermudian authorities went to great lengths to aid the aviators perceived to be in distress, who had given them no notice, intentionally remained silent, had been warned not to attempt it, and were pointedly informed that no assistance would be offered if they did.

Three times during the night the flyers spotted the lights of a ship in the distance. After considering the possibility that it might be out looking for them, at 3:15 a.m. they fired off the "Very pistol" (a flare gun). The ship, which turned out to be the Canadian steamer *Lady Sommers*, hove to and headed towards them. They could have communicated with her at some distance by code using a flashlight, but Yancey had lost the plane's only flashlight while inspecting the pontoons. Fortunately, this was a problem that even the dullest of the Radio Boys—much less Zeh Bouck himself—could easily solve. Gathering together a spare bulb, a couple of wires, and an extra flashlight battery he tapped out Morse messages, touching wire to battery terminal. The *Lady Sommers* had in fact been sent out to look for them and offered to take them aboard. Its captain was surprised at the flyers' reply; they did not wish to be rescued. They would weather the swells for the rest of the night and proceed to Hamilton in the morning, asking Captain Armit to kindly relay the message.

Land Ho!

At daybreak, around 5:40 a.m., despite the swells and seasickness, "Bill [pilot William Alexander] showed his mastery of a ticklish job, and for the first time in the history of flying, a plane forced down in the middle of the ocean took off again." Five minutes later the antenna was out again, the 50-watt transmitter and modified Pilot Super Wasp receiver fired up, and there on 41 meters was the radio operator at WHD New York, "as loud and clear as when we were over the East River," happy to find the adventurers alive and well and approaching Bermuda. He informed them that some other New York papers had already written them off as dead, "which news amused the lads up forward [Alexander and Yancey]." A copy of the message they sent to Edo 10 minutes after taking off praising the quality of their pontoons is shown in Fig. 15. At 6:15 a.m., an island was spotted dead ahead—Yancey had made good on his boast, guiding them on a beeline to Bermuda.

Bouck would go on to chronicle this flight in at least four publications: *Radio News, Radio Design, The New York Sun,* and *Yachting.*[97] These accounts differ slightly in length and a few minor details, but for the most part are quite consistent, even using the same text—recycling copy having always been popular among writers. The first three of these, however, end with the sighting of Bermuda in the distance that April morning and Bouck calling Yancey "the finest aerial navigator in the world." The reader is left

Fig. 15. Part of an advertisement for EDO pontoons. Note that the telegram's letterhead refers to the South American Good Will flight, which would not take place until later, but had apparently been in preparation for some time. Also note that Bouck is listed as navigator and Yancey's name is absent from the letterhead. (*Aero Digest*, June, 1930, p. 101)

with the impression that from there it was just a matter of setting her down in Hamilton Harbor—presumably to loud huzzahs—to complete their historic flight. In fact, the end of the journey was quite a bit more complicated, as Bouck related only in his article in *Yachting*. Since then, many secondary accounts of the journey either contain differing accounts of this stage or leave it out entirely. But of all the reports at the time or since, Bouck's eyewitness account most has the "ring of truth" to it and consequently is presented here.

With the islands in sight, Bouck asked Alexander how much fuel was left. "About one hour," he replied. But a few minutes later, "'Putt . . . putt . . . putt,' says the motor, and conked . . . Once having heard that sound, it is as easily forgotten as the shake of a rattlesnake's tail. We were definitely out of gas." An overly optimistic fuel gauge had deceived them. They had been spotted from shore by Commander Landman, the pilot warden, but they wouldn't know this until later. Alexander again set *Pilot Radio* down at sea, this time in an emergency landing about five miles short of the islands "just inside of the reefs." In fact, their improvised sea anchor actually caught on the rocks just a few feet below the pontoons, temporarily anchoring the plane in place. Bouck began stringing up an emergency antenna, but before they could call for help, the frayed anchor line snapped and the current caused the plane to drift west, "toward New York City," as Bouck said, but by way of the pontoon-piercing reef.

The story continues at that point: "Bill's genius rose to the situation. He figured that rocking around out there, as we had been doing for the past half hour, we might have sloshed a quart of gasoline down into the equalization tank. Lon [navigator Lewis Yancey] cranked the engine. She took instantly and Bill gave her the gun with Lon climbing through the door, and ten fathoms of rope and radio antenna streaming out behind. We had two minutes of gas—enough to set down definitely in the steamer channel just off Shelley's Bay." Here they were met by Messrs. Tucker and Meyer in a speedboat, the first two from Bermuda to contact the new arrivals. Informed of their dry tanks, they soon went back to get the flyers some gas. In the meantime, along came a more official delegation from Bermuda aboard the *Golden Wedding* (see Fig. 16). The flyers' arrival was commemorated on a Bermuda postage stamp many years later (Fig. 17). Mr. J. P. Hand, who had personally been involved in refusing Bouck permission to land in Bermuda, various newsmen, photographers, and others gathered around to gawk at and document the historic spectacle.

Arrests and Celebrations

Amid smiles, handshakes, and slaps on the back, Hand welcomed the crew (see Figs. 18 and 19), and then he proceeded to put them under arrest "for flying over Bermuda without a permit and similar diplomatic necessities." It wouldn't be the last time Bouck would be arrested in the course of his adventures. When

Fig. 16. The *Pilot Radio* arrives in Bermuda on April 2, 1930. Bouck is sitting atop the plane with "Pilot Radio" showing on his back. (Roddy Williams Collection, Bermuda Archives)

Fig. 17. Commemorative postage stamp issued by Bermuda in 1983 based on the figure above. (Author's collection)

Fig. 18. Another view of the *Pilot Radio*'s arrival in Bermuda. On the plane: Lewis Yancey, William Alexander, Zeh Bouck, and J. P. Hand. (Roddy Williams Collection, Bermuda Archives)

Fig. 19. Front: William Alexander, Zeh Bouck (sitting on wing strut), and J. P. Hand. Person on the rear pontoon wearing spats is probably a Mr. Richardson. (Roddy Williams Collection, Bermuda Archives)

the other boat arrived with the gas, Hand and a Mr. Richardson joined the crew on board the plane as it again went aloft, this time for a quick aerial tour of the islands, after which at last on April 2 at 8 a.m., the plane alighted in Hamilton Harbor (see Fig. 20) in a landing "so smooth that one could not have told that the plane was hitting water.[98] When asked if they wanted anything, Yancey replied, "Anything, as long as it's alcoholic." Obligingly, a boatload of cocktails and ale from the famous Inverurie Hotel, a favorite of Bouck's, was brought out to "liven up our brief period of incarceration." Soon "pratique" was granted, diplomatic rough

Fig. 20. The *Pilot Radio* arrives in Hamilton and is greeted by officials and spectators. Yancey, Alexander, and Bouck can be seen on the plane near the wing struts. (Roddy Williams Collection, Bermuda Archives)

spots smoothed over, and the silly arrest forgotten "through a mist of Martini drys." Later the crew was presented with flowers at the Inverurie Hotel in Hamilton (see Fig. 21). The Bermuda Governor would eventually go on to grant them *post hoc* landing permission.

Thus began the next phase of their trip, a grueling series of dinners, celebrations, toasts, and speeches. Bouck celebrated his 29th birthday in cocktail-laden Bermudian glory. At a dinner in honor of the flyers he was introduced as "outstanding among radio experts

Fig. 21. The flyers are presented with a bouquet of fresh lilies at the Inverurie Hotel in Hamilton on April 2, 1930. Left to right: Miss Kathleen Jones, Lewis Yancey, Zeh Bouck, and William Alexander. (Roddy Williams Collection, Bermuda Archives)

in the United States, and regarded as the young Fessenden."[99] In fact, Bouck took the occasion to make a pilgrimage to see the real Professor Fessenden and his wife, who were living in Bermuda. She wrote: "We counted it a fine tribute that Mr. Bouck devoted the better part of an afternoon of his short stay on the island to a call at 'Wistowe' to pay his respects to the man who had done so much to advance radio. When this call revealed to us the fact of his great physical handicap, it revealed too that the courage which led him to choose his profession must be of a very high order."[100]

While the receptions continued in Bermuda, back home the sponsors' PR machines had sprung to life. Yancey had made a promotional deal with Richfield Oil, which proceeded to praise the aviators for conserving fuel by landing at night rather than trying for the island in the dark. "And the famous Partners in Power, Richfield—California's famous gasoline and Richlube—100% pure Pennsylvania Motor Oil had scored another triumph."[101] Isidor Goldberg of Pilot Radio, of course, expressed his admiration of the consistency with which the flyers were able to keep in touch *at all times* using his company's equipment. Osborn of pontoon-maker Edo was especially pleased with the ocean landings. Pioneer Instruments, manufacturers of the plane's navigation equipment, noted that the water landing (only one or two were mentioned in American news reports) "served to dispel popular beliefs that sea landings are always disastrous unless saved by an unusual stroke of luck."[102] The *Times* in its inimitable way pontificated on lessons learned from the flight, finding the radio signals "remarkable for their clarity all along the 759-mile stretch" and concluding that there should certainly be radio beacons and radio direction finders installed in Bermuda to make flights routine rather than dependent on extraordinary navigation. It found that "what aviation needs is compact, light equipment in the form of receivers, transmitters and radio direction finders."[103] But it said nothing about Pilot Radio equipment—the publicity value of the flight for Pilot was minimal. Most accounts referred to it as "Yancey's flight" and not "Pilot Radio's flight"; almost none of them mentioned the Super Wasp. Again, the spotlight had been directed elsewhere.

In Bermuda, the flyers met with local U.S. and British officials, which must have been anticlimactic for Yancey after his audiences with Mussolini and the Pope in Rome. Now that the airmen had actually made the journey and lived, the Bermuda Board of Trade, the organization that had earlier offered and then withdrawn the £2,000 Bermuda Safety Prize, voted $1,000 to each of the crewmen to express their gratitude, which must have seemed something like the Bermuda Consolation Prize, but was no doubt still welcomed. Alexander applied for permits to fly local officials around and then fly back home.[104] As to how Bermudians viewed the flight, editorials suggest excitement over what it augured for eventual connection with North America and Europe by air, but also plenty of caution. "The fact remains that a forced landing happened under favourable conditions and converted what might have been a disaster into a mere unfortunate incident."[105] The extraordinary nature of their flight underscored the need for a radio beacon. "I hope no one else will try this flight until we put in radio beam facilities here, and I believe Captain Yancey would say the same," Hand concluded.[106] Those facilities were a long time in coming, but were in place seven years later when Pan American Airways and Imperial Airways began regular service to Bermuda, employing constant radiotelegraph communications just as Bouck had proposed.

The Heroes Return

The *Pilot Radio* was inspected by British Navy mechanics, who found a serious problem: the landings at sea had damaged one of the pontoon struts. Lacking the special equipment needed to weld the duralumin alloy they could try fixing it, but couldn't guarantee that the weld would hold when the again heavily-laden plane took off. There were also other potential problems. No aviation-grade fuel was available in Bermuda, and it would take three weeks to ship some in. The regular gasoline that the plane used for the last few miles would do in a pinch but not for a long flight. And after everything that the Bermudians had already gone through, they were none too keen on the prospect of potentially mounting another search-and-rescue mission, especially for the same flyers.

So the plane was partly dismantled and hauled up onto the deck of the SS *Araguaya* (see Fig. 22), which sailed for New York with plane and crew. They arrived to a festive reception featuring flyovers by fellow aviators including Emile Burgin, a friend of Yancey's who had flown the *Pilot Radio* before and would soon do so again. They shook hands with officials, were photographed, were met by their wives, and feted at the Majestic Theatre that night. Guests of Isidor Goldberg and 200 others at the Biltmore the following evening, they spoke of their overnight ocean experience, which they all agreed was "not bad," over the NBC radio network via station WJZ. As far as their having made a stop en route (actually, from one to three stops, depending on how you defined the destination), they were satisfied that they had still met their primary but unstated objective, proving conclusively that an air service between New York and Bermuda would be feasible with the proper equipment. When a newspaperman (perhaps the one who laid the unsuccessful curse on Bouck?) tried to spoil the party by telling Alexander of a bootlegger who claimed to have already made regular flights to Bermuda, he dismissed the claim. "I don't think anyone ever flew there before," he said.[107]

A few weeks later Bouck, speaking over WGBS in New York, summarized what their flight had proven: 1) that it was possible to "come down in the middle of the ocean, spend a night, and then take off again," 2) that it was the first time any plane was able to find

Fig. 22. Crew and plane returning to the United States aboard the steamer *Araguaya*. Left to right: Lewis Yancey, William Alexander, and Zeh Bouck. (Collection of Tom Singfield)

Bermuda, and 3) that a two-way wireless conversation (in code) could be carried out over the whole route by HF.[108] In fact, he was pleasantly surprised that there was no sign of a "skip distance effect," which at some point (they had estimated 500 miles) would cause the signal to be lost. Quite to the contrary, Bouck had needed to attenuate the overly strong signal at times. In light of these successful communications, it made little sense to add the weight of a longwave set. He again emphasized that planes making the journey should be in constant contact with a land station.[109] When asked whether shortwave communications could be carried out from a plane by "phone" (voice) he said that it could, but would require heavier equipment.[110]

While the dinners and speeches, toasts, interviews, and photos continued, the *Pilot Radio* was quietly being overhauled. Workers removed her pontoons and gave the plane back her land legs (wheels). She would soon depart on a marathon journey that would make her last adventure seem like a short stroll in the park.

To be continued. . . .

Endnotes

1. The South American flight of the Pilot Radio (to be addressed in Part 2) was sponsored by the Hoover administration, and as a member of that party, Bouck was something of an unofficial U.S. ambassador.
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5. *Who Was Who Among North American Authors 1921–1939*, Volume I (Gale Research Co., Los Angeles, 1976), p. 185.
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13. H. Gernsback, "The Old E.I. Co. Days," *Radio News*, Mar. 1938, p. 632.
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20. Robert Hertzberg, "Super-Wasp Short-Wave Set," *Old Timers Bulletin*, Vol. 11, No. 3, Dec. 1970, p. 17.
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22. Quotation from aviation magazine provided by Ed Lyon. My thanks to Ed for this and other valuable insights into early flying and radio communications.
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25. A. K. Ross, "Making Radio Easier for Aviators," *Radio News*, Sep. 1928, p. 202.
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32. A. Lynch, "Radio and Aviation," *Radio News*, May 1929, p. 985.
33. See, for example I. M. Philpott, *The Birth of the Royal Air Force* (Pen and Sword Military, South Yorkshire, UK, 2013), pp. 304–306. For early radio experiments on U.S. Navy planes, see L. S. Howeth, *History of Communications-Electronics in the United States Navy*, chapter XIV, available at http://earlyradiohistory.us/1963hw14.htm.
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63. C. A. Pomeroy, *The Flying Boats of Bermuda* (Colin A. Pomeroy, 2000) p. 10.
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72. "Dinner in Honour of the Fliers," *Royal Gazette and Colonial Daily* (Hamilton, Bermuda), Apr. 9, 1930.
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95. "Zeh Bouck, Well Known Here, in Plane that Flies to Bermuda," *Schoharie Republican* (New York), Apr. 3, 1930 says that WGY programs were interrupted. "Plane Flying New York–Bermuda Comes Down in Calm Sea Sixty Miles North of Here," *Royal Gazette and Colonial Daily* (Hamilton, Bermuda), Apr. 2, 1930 lists WEAF among the stations maintaining radio silence.
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97. Zeh Bouck, "W2XBQ Flies to Bermuda;" Bouck, "How the Pilot Radio Made the First Bermuda Flight;" Bouck, "The Story of Three Men in a Tub—On Wings;" and Bouck, "The First Airplane Reaches Bermuda," all cited above.
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103. "On the Way to Bermuda," *New York Times*, Apr. 6, 1930.
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About the Author

Bob Rydzewski, KJ6SBR, is a native of Chicago, Illinois, where his parents had worked at various times for Teletype Corporation, Belmont Radio, and Zenith. One of his earliest memories is of looking up to the eerie green magic eye of a 1930s Zenith console. His interest in electronics as a hobby began about the time he assembled an Eico 460 oscilloscope in a high school physics lab. Around 2000 he developed an interest in collecting and restoring old radios. Inspired by Alan Douglas's *Radio Manufacturers of the 1920's*, he began searching out the fascinating and often forgotten stories behind the early days of wireless.

Bob received an MS in chemistry from DePaul University and went on to a 25-year career in pharmaceutical and biotech R&D, eventually penning a textbook on drug discovery. His writing abilities came to the fore in his current career as a professionally accredited medical writer, helping doctors present clinical trial results through journal articles and congress presentations. Bob and his better half live in the San Francisco Bay Area where he is a proud member of the California Historical Radio Society.

Bob Rydzewski

A Soviet Era Broadcast Receiver System of the 1950s for Remote Locations

For nearly 20 years I have taken a special interest in studying how the various national broadcast systems of the world have developed. These variations have often resulted in the development of very different hardware to serve these systems. I was recently given a Russian made thermoelectric generator of the 1950s in very poor condition prompting me to research its significance before investing time in restoration. I was already aware of their existence for powering small broadcast receivers in remote locations of the former USSR and English language Google searches produced links to basic information. Examination of serial numbers found in Google Images searches lead me to believe that these generators were at least made in the tens of thousands and not just a novelty. With little to lose in trying to make my unit presentable, I started preservation and restoration activities. After about 15 to 20 hours work, I concluded that it could be made presentable for exhibition; this prompted me to locate an appropriate radio that would have been powered by these generators. A fellow collector provided me with a fine example that turned out to have one surprising construction method, perhaps making a virtue of necessity, and several other very interesting features that prompted a new round of research. This paper describes my research into this broadcast receiving system, and provides a narrative of how these artifacts were prepared for conservation and exhibition. Many aspects of this receiving system and these artifacts will be largely unfamiliar to American readers.

Introduction

Based on 20 years of study, it became obvious that very different types of hardware were developed to support the various national broadcast systems of the world. I wrote two papers on this subject for the *AWA Review* describing various aspects of broadcast receiver development outside of the United States, the first treating Italian systems and the second treating radios from a number of other western European countries.[1] This paper addresses several unique broadcast radio systems in the Soviet Union.

Beginning in the early 1920s and into the early 1930s, the Soviet Union recognized the value of establishing a broadcast radio system to unite, indoctrinate, and educate the populace. At that time, the primary means of providing radio reception to the populace was accomplished by placing radios in administrative buildings with loudspeakers distributed along city and town streets or by centralized receivers with wire lines going to subscriber apartment buildings, factories, public halls, schools, etc., which were operated much like telephone exchanges. The same type of receiver could be placed in an apartment block, dormitory, factory, or school to drive 50 to 250 small speakers. This distribution from a single receiver to multiple loudspeakers in an area was referred to as "radio-diffusion exchanges," "cable radio," or "wired radio." People paid a small subscription fee for the service. At least from the late 1940s, these wired networks distributed program content from 6 a.m. to midnight.

The number of receivers in the Soviet Union reported in census figures during the 1930s are considered to be highly suspect by Western historians. The official claim of 170.6 million people in the 1939 census is believed to be inflated by 10 to 20 million. Reports of Soviet statistics in 1940 claim 1.1 million radios at that time, but that is actually the tally of radios manufactured since 1932.[2] According to the research of Alex Inkeles, the whole of the Soviet Union possessed 650,000 receiving sets in 1936; of these, 270,000 were crystal receivers, and about 200,000 were considered outmoded types in need of replacement.[3] The Radio Committee was able to claim only 500,000 sets as being "ready" to broadcast Stalin's address before the Supreme Soviet on November 25, 1936. The number of broadcast receivers in operation as of 1940 was reported to be 760,000, with more than five million wired speakers of the cable radio systems. After the ravages of World War II, less than 18% of listeners in 1947 were said to be receiving their programming via individual receivers. It should be noted that in the rural areas, only a small percentage of the population heard any radio programming on a regular basis. In any case, the penetration of broadcast radio reception via individual receivers lagged far behind most modern industrialized countries that the Soviets were trying to surpass.

The government realized that postwar efforts to manufacture broadcast receivers would have to be dramatically increased, and so design bureaus within ministries, universities, and a few radio factories were tasked to develop new designs for low-cost, mass-produced radios. These designs were reported in detail to the public in the pages of the Soviet magazine Радио (*Radio*) beginning in the very late 1940s.[4] Actual volume production was low and did not begin to increase significantly until after 1953, due in large part to the deemed higher priority of rebuilding the electrical, electronic, and communications resources of the Red Army. It was not until the latter half of 1956 that all radio assembly plants were reportedly operating on a continuous assembly-line basis.[5]

Rural electrification in the Soviet Union lagged behind that in the United States by some 25 or 30 years, such that there was still a significant need for battery-powered broadcast receivers into the 1970s. Adequate distribution of expensive dry batteries to remote locations was at times unreliable and, of course, a continuing expense. Many people remember magazine, newsreel, and television coverage of long lines of Soviet citizens in seeming endless queues for basic goods. Consequently, the Soviet Union began to develop thermoelectric generators as an optional power source.

I recently obtained a Russian-made thermoelectric generator of the 1950s in very poor condition, which prompted additional research to determine its significance before investing in a restoration project. English language Google searches for thermoelectric generators that powered small broadcast receivers in remote locations of the former USSR produced links to basic information. Examination of serial numbers found in Google Images searches determined that these generators were made at least in the tens of thousands—not just as a novelty. After 15 to 20 hours of preservation and restoration work, it became apparent that it could be restored to a condition suitable for presentation. It was obvious that a presentation of the generator would be much enhanced by connecting an appropriate Soviet radio to the generator. A fellow collector provided a fine example of a Soviet radio that turned out to have one surprising feature and several other very interesting features that prompted a new round of research. These features will be described in Part II herein addressing Soviet receivers powered by thermoelectric generators.

This paper combines my research into thermoelectric generators in particular and Soviet broadcast receiving systems in general. A description of how these artifacts were prepared for conservation and exhibition is also included. A great deal of this information will be new to most American readers.

PART I. THERMOELECTRIC GENERATORS

Early Thermoelectric Generators

The fact that heated junctions of dissimilar metals can create a magnetic field was discovered by Seebeck in 1821. Seebeck thought that the phenomenon he observed was that of conversion of heat into magnetism. It was left to Ørsted to correct this misperception and properly describe it as creation of an electric current, and in doing so he coined the term "thermoelectricity." The electrical output of individual dissimilar metallic junctions is very small, generally seldom more than 3 to 15 millivolts.

The first patent for the use of thermoelectricity instead of batteries for useful work in electroplating was by Moses Poole in 1843.[6] By the middle 1860s, thermopiles (assemblages of multiple thermocouple junctions to provide useful voltages and currents) were being noted in journals of scientific societies. The junctions were of metals and metallic alloys with junction potentials well under 20 millivolts.

These early thermopiles were said to have been unsuccessful for continuous work because of oxidation of the metals and junctions as well as stress fracturing of constituent metals during cooling or heating.

By 1874, a gas fired commercial version of the Clamond Thermopile was reported to be in operation at the printing works of the Banque de France, presumably for electroplating copper in the electrotyping print process.[7] In 1876 the (British) Government Telegraph Service under the direction of Sir W. H. Preece issued a contract to the Thermo Generator Company to supply thermopiles as a replacement for the usual system of electrochemical batteries, but the project was in short order declared a failure. Preece indicated it was his opinion that the faults could be corrected, but the company collapsed before they were able to complete the contract.[8]

There were a number of investigators in the last quarter of the 19th Century that attempted to overcome the deterioration of junctions and improve efficiency, but the development of practical small dynamos for electroplating virtually eliminated the primary market for thermopiles. In 1909, engineer Edmund Altenkirch is credited with expressing a mathematic relationship between physical properties of thermoelectric materials and the efficiency of a simplified thermopile.[9]

Thermoelectric Generator Applications to Wireless Sets

The Science Museum in London has exhibited a *Thermattaix* gas-fired thermopile designed circa 1925 for charging "wireless set accumulators" (vacuum tube radio receiver filament supply batteries) over the range of 2 to 10 volts (see Fig. 1). The magazine *Amateur Wireless* for April 1929 carried an ad for a *Thermattaix*, claiming that it could work your wireless set by gas, petrol, steam, or electricity. . . . Electricity? On the surface, this claim to operate a radio by electricity seems to be an oxymoron, but it is one way to convert high-voltage alternating mains to the low-voltage direct current required for charging accumulators. Or, if the high voltage mains came from a jittery one-cylinder motor/generator outfit, it could act as a voltage stabilizer. The ad goes on to claim that amongst their customers were gas companies, the Italian Air Force, architects of note, and guides for big game expeditions in Africa and India. It is not known how many units were manufactured, but very few, if any, are in the hands of collectors.

Fig. 1. *Thermattaix* gas powered generator for charging filament batteries. (Science Museum, London)

In the mid-1930s, the Cardiff Gas Light & Coke Company (South Wales, UK) placed the ad shown in Fig. 2 that advertised "THE THERMO-ELECTRIC GENERATOR which makes your Battery Set Independent of Batteries of any kind." There were mentions of this outfit in *Wireless World*, and the son of a dealer reports his father having sold a number of these. The advertisement shows a radio of a style that would leave us to presume the thermopiles must have produced 2 volts at 0.5 amps for the valve filaments and 90 to 120 volts at 10 milliamperes for the plate circuits. But again, neither the actual number placed in service nor the cost is known, and there appear to be no surviving examples.

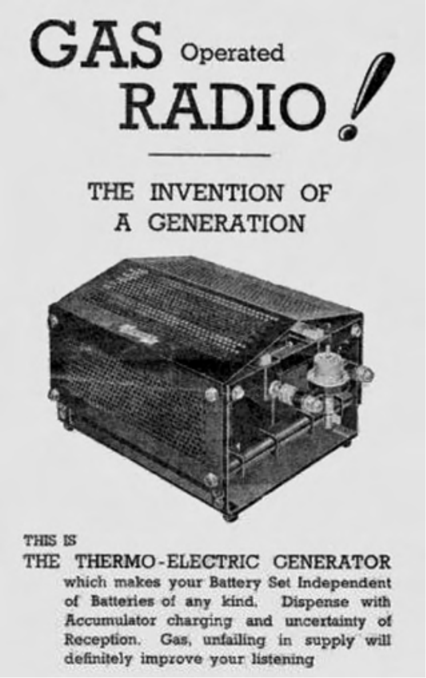

Fig. 2. Dating from circa 1934, this thermo-electric generator may have been the first product to supply all the power needs of a conventional battery powered broadcast receiver. It was built only in very small quantities. (*http://www.douglas-self.com/MUSEUM/POWER/thermoelectric/thermoelectric.htm#ca*)

Four articles on thermoelectric generators to power radio receivers and radiotelephones have been found in the Russian language magazine *Radio* (Радио), which began publication in 1946. The February 1952 issue states that under the direction of the prominent Soviet physicist and academician Abram F. Ioffe, investigations in the 1930s turned towards a search for semiconductor materials such as a zinc–antimony alloy (SbZn) bonded to a copper–nickel alloy (constantan) that could produce significantly greater potentials (55 mV in production devices) at higher thermal efficiencies (still, well under 4%). It was stated that the first claimed Soviet use of thermocouples using semiconductors was in "The Great Patriotic War" (WW II) to power small—presumably headphone-only—radio receivers used by partisan forces. One very small line drawing shows a hanging cast metal pot with a flat bottom. The thermocouples are bonded to the bottom of the pot, and the pot is suspended over an open campfire. Water boiling in the pot becomes the "cold" side for this primitive thermopile.

TGK Series of Soviet Thermoelectric Generators

Later, in 1949–1956, Ioffe derived a "ZT" value parameter as a figure of merit to indicate how efficiently a material converts heat into electricity. He used the new parameter to calculate the practical efficiency of thermoelectric generators.[10] A team of engineers then developed a thermoelectric generator powered by a kerosene lamp burner that was capable of delivering 3 watts—enough to power a low-power vacuum tube radio with loudspeaker (see Fig. 3). These generators were made at the Metallamp factory in Moscow. A TGK-3 version of the generator described in the February 1954 issue had two thermopile circuits; one circuit supplied 2 volts at 2 amperes to a synchronous, mechanical, vibrator-type of DC-to-DC converter. It provided 90 VDC for the plate circuits of the radio and -9 VDC for grid bias. The other thermopile circuit provided 1.2 VDC at a nominal load of 300 mA for lighting the vacuum tube filaments. No storage battery was used in this power system.

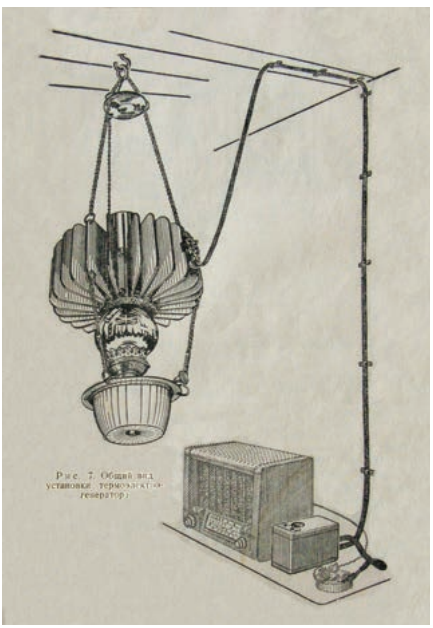

Fig. 3. The TGK-3 generator powered a DC-to-DC mechanical converter to provide +90 and -9 volts for a vacuum tube receiver. (TGK-3 Instruction Manual)

The February 1956 issue of *Radio* announced an improved generator, TZGK-2-2, that eliminated the need for a vibrator power supply with its inherent RFI emissions.[11] This was a matter of considerable importance because many of these generator-powered radios were in weak signal areas at considerable distances from broadcast transmitter sites. This new generator provided the 90 VDC for plate circuits and -9 VDC for grid bias directly from a series string of approximately 2600 pairs of hot and cold junctions.

In the same year, another low-voltage version of the generator, designated TGK-10, was announced in the September issue of *Radio* (see Fig. 4). This unit did not serve the double purpose of providing room lighting in addition to radio power. This somewhat higher power version, 10–12 watts, was only for battery charging service. A vibrator type power supply sourced by a storage battery was still needed to deliver the peak power requirements of the KRU-2 "cooperative radio center," which used a multi-band broadcast receiver designed to drive up to 50 low-power loudspeakers in apartment buildings, dormitories, etc. This was for the "cable radio" scheme of distributing broadcast programming in "off-the-grid" communities or collectives.

This generator was also employed to power the "Vintage U-2" and "Harvest-1" low-power, 2–3 MHz, AM radio

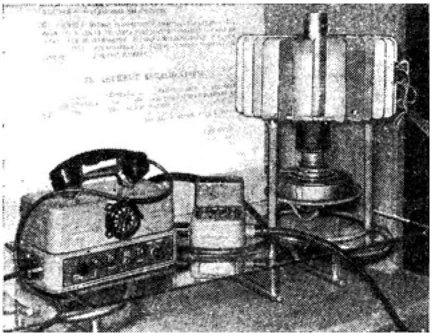

Fig. 4. This TGK-10 generator was used to charge batteries in "Harvest-1" low-power HF radio telephones. (*Radio*, No. 8, 1956, p. 7)

telephones used on large agricultural collectives, etc. An article published on the www.radionic.ru web site states that 20,000 of the *Harvest* radio telephones would be manufactured in 1956, with another 25,000 scheduled to be built in following years. The article states that 70,000 radiotelephone stations will be in service.[12] It is unknown if those production goals were ever achieved, and there are no comments on how many were powered from the thermoelectric generators.

Small Thermoelectric Generators to Power Broadcast Receivers

The thermoelectric generator in my possession is stamped ТЭГК-2-2 (1958), which translates to TZGK-2-2 in English (see Fig. 5). The "2-2" of the part number is the guaranteed minimum power output of the generator (*i.e.*, 2.2 watts). This generator seems to have the same outward appearance as the one described in the February 1956 issue of *Radio*. Web searches of images indicate that the 1958 in parenthesis

Fig. 5. A TZGK-2-2 (1958) Thermoelectric Generator. (Author's collection)

does not represent the year of manufacture; instead, it is an indication of a new model. I have not been able to determine what changes were made internally that would have caused the model number to change. The operating instructions give specific requirements for placement of the generator in a room. It must be near a window and hang from its supplied chains at a minimum distance of 10 cm from the ceiling and at least 1.5 m from any wall.

The generator provides 1.2 volts to light the filaments of 7-pin miniature tubes, which are in many ways electrically and dimensionally interchangeable with the miniature tubes introduced by RCA in 1939 and first used in the *RCA Victor* BP-10 pocket portable radio of 1940 (see sidebar). Another bank of thermocouples provides a nominal 9 volts for grid bias, and a third bank produces 90 volts at a maximum of 10 mA for the plate circuits.

These thermopiles are built around a cast aluminum core with six prismatic-cross-section channels at the center for the hot gasses to pass through. A sheet metal flue at the top improves draft. The thermopile is heated by a kerosene lamp burner of the *Argand* type to raise the temperature of the hot junctions to about 400°C.[13] In the case of the TGK-3 and TZGK-2-2, the clear glass globe allows it to serve double duty as room lighting that should produce something approaching 200 lumens. The font holds enough kerosene for about eight hours of operation.

Russian language publications provide extensive analyses of various thermocouple materials and thermocouple theory but provide no information on how the thermocouples are actually fabricated for these generators. English language Google Images searches produced no internal construction photographs of these generators. Eventually, I was able to use Google Translate to craft Russian language queries that produced links to a number of dissected generator photographs made by a former Soviet region vintage radio enthusiast in 2009. Even these photographs shed little light on how these junction slabs were fabricated.

It is apparent from inspection that the thermocouples were fabricated in many multi-layer monolithic slabs,

How Did the Soviets Develop Their "Finger Lamp" Technology?

How the Soviets acquired the vacuum tube technology described here is an interesting question. Was it acquired directly from RCA or via Lend-Lease agreements with the Soviets during World War II. RCA had indeed entered into contracts with the Soviets during the 1930s but they were completed by 1938. Most notable was the contract providing a complete electronic TV broadcast system in Moscow. There were attempts to renew agreements during the war and shortly thereafter, but deteriorating government relations ended cooperation by 1949. The Lend-Lease policy enacted in March 1941 did not have in its scope the transfer of technology—only goods. Alex Magoun of the IEEE History Center commented to me in a 2016 e-mail: "American officials were puzzled and frustrated by Soviet refusal to let them observe the use of equipment on the Eastern Front so that they could ensure the Soviets were getting the right goods or using them effectively. I suspect that you'll know better than me if these tubes were in standard military radios and other electronic combat devices. If the U.S. didn't ship tubes separately and the glass-based tube was not part of the RCA contract, it certainly would not have been hard for the Soviets to remove tubes from the radio equipment shipped under Lend-Lease and reverse engineer it."

In 2009, the RKK Radio Museum of Veleriy Gromov in Moscow exhibited radios identified as having been provided to the Soviets via various Lend-Lease agreements. One showcase holds a BC-611-B handy-talkie containing the 7-pin miniature tubes developed by RCA.

Close examination of Soviet made miniature tubes do show different internal construction details, although by the 1950s, a number of the tubes were carrying dual part numbers that include 1R5, 1T4, 1S5, etc. However, some tubes they made do not have electrically identical specifications to U.S. tubes. Therefore, it seems likely that their "finger lamps" are indeed the product of reverse engineering. The same could be said for the immediate post-war agreements between RCA and the Soviets, as outlined in a speech by Alex Magoun in 2004:

"This [agreement] was apparently signed, and new Russian engineers appeared at RCA's factories. They gained access to the licensing bulletins and craft knowledge behind RCA's electron microscope, a device championed by Zworykin as another, more beneficial means of "distant vision;" the latest in cathode-ray tube technologies for radar and television displays; radio-frequency heating for various industrial processes; the beginnings of electronic computer memory; and RCA's image orthicon, developed for guided missiles during the war and converted to commercial cameras 100 to 1,000 times more sensitive than the pre-war iconoscope. The sale of information and technology came to a halt when the U.S. Commerce Department established an export control system in 1949 to go into effect by midnight, Monday. Between the announcement Saturday and the deadline, an American Amtorg official located a cargo ship and arranged for the loading of $5 million of machinery. This included RCA cameras and electron microscopes, useful in the processing of materials for nuclear weapons. By the time the FBI arrived to impound the goods, the ship was already in international waters." (Alex Magoun, "Adding Sight to Sound in Stalin's Russia," speech presented at the Society for the History of Technology (SHOT), Amsterdam, October 8, 2004).

but without having slabs to dissect, the method of fabrication could not be determined. A small line drawing appearing in several contemporary articles purports to show a side face of an assembly, but it does not look anything like the photographed assemblies (see Fig. 6).

The outside of the cast aluminum core has 14 flats. Each surface is covered by a mica insulating sheet, and one edge of the junction strip is in contact with the mica. This becomes the HOT side of the junctions. Another mica sheet covers the outer face of the junction strip and is in contact with a dual-fin soft aluminum radiator, thus becoming the COLD junctions. A heavy gauge steel U-channel bar clamps the dual-wing radiator fin to the core end caps. There is no evidence of any type of "thermal grease"; that type of material did not enter the market until the early 1960s.

The bottom junction strip pictured in Fig. 6 is part of the 1.2-volt, 300-mA circuit to light the tube filaments. Each junction strip has 18 pairs of hot and cold junctions, and these are mounted to 5 of the 14 flats of the thermopile core. The top junction strip pictured is actually four smaller scale 50-pair junction strips bonded together and connected in series to form the 9-volt bias supply circuit (see Fig. 7). The 90-volt plate circuit supply is made of the same small-scale, 50-junction pairs as the 9-volt bias supply but they are bonded in groups of six and mounted to the eight remaining faces of the thermopile core in the same fashion. There are wedges of corrugated asbestos between each bank of thermocouple slabs. The area between each bank of junctions is

Fig. 6. The two configurations of thermocouples for low- and high-voltage circuits. (Author's collection)

topped off with an asbestos-filled caulk. By the nature of this construction, the asbestos is well protected from any possible abrasion.

Note the void highlighted by the arrow in Fig. 6. There is a space of about 4 mm between the aluminum central core casting and the bottom heavy-gauge steel end plate of the thermopile, which forms a necessary thermal break. There was evidence of random gaps in the caulking of the thermal break that would allow flue gasses to condense onto the end connections of the junction slabs. Heavy corrosion is evident at these gaps. It would be interesting to know if this was a common defect such that few or none of these generators actually put into general service are still operational.

An article in *Radio* for September 1956 describing the TGK-10 version of these generators designed to charge the batteries of the KRU-2 "cooperative radio center" states that the thermocouples last for about 4,000 hours before the internal resistance of the thermopile becomes too high to service the load.[14] This referenced 4000 hours would suggest that the generators may have had a practical lifetime of 3 years or less if in continuous service, but that is not necessarily the case. The KRU-2 was initially designed to accept power from a wind generator to charge the batteries, in which case the thermoelectric generator would have been a backup device.

An article found on the Internet states that the TZGK-2-2 generator was rated for 5,000-hour service life.[15] The article also describes a lower-power generator designated TZGK-9 (9-volt output at 300 mA) with a service life of 10,000 hours, which was developed to power transistor radios. It may not have been produced in significant quantities since rural electrification had grown considerably by the time Soviet transistor radios reached significant production levels. No other references to the TZGK-9 have been found.

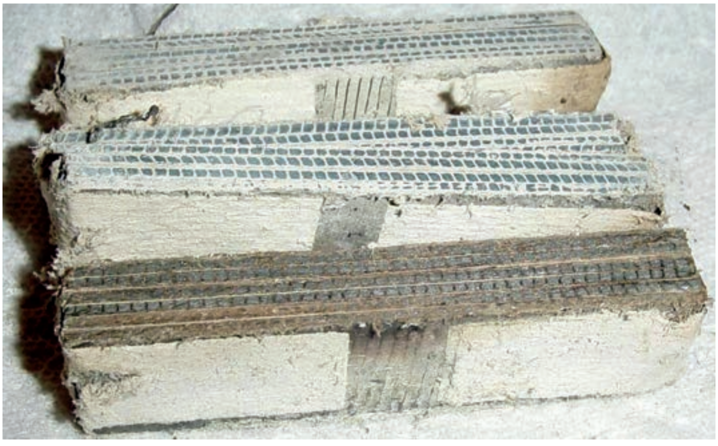

Fig. 7. Bundles of TC slabs in groups of 4 and 6. (www.mobipower.ru)

New old-stock (NOS) TZGK-2-2 generators have been found in South America, Africa and Eastern Europe. These were most likely used at Industrial Trade Shows, available for retail sale and maybe also for distribution as aid to Communist Party affiliated activities. They rarely show up for sale on eBay, but when they do, asking prices are well above $800 and shipping to the United States can add another $250. However, they don't seem to attract many bids.

The TZGK-2-2 and TGK-3 generators are stamped with serial numbers. Images found on the Internet have shown numbers ranging from 43,000 to 84,000. There were also three examples that use a letter plus a 5-digit number. Therefore, something around 50,000 may have been manufactured over a ten-year period. (This does not include other models.)

Conservation and Restoration of the Generator

The TZGK-2-2 generator was in very poor condition when it was acquired, and there was little expectation of being able to make it presentable for exhibition. Resistance measurements revealed that the 9-volt bias-circuit thermocouples were almost open circuited. The 90-volt circuit measured an erratic 20kΩ to 50kΩ and the 1.2-volt circuit measured a few hundred ohms. In order to determine if it was possible to generate an electric current, the 1.2-volt and 90-volt circuits were connected in series, and heat was applied to the core with a 1,100-watt heat gun. After 5 or 10 minutes of blowing heat through the core, the open circuit voltage climbed to about 15 volts. At that point a single white LED was connected to the circuit and the LED did light! But not very brightly. The series resistance of the circuit was simply too high, perhaps due to the heavy corrosion at the ends of the thermocouple slabs. It was clear that restoring the electrical connections would require the total disassembly of a thermopile filled with asbestos sheeting and asbestos filled caulking. The generator certainly appeared to have been in service for a considerable period of time, so that the thermocouples were probably nearing their end of life anyway. Since there was no point in trying to make it service as a practical source of current, the goal changed to preserving the unit as a historical artifact.

At the time of acquisition, the lamp burner was heavily rusted with the nickel plating almost completely gone from some parts (see Fig. 8). The rusted kerosene font had a 2mm pin hole rusted in the bottom. The original flue had been replaced by a scrap length of aluminum pipe. The original nickel-plated "sash chain" from which the generator hangs was missing and replaced with incorrect welded-link chain.

The lamp burner is made of four stampings that are swaged together. Some of the rust could be scraped off to the point that it could be re-plated with nickel, but other parts of the same swaged assembly were so heavily rusted that virtually no good metal existed on which to plate. Consequently, the assembly was scraped and wire brushed,

Fig. 8. Burner made of four swaged stampings, some too rusted to be re-plated. (Author's collection)

cleaned with a solvent in an ultrasonic cleaner, sprayed with a zinc-rich cold galvanize paint, and finished off with a coat of decorative nickel lacquer.

The metal around the pin-hole in the bottom of the font was sound enough to scrape down to bare steel, insert a fragment of copper braid into the hole, and flare the braid on the inside by fashioning a steel-rod tool that could be worked from the kerosene filler opening. The braid was then flooded with low-temperature silver solder and the bump was filed down to an almost flush surface. There was no point in filling the lamp since electrical tests indicate that the generator thermocouple connections have corroded to the point it surely cannot deliver the minimum of approximately 1.6 watts to operate the 4 to 6 tube radios intended to be powered by the generator.

One can find two versions of the kerosene font on the Internet. One is silver colored and the other is green. Fortunately there were traces of the original paint visible on perhaps 5% of the font and a few small spots where the remaining paint was thick enough to scrape with a razor knife to reveal the true color. It is a spruce-green enamel that is easy to match with commonly available spray lacquers.

There was very heavy rusting on both the nickel-plated steel thermopile end caps and most of the U-channel steel clamp bars holding the radiator fins in place. After soaking the clamp bar screws overnight with *Liquid Wrench* penetrating oil and using light hammer blows, the screws came loose. Two of the clamp bars still had more than 95% of the original nickel plate, so after cleaning, they were given a coating of high-temperature clear lacquer to attest to the fact that these were indeed originally nickel plated. The other clamp bars were so heavily rusted that they were simply cleaned in an ultrasonic cleaner, sanded level, sprayed with a coat of the cold galvanized paint, and finished with a coat of the decorative nickel colored lacquer. Because of their placement at the bottom of the radiator fins, the difference between the original nickel plate and the nickel colored lacquer is only noticeable under critical inspection.

The screws and lock washers were cleaned in the ultrasonic cleaner as well, but as an added step, the parts were then soaked in a Sunbelt Chemicals Corp. SMART #3000 "*Rust Converter & Metal Treatment*." This was necessary because the very fine metric threads could not be cleaned effectively with a wire brush. This phosphate conversion solution produces an excellent bonding surface for primers and paints. The fasteners were coated with a high-temperature clear lacquer before installing the screws, and the screws were then painted with a clear lacquer as they were screwed into the tapped holes of the thermopile end caps. Afterwards, the threads were painted again with the clear lacquer to maximize delay in new rusting. The top of the glass globe was sealed and cushioned by a thick but soft asbestos gasket that was missing. A replacement was fabricated of ceramic fiber matting engineered to replace asbestos in just such applications. Fortunately small sheets are available on e-Bay at low cost. Had the original asbestos gasket remained, it would have to be removed for safety reasons because it is positioned so as to be subject to considerable abrasion every time the generator is disassembled for transport or cleaning—unlike the protected asbestos on the generator radiator fins.

The pure aluminum radiator fins were first cleaned in solvent to remove cooking grease and then sprayed with a full strength caustic cleaner named SuperClean "Cleaner-Degreaser." After a rinse, it was washed down with a cloth saturated in a weak acid solution of sodium bisulphate in water, followed immediately with a hot rinse in tap water and a quick force-dry with a hot air gun. This produces a clear matte finish that must be protected by spraying with high-temperature clear lacquer. Sodium bisulfate in granular form is added to spas and swimming pools to increase the acidity (lower ph); therefore, it is widely available in retail stores and very inexpensive.

While the correct 60-cm top suspension chains were missing, the lower chains, springs, spiral wire rings, and flat rings were present, and although very grimy with cooking grease and rust, they cleaned up well enough. Exact duplicate rings were made for the top suspension chains using a scrap piece of steel salvaged from the cabinet of an old microwave oven and then nickel plated to match the originals. I searched for chain that I eventually learned is called "sash chain." It comes in three different metal gauge thicknesses. This lamp requires the lightest gauge but is apparently only available in 160 foot long bulk reels at about $95. I opted to spend $24 for a 10-foot length of much heavier gauge chain but of the same pattern and scale.

The original sheet metal flue was missing. Photos on the Internet indicate that there were two variations of the flue. One is a rolled sheet of steel riveted closed at one end only, and the other is brass, or possibly steel, thin-wall tubing that is nickel plated. Both styles of flue have rolled beads at each end. Finding the correct metric specification tubing would be difficult here in the United States. Fortunately, a local sheet metal shop had an old bead-rolling tool small enough to do the job with rolled sheet steel. The precise length of the flue is only a guess. There appears to be a variation in length from picture to picture in photos found on the Internet.

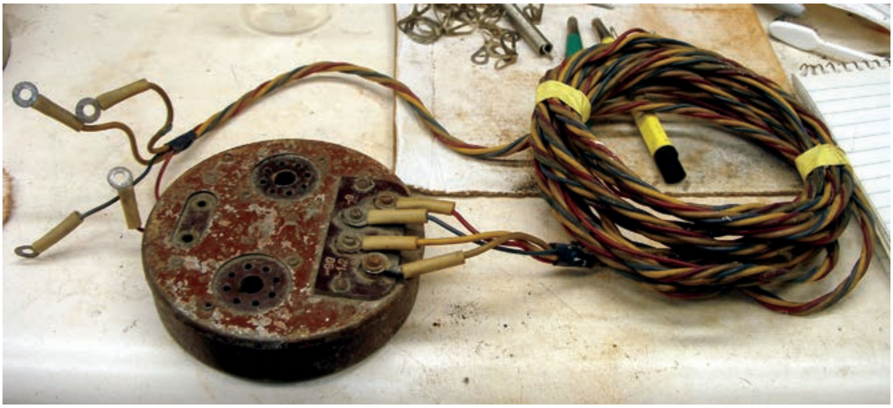

Fig. 9. The generator termination box duplicates receptacles of standard dry batteries. (Author's collection)

The more than four-meter-long power cord and the termination box are original, but they were in a sorry state requiring radical cleaning, filling of rusted metal with glazing putty, and spray painting (see Fig. 9). The original vinyl insulated wires were filthy, but the vinyl insulation was able to withstand cleaning with the SuperClean brand caustic cleaner. The cable was completely unwrapped to gain access for cleaning. The careful cleaning and application of paints and clear coatings will preserve the appearance for a very long time if exhibited in controlled environments.

More Recent Thermoelectric Generators

From time to time in the age of transistor-equipped radios, and in other parts of the world, there have been attempts to make kerosene lantern-powered thermoelectric generators. The argument for this power source is the continuing expense of batteries for radios receiving educational instruction in areas of extreme poverty. With transistor radios, the generator need only deliver a half a watt of power. From the 1960s onward, developers attempted to use semiconductor base junctions because of their higher efficiencies, but in practice they were apparently not able to develop a cost-effective means of limiting the maximum temperature to which the junctions could be subjected in such lanterns.

In bringing these generators to market, there has been little indication that the developers received significant government-sponsored engineering support, subsidized manufacturing, or assistance in distribution, all of which occurred in the former USSR. The net result is that none of the products to date have proved reliable enough or cheap enough to sell into the marketplace.

One can search for consumer-grade thermoelectric generators today on the Internet and find a number of products designed to charge cell phones, but in evaluating the literature it appears that all these products have the same high vulnerability to excess heat damage. Also, the price of these devices can easily exceed that of a cheap cell phone. Thus, the generators remain more of a novelty for "gadgeteers" with disposable income than a practical solution for the needy and isolated of the world.

However, there are still viable applications for thermoelectric generators. Generators using radioisotopes as a heat source power all deep-space satellites, and there are highly specialized applications for powering remote instrumentation here on earth today.

PART II. SOVIET BROADCAST RECEIVERS POWERED BY THERMOELECTRIC GENERATORS

The second part of this article addresses receivers that could be powered by thermoelectric generators in lieu of a set of non-rechargeable dry batteries. According to the book *Reference Broadcasting Receivers*, there are at least 12 Soviet battery-powered receivers that were "plug compatible" with the receptacles of the TGK-3 or TZGK-2-2 generators (see Table 1).[16] One of these radios now in my collection is a 4-tube *Iskra* (*Искра)* radio made in 1958 (see Fig. 10), which presents a proper load for the thermoelectric generator described in Part I. The word *Iskra* translates to *Spark*, and *Spark* (1958) is the designation that will be used for this model in the remainder of the paper. Other than having no tubes, this radio is in very good condition with no obvious modifications. Fortunately, the correct Soviet-made tubes were available at a modest cost.

Table 1. Twelve Soviet battery powered receivers that were "plug compatible" with the TGK-3 or TZGK-2-2 generators.

Radio Model	*a.k.a.*	*Description*
Iskra 49	Spark 49	Stamped metal cabinet
Iskra-53	Spark-53	Molded resin cabinet table model
Iskra (1958)	Spark (1958)	Molded resin cabinet table model
Nov		Molded resin midget mantel set
Voronezh		Molded resin cabinet portable
Voronezh		Molded resin cabinet table model; 3 and 4 button versions
Rodina		Wood cabinet table model: 52, 52A, 52M, 52U, 58

Fig. 10. This Spark battery-powered receiver was made in 1958. Note plugs for connection to standard batteries. (Author's collection)

This *Spark* (1958) receiver released for mass production in 1958 is the second update to the ARZ-49 reference design released for production as the Spark 49. The first radio series designed to be equipped with Soviet-made, battery-powered, 7-pin miniature, all-glass envelope vacuum tubes commonly referred in Russian slang as "finger lamps." The reference design identified as "ARZ-49" came from engineers and designers at the Alexandrov Radio Factory of the Ministry of Communications Industry of the USSR under the direction of A. K. Kulesheva with the help of the Institute of Broadcasting and Acoustics, also known as the IRPA (see Fig. 11).[17]

The ARZ-49 reference design was released for limited production as the *Spark* 49, the first entry in Table 1. A detailed description of the Spark 49 and a follow-on description of circuit changes made for the *Spark*-53 update appear in the Russian magazine *Radio*.[18]

At the same time, a new set of standardized batteries with an unusual configuration was developed to provide the most efficient powering of the radio for 1,000 hours, then considered

Fig. 11. From left to right: V. M. Khakharev, Chief Designer of Alexander radio factory and Stalin Prize winner; I. A. Averin, chief designer; and A. K. Kuleshov, chief designer of the "*Iskra*" receiver. (*Radio*, No. 12, 1950)

to be about a year of typical use. A few years later, another standardized set of batteries is configured to power these "finger lamp" sets for 300 hours. These were designated as a "holiday pack."[19]

The Spark 49 Receiver

The *Spark* 49 has a three-piece sheet metal cabinet. The front and rear panel were die stamped, and a single folded sheet formed the top, bottom, and sides. Spot welds are used to attach the front panel to the folded sides and small welded brackets support the chassis. For better acoustic properties a thick wood baffle board provides mounting for the loudspeaker. The cabinet is painted in a textured lacquer to hide sheet metal blemishes.

The four-tube superheterodyne circuit uses a 1A1P (1R5) for the mixer frequency changer, 1K1P (1T4) for the intermediate amplifier, 1B1P (1S5) for the detector, AGC and first audio, and a 2P1P for audio power output. (There is no direct U.S. equivalent for the 2P1P.) The tuning range is in two bands: long wave—150 to 410 kHz (2000 to 732 meters) and medium wave—520 to 1600 kHz (577 to 187 m). The performance of the receiver generally meets the electric and acoustic parameters for battery operated broadcast receivers of the 3rd class (the State standard for broadcast receivers GOST 5651-51 effective January 1, 1952).[20] In this classification scheme, the "1st Class" receivers were the best with the most features, usually made in limited quantities and often exported to raise hard currency. The 4th Class receivers were the absolute basic 1- to 3-tube "local" receivers and the only ones not using some form of superheterodyne circuit.

Key Spark 49 Receiver Parameters

- Sensitivity: better than 400 μV. Selectivity at detuning at 10 kHz: 15-20 dB. Image rejection: 20 dB.
- Rated power to the speaker: 0.15 watt.
- Acoustic frequency response of the entire receiver path allows the passage of frequencies between 200 and 3000 Hz at no more than 15 dB variation.
- Harmonic measured sound pressure is not higher than 15%.

- The AGC allows the output voltage to change by no more than 10 dB when the input voltage changes 26 dB.
- Filament current: 0.3 A. Anode current: 6 mA with no signal; average: 12 mA.

Spark 49 Schematic

When choosing a receiver circuit, the main focus was on simplicity and reliability of design as well as obtaining sufficiently high electrical parameters and power efficiency. The receiver is a superheterodyne with a rather low intermediate frequency (IF) of 110 kHz. The IF amplifier has the usual dual-circuit input filter and a single-circuit output filter with aperiodic coupling to the detector. A series resonant circuit is connected to the antenna input to suppress the IF frequency. The local oscillator and IF coils have carbonyl iron cores.

Surely the most significant functional feature of this receiver circuit is the provision for a "creeping point" bias voltage for the audio output tube. This is achieved by using a copper oxide diode that rectifies a portion of the audio output obtained from the plate circuit of the output tube. The loudness-dependent audio voltage subtracts from the nominal negative 9-volt "C" bias from the battery pack, allowing maximum amplification while significantly reducing the quiescent plate current of the audio output vacuum tube at low volume. This action significantly reduces the perception of background noise in the receiver because, at low audio signal levels, the gain of the output tube is reduced. The RC time constant of the circuit is such that distortion caused by having the audio abruptly increase without optimum bias is limited to about 10 milliseconds which is said not to be objectionable.

The receiver gives undistorted output power of 0.15 W at rated nominal power supply of 90 volts and 1.2 volts. However, to use the pair of "B" batteries to a final voltage of 60 volts and the filament "A" battery to 0.95 volts at the end of its service life, the listener must be content with much lower power of 80 mW. Therefore, the receiver circuit employs a particularly sensitive dynamic speaker, 1GD-2, which develops an average sound pressure of at least 4 bars at a distance of 1 meter with input power of 0.1 W.[21]

***Design Revisions Made for the Introduction of the* Spark 53**

According to articles in *Radio*, the metal cabinet of the *Spark* 49 was replaced by a compression-molded, single-piece cabinet made of a thermosetting resin similar to Bakelite. This same cabinet was also used for the AC-powered *Moskovich* and again *circa* 1956 in a demonstration model of a broadcast receiver using Soviet-made transistors.[22] The dial scale previously tilted upwards by about 15 degrees was then mounted in the plane of the cabinet front face. Metal tube shields were eliminated, and a two-pin receptacle was added for connection to the "Cable Radio" local network so that the radio loudspeaker could be used to play the network audio. There was no switching arrangement within the radio for this input; the listener simply plugged in or unplugged from the receptacle.

The "creeping point" bias circuit was revised to employ a third winding on the output transformer to create a bias voltage dependent on the audio signal level that subtracts from the fixed -9 volt bias supply in a presumably more effective manner (see Fig. 12). There were few other electrical circuit changes made between the two models. However, between 1956 and 1958, the chassis layout and general construction for the *Spark*-53 was radically revised. This new chassis version was then simply called *Spark* (again). While the *Spark* 49 and *Spark*-53 used traditional coil formers for the RF and oscillator coils, the new mechanical design made use of self-supporting bobbins wound onto thin plastic spools with an internal thread to accept screwdriver-adjustable,

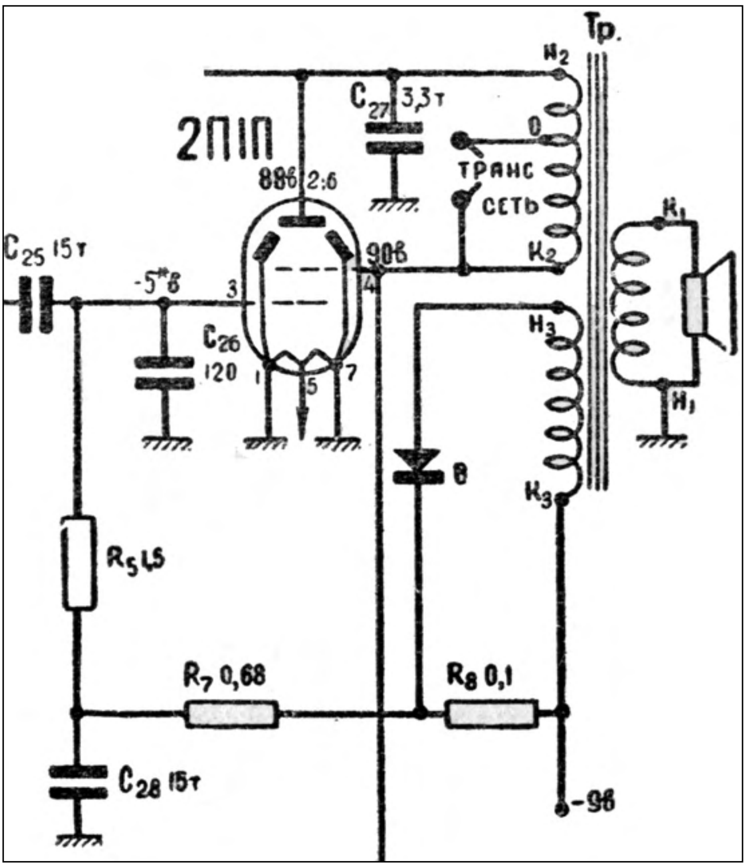

Fig. 12. In the *Spark*-53 version, a third winding on the output transformer provides the voltage to control quiescent plate current. Also, note primary winding connections for "cable radio" service. (*Spark* users manual from author's collection)

carbonyl-powdered iron cores. These bobbins are cemented on one side to a die-punched, phenol resin-impregnated, paper board sheet about 1.5mm thick that also serves to hold the wave change switch contacts. The same type of self-supporting coil structure is used for the input and output IF transformers.

Observations of My *Spark* (1958) Manufactured in 1958

Cabinet

The molded phenol resin cabinet is very similar to the *Spark*-53 but different in that a top-center, front face crest feature has been eliminated. Examination of this receiver from the opened back shows little that is very surprising to the American eye other than the apparent uncommon structure of the IF transformer and the lack of a metal shell to contain it (Fig. 13).

Welding of Joints – a Surprising Discovery

What really caught my eye is the underside of the chassis. In order to remove the cotton braid that covers the battery supply cable for cleaning, it was necessary to unsolder the connections on the underside of the chassis. I was surprised to find that the (presumed)

Fig. 13. Back cover removed on 1958 version of Spark receiver. (Author's collection)

solder showed no signs of melting. On close inspection, I was astonished to note that the connections were not soldered with some type of conventional tin/lead solder but welded! Note the copper balls that formed in the welding process (Fig. 14).

The "how" and the "why" of such an unexpected assembly technique is very interesting. English language searches with Google failed to turn up any clues. I corresponded with an American engineer, Joe Sousa, who has written extensively on the radiomuseum.org site. Joe posted a query on my behalf, and within a day I received some really good background information on the origin of the technique.

The German magazine *Funkschau* from 1941 and 1943 provided descriptions and photographs of the equipment German firms developed to make these types of welds. The articles also illustrate the proper ways to wrap wires around terminal tags. In general, the technique directs that one wire lead be wrapped and left with a tail about 4 mm long that sticks out above the terminal. The electrode is brought down on the tip of the wire extension and begins to form a droplet of molten copper that ideally envelops the connection.[23]

Fig. 14. Note balls of copper formed when prepared mechanical connection is welded. (Author's collection)

One article mentions that tin-bearing minerals did not exist in Germany in commercial quantities. This became a critical import supply issue when Germany went to war. This supply issue had been identified in the late 1930s and some development work had started, but practical tools and assembly techniques were not fully developed until 1941–43. By 1943 a significant percentage of German military electronics was welded rather than soldered.

Several types of hand tools were developed to assist in the welding process. In one version of a hand tool developed by A.E.G., there is a current regulator box, foot switch, and a two-electrode hand piece (see Fig. 15).[24] Despite claims to the contrary, it is evident that this welding operation requires a greater skill level and greater care in preparing the junction than conventional tin/lead soldering. And, of course, welding would complicate rework and field repairs. Another hand tool made by Siemens & Halske apparently grasps the base of the terminal for one connection, and an electrode in the center of the tool touches the top of the wrapped wires to form a ball of molten copper. This technique carries over into the very early post-war period in the manufacture of some basic German home broadcast receivers made largely from war surplus materials.

It is well known that all the western allies were researching Axis Powers technological development and recruited technical people to interpret and transfer technology at the end of the war. The Soviet Union was no different in their desire to acquire such knowledge. "October 22, 1946 became a crucial date in post-war Soviet-German scientific and technical cooperation in the military sphere. On that day, the mass deportation of German scientists, engineers, and workers to the USSR began. The movement of 7000 German specialists from various disciplines

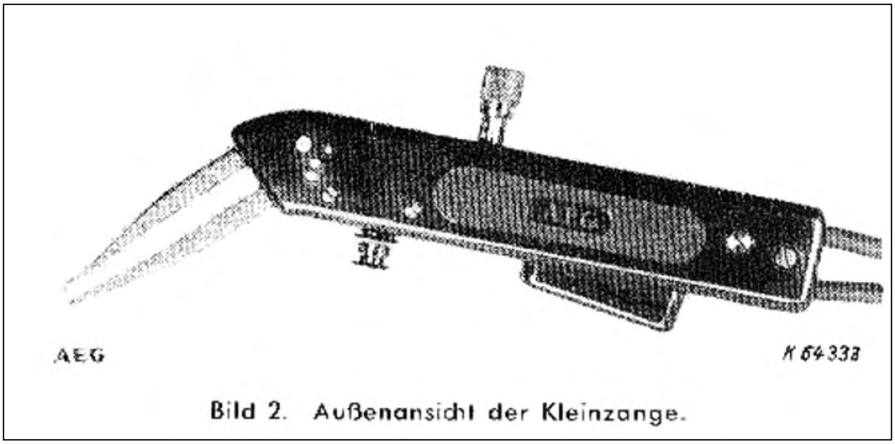

Fig. 15. Assembler's hand tool for the AEG welding system. (Users Manual, http://cdvandt.org/AEG-Mitteilungen-9-12-1943.pdf)

from Germany to the USSR was accomplished precisely and quickly. Stalin and his clique had experience in deporting entire nations. Two weeks after the operation began, all the Germans were already distributed among 31 enterprises of 9 ministries in different areas of the Soviet Union."[25]

The Soviets largely copied features of a number of World War II vintage German military radio designs such as the Torn Fu.g.[26] Throughout the same period, the Soviet reserves of tin were regarded as uncertain by Western observers, but a 1969 report by the U.S. Geological Survey (GS 69-367) indicates that the Soviet Union was not a significant importer of tin at that time. It appears that domestic reserves of tin in the 1960s were adequate.[27]

The resistance welding scheme could certainly prove advantageous to circuitry exposed to very high operational temperatures, shock, and vibration, and it apparently found a niche in the Soviet manufacture of military radios, radars, avionics, and missile control systems. G. Donald Wagner reports that the 1965 U.S. military reliability handbook, MIL-HDBK-217A (December 1965), states that welded connections exhibited just 2% of the failure rate experienced with hand-soldered connections.[28]

References indicate that the *Spark* receiver was manufactured at the Alexandrov Radio Works in Alexandrov, Vladimir Oblast, Russia, about 120 km northeast of Moscow. At the time, this may have been one of the closed cities of the USSR since the Radio Works only had a Moscow postal address in the 1950s. These references also state that this factory produced military communications and other special electrical devices. The radio works may have used the production of the low-cost *Spark* receiver as a convenient means of training the production staff to assemble high-value military equipment. It is even possible that this assembly technique (i.e., resistance welding) might have inspired the name of the receiver, because the initiation of virtually any electrical weld is going to cause a "Spark." I have not been able to locate anyone that can provide photos or drawings of the hand welding tools employed in the Soviet factories for this type of wiring.

The *Spark-53* and *Spark* (1958) are not the only Soviet era broadcast receivers to use welded connections. The *Rekord 54M* and *60* receivers made in the late 1950s were also welded, as were the lowest-cost televisions, *Dawn* and *Dawn 2* produced at the Leningrad plant "mailbox 443." A recent correspondent tells me that his father worked at this plant for 38 years and states that the main activity of the plant was the production of radars in which the assemblies were connected using welding. Another correspondent states that most electronics factories produced goods for military, aerospace, and consumer applications. It appears that this was indeed a convenient way for workers to develop their assembly skills.

However, other recent correspondence with former Soviet Union vintage electronics enthusiasts express the opinion that the use of the technique was purely a matter of economy due to the high cost of tin. But these correspondents admit that they do not have firsthand exposure to the use of the technique in factories. While domestic tin reserves may have been adequate, it does not necessarily mean that Soviet industry was able to deliver a low-cost product to the electronics industry of that time. In a planned economy, the relative costs of materials and labor could be different than in the western style capitalist industries.

Resistors

The resistors appear to be an exact copy of *circa*-1940 Siemens products, which can be seen clearly in museum examples of the famous German *E52 Köln* communications receiver manufactured from mid-1942 to the spring of 1945. The end cap terminations are a deep-drawn stamped ribbon of tin-plated copper, looking something like a long-handled pot that is missing its bottom.

Very Heavy Corrosion at Chassis Grounds

While the chassis of my little receiver was relatively rust free, there is very heavy corrosion around the two chassis ground connections. It is evident that a very aggressive flux was required to achieve a copper-to-steel, resistance-welded connection. Other chassis photographs found on the Internet confirm that this is not unique to my particular receiver.

Transparent Color Inspection Lacquer

Each connection is coated with a purple transparent marking dye to indicate that the joint had been inspected for defects. This dye is typical for all Soviet made radios of the 1950s, and this practice is also seen in civilian radios of other European countries.

RF, Oscillator, and IF Coils

Wave wound,[29] self-supporting coils of small gauge wire are wound on plastic bobbins; the coils are glued on one side to a die-stamped, phenol-resin-impregnated, paper board stock (see Fig. 16). These very fragile coils certainly call for careful work on the part of the assembler, but once they are in place, they should present few problems. Threaded, powdered, carbonyl-iron slugs screw into the bobbins for tuning. The entire coil assembly is not considered to be repairable. Fortunately for this low-power, battery-operated radio, there is almost no possibility that the coils will be damaged by circuit faults other than lightning. There appear to be no special precautions taken to protect circuitry from environmental conditions.

Use of 'Gimmick' Capacitors

Short lengths of heavy-gauged, enamel-insulated magnet wire are welded to switch contacts to form a stub. Fine-gauge, cotton-covered wire is then tightly wrapped around the stub and secured with a light coat of lacquer or shellac. Excess turns can be pulled off the end of the stub in order to reduce the capacity, if necessary, during alignment of the receiver.

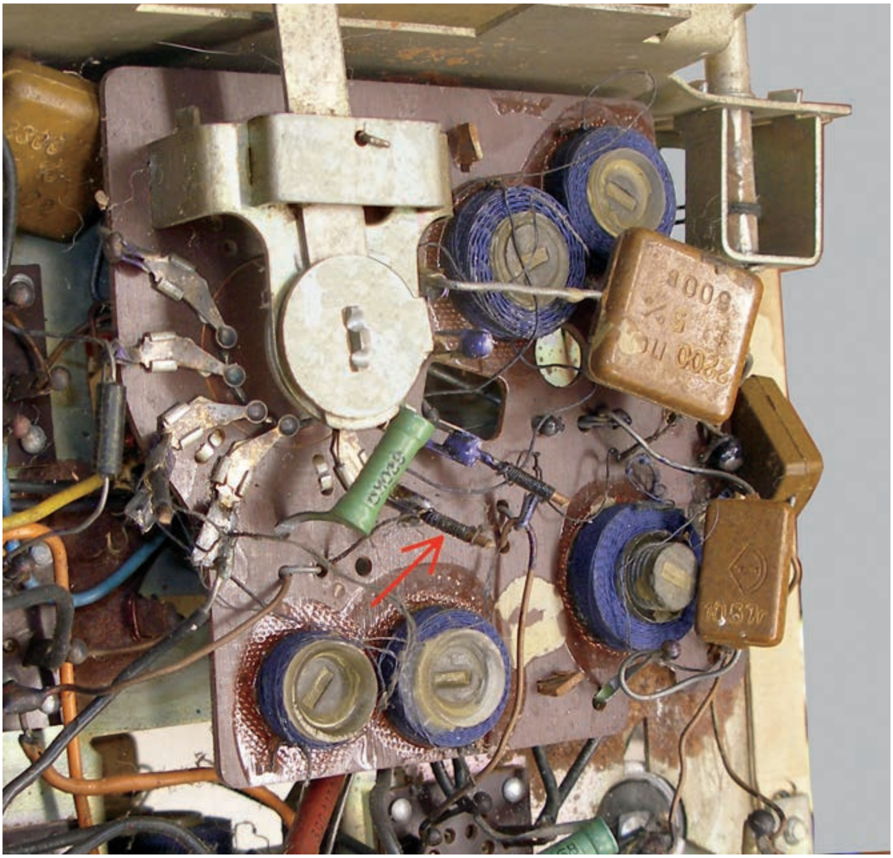

Fig. 16. Novel method of mounting of wave wound coils, "gimmick" capacitors, and resistors. (Author's collection)

Battery Management

No photographs or detailed drawings of the dry batteries specified to power this radio are available. A battery specification article in *Radio* for May 1956 states that the full size, 1000-hour life, combination "B" and "C" battery, of which there are two, is 160 × 160 × 190 mm.[30] The users manual provides instructions on how to obtain the maximum watt-hours (energy) from these two 60-volt "B" batteries. Each battery is fitted with an octal style socket for connections. There are two key slots in the socket to receive the plug spigot. When plugged into a new battery one way, the radio is connected to a 45-volt tap in the cell assembly. After a certain number of hours, the user is supposed to check the battery voltage, and when it drops to 30 volts, the user is supposed to rotate the plug to the other key slot in the receptacle to make connection to the 60-volt tap. The battery is then run in that position until the 60-volt tap drops to 30 volts. It was claimed that this battery connection strategy extracted the greatest possible watt-hour per unit weight of these carbon/zinc cells. It was not stated whether the cells within the battery pack were of different sizes. The nominal 1.28 volt filament supply dry battery is almost the same size (160 × 160 × 185 mm).

Back Panel of the Receiver

On the back panel of the receiver there is a pair of two-connector receptacles (see Fig. 17). One is obviously for the antenna and ground, but the purpose of the other pair is not obvious to anyone unable to read Russian. One might think that the other receptacle is for a phonograph pick-up or external speaker, but it is not. As mentioned earlier in this paper, during the Soviet era, a large percentage of workers' apartment buildings, dormitories, and other housing at farm, mining, and forestry collectives had wiring installed to connect to a central radio receiver ("cooperative radio center").

The cooperative radio center was usually outfitted with a microphone for announcements and sometimes a built-in or auxiliary phonograph. A room in

Fig. 17. Back panel of Spark (1958) showing connection for "cable radio" input. (Author's collection)

each living unit had a two-conductor wall receptacle that looks exactly like a two conductor mains outlet. This outlet is actually where a table-top loudspeaker or headphones could be connected. In the case of the *Spark*-53 and *Spark* (1958), this second receptacle accepts a mating plug cord from the wall outlet that connects a portion of the output transformer primary to the wired radio network so the radio speaker can play the wired network content even if the radio is turned off.

What Did You Hear on Your Little Radio?

In the 1950s, the state-run broadcasting service ran home services programs from 6 a.m. to midnight local time. The central radio for the local cable radio network most likely would have been tuned to the *All Union First Programme*, which in the various Republics could have local opt-out program segments described as having a political focus. It could also have been tuned to the second channel, *Radio Mayak* (Radio Beacon), which was a music and speech entertainment channel intended to be the "beacon" of Soviet culture. Depending on one's location, the receiver could have tuned in other regional stations offering content in a number of other languages, but it was almost certain that the Communist Party apparatus was in place to make sure there were no significant deviations from the professed ideology of the party.[31]

Production Runs for the Sparks

The publications seem to indicate that prototype receivers were built for about 18 months before the factory received permission for limited production of the Spark 49 in mid-1950. The *Spark*-53 went into production in 1953 with a greater production rate, but as mentioned earlier, it may have been 1956 before production occurred on a continuous assembly line. My *Spark* (1958) receiver is dated 1958, and production of this model is reported to have continued until 1963.

Passport Manual

Fortunately, my radio has an original example of the 16-page "passport manual." This manual contains registration papers to be filled out and returned along with forms to use if the radio must be serviced at state-run service shops in population centers or returned to the factory within the 60-day warranty period. The remainder of the manual covers the usual installation and operation instructions as well as a detailed schematic.

Conservation of the Spark

This Spark receiver, which was engineered for very low-power consumption, has higher resistor values than were used in typical receivers powered by lighting circuits. Consequently, the leakage resistance within coupling and bypass capacitors has a greater effect on the operating parameters of the vacuum tubes used in these receivers. This particular design has four paper dielectric capacitors that now exhibit varying degrees of excess leakage. If they were replaced, the receiver would no doubt receive at least local stations.

However, this receiver is fabricated in such a way that these capacitors are buried under resistors and wiring that is all *welded* in place. The only way to extract and replace the parts would be to cut many welded component leads and associated wiring, followed by splicing and soldering all the connections back in place. Such an invasive restoration procedure is not justified for this receiver.

As a collector and amateur historian, my higher goal is to preserve the historic artifact in a state that most accurately maintains the original design as well as its fit and finish—regardless of current opinion as to whether the execution of the work was good or bad. None of these vintage radios were ever designed from the outset to remain operational for many decades. Careful inspection leads me to think that there were never any repairs made to this receiver. These radios are no longer common even in the former Soviet Union, much less in the United States; therefore, I think at least one receiver like this should remain as an accurate historical record. There are certainly a great number of radios surviving today that have already undergone extensive repairs and substitutions and now possess little value as reference artifacts. Such sets are good candidates for a hobbyist to have fun by making them functional again for a little while longer.

Cleaning the Chassis

This chassis was reasonably clean but it was evident that it had not been professionally cleaned. The rear panel of the chassis was discolored by corrosion, and the appearance was substantially improved by very careful application of the SMART #3000 "*Rust Converter & Metal Treatment*" followed by a washdown of denatured alcohol. When cleaning any metal surfaces such as the top side of the chassis and metalwork, I finish my work by applying a clear satin acrylic lacquer using a brush or air brush. While these surfaces have already been compromised by the ravages of time, the lacquer will slow further deterioration, and lacquers can easily be removed by future conservators if necessary.

Conserving the Loudspeaker Grill Cloth

The grill cloth covering the loudspeaker, while free of tears, had loosened considerably over time, and it was soiled and somewhat bleached. The pattern of the cloth made the disarray of the cloth particularly unpleasant to view. I found a number of photos on the Internet that verified that the cloth is indeed original to this particular version of the *Spark*. I determined that the grill cloth was attached to the thick wood baffle board using traditional hide glue, so with patient work I was able to soften the glue with plain water and remove the cloth. I was happy to discover that the weave presents the same pattern on both sides.

I sandwiched the cloth between two sheets of #10 polyethylene mesh, "plastic canvas," commonly used in yarn crafting. The sandwiched cloth was moved up and down through a pan filled with ordinary dish washing soap and warm water to soak out the remaining hide glue without causing the edges of the cloth to unravel. While still sandwiched by the mesh, the cloth was rinsed with warm water from the kitchen sprayer. Then began the tedious task of aligning the warp and weft of the slightly damp cloth with push-pins inserted into a foam plastic backing board (Fig. 18). After drying, I could see that the cloth looked much better on the inside, so I decided to position that face to the outside. The grill cloth was attached using hide glue to

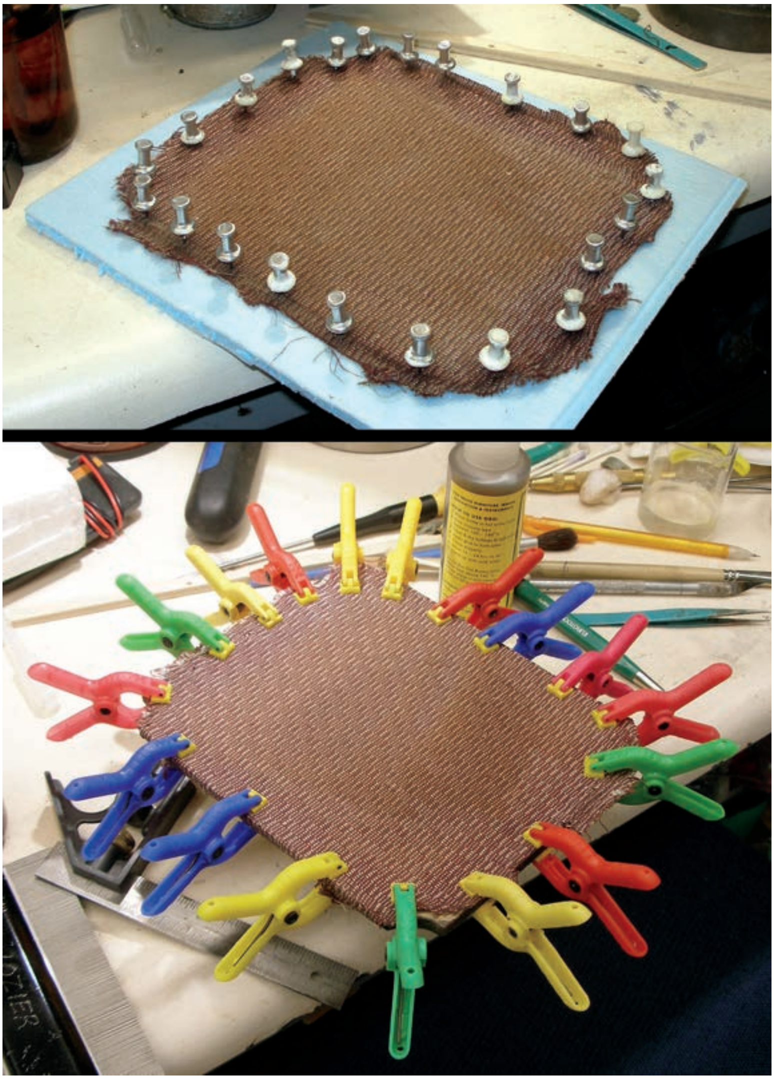

Fig. 18. Aligning warp and weft of damp cloth (upper), and using hide glue to mount reverse face to baffle board (lower). (Author's collection)

match the original. The preservation effort required no substitution of parts and avoided detraction from the overall appearance of this artifact.

How to Illustrate Interesting Internal Construction

In the course of seeking an appropriate receiver, I located another *Spark (1958)* receiver. For reasons unknown, this receiver had been *completely* disassembled. Every component, all wiring, tube sockets and subassemblies had been cut free of the chassis. Virtually everything was there *except* for the bare chassis stamping. The cabinet, baffle board, loudspeaker, back cover, hardware, and battery cable were all present. This was a good opportunity to take some of these components that would not be viewed in a typical exhibition and mount them on a panel to show that their fabrication techniques are so different from contemporary American manufacture (see Fig. 19). This is my way of inviting people to look more closely into why many artifacts are worthy of study and preservation.

Summary

I am unaware of any similar hardware combination of radios and thermoelectric generators being applied in any significant quantity anywhere else in the world during the era of vacuum tube radio technology. The examination of its components prompted me to gain many interesting insights into the sequence of events and circumstances leading up to the development of this workable system solution that was deployed in at least the tens of thousands. While I have some experience in various western European languages, working with a radically different alphabet and language proved to be quite a challenge.

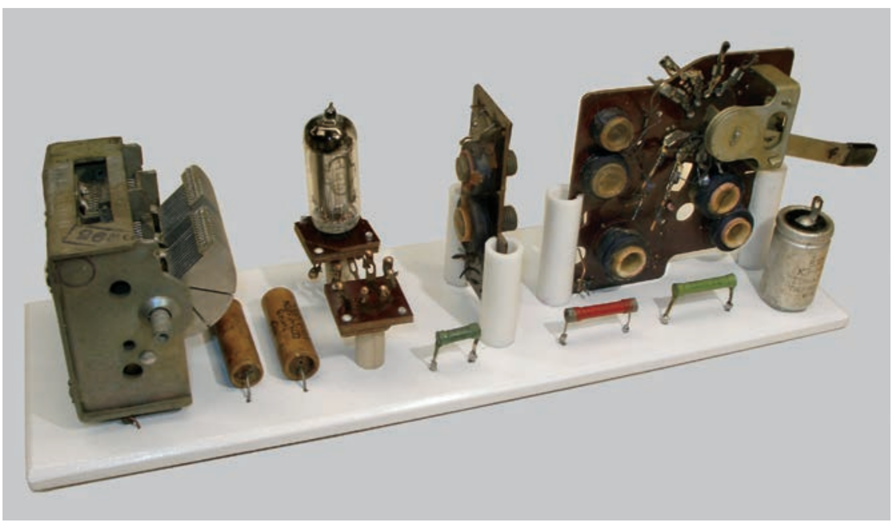

Fig. 19. Display of Spark (1958) receiver components showing fabrication techniques unfamiliar to most American readers. (Author's collection)

I certainly must credit the increasing capabilities of Google Translate and low-cost methods of optical character recognition and image processing for transforming a significant percentage of tasks formally done only by professional translators. I also must credit several Russian language vintage radio enthusiasts for having the patience to communicate in this less-than-perfect way.

Once again, I was reminded that while the United States might well have been able to boast of 50% of all contributions to the field of communications in the 19th and 20th centuries, that still leaves a vast opportunity to explore developments abroad that are seldom brought to the attention of radio history enthusiasts here in the United States. For someone like myself who is now approaching 50 years of fascination with vintage radio and its history, an extensive examination of this "new" foreign history is surely a task I will never live long enough to exhaust. And in my opinion, that is a good thing.

Endnotes

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8. Ibid., p. 47.
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11. "ТЕРМОЭЛЕКТРОГЕНЕРАТОР «ТЭГК-2-2»"("Thermoelectric Generator TZGK-2-2"), *Радио* (*Radio*), No. 2, 1956, p.23.
12. http://www.radionic.ru/node/637.
13. See Encyclopedia Britannica at https://www.britannica.com/technology/Argand-burner. Argand burner, first scientifically constructed oil lamp, patented in 1784 in England by a Swiss, Aimé Argand. The first basic change in lamps in thousands of years, it applied a principle that was later adapted to gas burners. The Argand burner consisted of a cylindrical wick housed between two concentric metal tubes. The inner tube provided a passage through which air rose into the centre to support combustion on the inner surface of the cylindrical flame in addition to that on the outer surface. A glass chimney increased the draft, allowing more complete burning of the oil; an Argand lamp gave about 10 times the light of an earlier lamp of the same size, as well as a cleaner flame, but its oil consumption was greater.
14. V. Daniel-Bek, S. Kurfirst, N. Roginskaya, "ТЕРМОЭЛЕКТРОГЕНЕРАТОР ТГК-10," ("The TGK-10 Thermoelectric Generator), *Радио* (*Radio*), No. 9, 1956, pp. 15–16.

15. http://samodelcin.nethouse.ru/page/80998. With respect to the 9-volt generator, the article reproduced on this website says: "[This figure] shows a thermoelectric generator TEGK-9, designed to power radio-types "Sunrise" and "Minsk," operating on transistors. It has one thermopile giving 9 volts at a current of 40–50 mA. Output power 350 milliwatts. Its ten linear working thermoelectric generating junctions are powered by a kerosene lamp. Its service life is about 10,000 hours. Kerosene consumption is 15–20 g per hour."
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21. The bar is a unit of pressure defined as 100 kilopascals and is approximately equal to the atmospheric pressure on Earth at sea level.
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27. C. Sainsbury, *Tin Resources of the World,* U.S. Geological Survey Bulletin 1301, 1969 pp. 47–49. *https://pubs.usgs.gov/bul/1301/report.pdf.*
28. G. Donald Wagner, "History of Electronic Packaging at APL: From the VT Fuze to the NEAR Spacecraft," *Johns Hopkins APL Technical Digest*, Vol. 20, No. 1 (1999), p. 10.
29. When winding a self-supporting multi-layer coil, there are two ways to wind the layers; Honeycomb winding, which minimizes the self-capacity of the coil, or wave winding, which packs the winding into the smallest volume. In both cases, the wire feeding onto the winding mandrel is guided to oscillate from the right limit to left limit of the coil width approximately every rotation of the mandrel. The setup of the winding machine determines the spacing between adjacent turns. Both coils have the wires of successive layers running at more or less right angles to reduce self-capacity when compared to a multilayer plain helix as used in common transformers or electromagnets.
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Acknowledgements

My thanks to Louie Scribner for his gift of the TZGK-2-2 thermoelectric generator that prompted me to begin this project. Louie had collected this generator and USSR-manufactured broadcast receivers in the 1990s as a byproduct of having business dealings with industry in the former USSR during the period of *glasnost.*

My thanks to Barry Ethridge for allowing me to purchase his two *Spark* (1958) receivers and bringing to my attention a number of interesting Soviet publications and equipment offered on eBay. My thanks to Douglas Self and Achmed Khammas for their maintenance of Internet web pages: http://www.douglas-self.com/MUSEUM/POWER/thermoelectric/thermoelectric.htm and http://www.buch-der-synergie.de/c_neu_html/c_05_03_waermeenergie_3.htm. My thanks to Eric Wenaas for obtaining a translation of one Russian article and encouragement to write this paper.

About the Author

For over 49 years, **Robert E. Lozier, Jr.** has been a collector and amateur historian of radio broadcast receivers and related items. He enjoys preparing radio equipment for exhibition while also documenting the hardware and methods employed for conservation and restoration. Some of his work has appeared in the pages of *Radio Age*, the *Bulletin of the British Vintage Wireless Society*, and the Italian magazine *Antique Radio*.

He has prepared lectures and demonstrations on numerous occasions on subjects as diverse as the history of the Magnavox Company, radio collecting in Italy, ultrasonic cleaning and electroplating techniques, and demonstrations of electromechanical scanning television and its history. His papers, "Ricevitore Popolare Italiano" and "Strange To My American Eyes" were published in volumes 7 and 27 of the *AWA Review*.

In recent years he has become aware of the near complete loss of battery artifacts manufactured before 1935. These are items absolutely necessary for the operation of a large percentage of receivers that are so prized in various collections today. He now spends a significant portion of his spare time in creating museum grade replicas and making his recreated graphics and construction methods available gratis to all on his web site.

He retired in 2012, having worked a lifetime in industrial engineering departments of electronic instrumentation manufacturers until their closings. The final 13 years before retirement was spent at a small contract engineering firm as Compliance Test Engineer and 3D Electromechanical Design Engineer.

Robert E. Lozier, Jr.

Westinghouse Radio and Television Production

"*You can be sure* . . . if it's Westinghouse!" This was the familiar advertising slogan used by the Westinghouse Electric Corporation for many years. Today, if it's a Westinghouse, even an experienced collector may have many questions about his or her radio or television. When was it made? Where was it made? Why are the ID tags on two radios so different? Surprisingly, the collector may have to ask, who really manufactured it? Read on, and we will puzzle through some of the mysteries. Successful companies must respond to changes in business conditions and changes in the marketplace. They also must incorporate new technologies into their business. By adhering to these principles, the Westinghouse Electric Corporation was able to endure as a successful company for nearly a century. For over fifty years they were leaders in the radio, television, and consumer electronics business. The changes Westinghouse made over this period, when studied today, make it difficult for us to make sense of their decisions. By understanding the business decisions they made over time, it may be possible to understand the effect they had on the artifacts found today. Locations, licensing issues, contractual issues, legal issues, new technologies, the Great Depression, three wars and more, have combined to make following the Westinghouse story an interesting journey.

The Beginning

George Westinghouse (1846–1914), inventor and industrialist, organized the first of many Westinghouse companies, the Westinghouse Air Brake Co., in July 1869 to manufacture his own inventions as well as to utilize other inventions and the new technologies of his time. He started the Westinghouse Electric Company in 1886, changing the name to Westinghouse Electric and Manufacturing Co. in 1889. This company utilized the inventions of Nikola Tesla and others to wage the battle for alternating current (AC) over direct current (DC) as America was beginning the process of making electricity a household utility. Sadly, George Westinghouse would lose control of this part of his company to financiers during the financial panic of 1907, and he passed away in 1914. The Westinghouse Electric and Manufacturing Company went on to win the "battle of the currents" and installed the AC power generation facility at Niagara Falls. As the company grew, it also went on to become a major player in the radio industry, enduring for most of the 20th century. But George Westinghouse himself never played a part in the radio and electronics business.

In 1915, the management of the company first took an interest in radio by forming the Radio Engineering Section in Pittsburgh. In 1917, under contracts to supply radios for the Signal Corps, Westinghouse built 75 model SCR69 transmitters and 150 model SCR70 receivers. In 1918, to fill a contract for the Navy Bureau of Steam Engineering, Westinghouse built the Navy-designed Model SE1012A and SE1414 receivers at the Westinghouse Newark Works in New Jersey (see Fig. 1). In 1920 at this location, they also manufactured the Model RB long-range receiver for use in commercial shipping.[1] After the contracts for these radios were completed, Westinghouse moved to gain a stronger foothold in this field. It was in the company's interest to keep their business rival, General Electric (GE), from gaining control of radio technology. Their first move was to obtain an option to purchase the International Radio Company, which they later bought. International controlled the National Electric Signaling Company (NESCO), which in turn controlled the heterodyne and other patents of Reginald Fessenden. They also purchased options on, and later the full rights to, the patents of inventors Michael Pupin and Major E. Howard Armstrong.[2]

Frank Conrad, KDKA, and Pittsburgh

Westinghouse engineer Frank Conrad developed radio receivers to fill the government orders for radios needed during World War I. To test these receivers, he transmitted music to the nearby Westinghouse factory from a transmitter in his garage at home using a phonograph and borrowed records. Before long, a curious community discovered that free evening concerts were being broadcast through the air on a

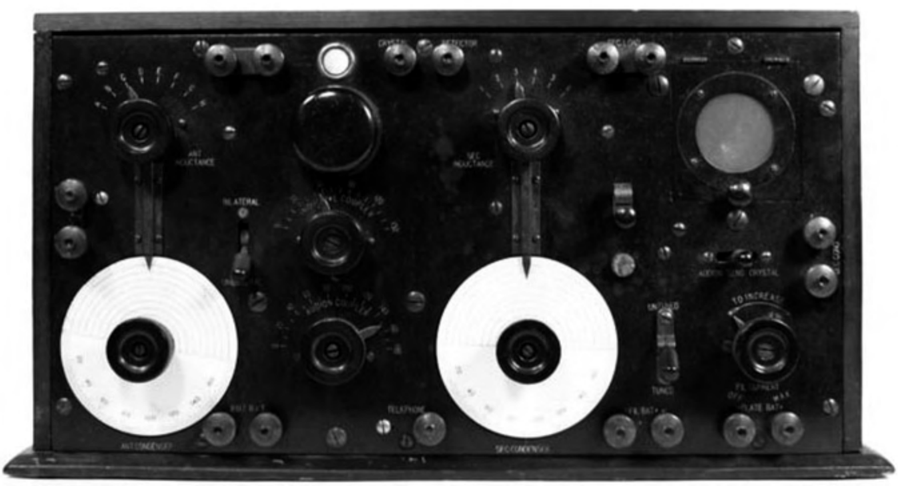

Fig. 1. SE 1012A receiver made at Westinghouse Newark Works (Courtesy of Radiomuseum.org)

station with call letters 8XK, a Special land station license belonging to Conrad. When the war was over, the income from government contracts ended, and Westinghouse cast about for new applications to support their fledgling radio business. Westinghouse saw little chance for commercial radio business because GE and the new company it had formed, the Radio Corporation of America (RCA), had locked in long-term contracts with many foreign countries for worldwide radiogram service. Vice President H. P. Davis found out how popular Conrad's music broadcasts were when he learned that the Horne Department store was selling radios to hear his concerts.[3] Thus, the idea of creating a broadcast station to sell radios was born. Westinghouse began to construct a broadcast station on the rooftop of its factory in East Pittsburgh at the end of September 1920, and station KDKA was inaugurated with the broadcast of presidential elections on November 2, 1920.

Fortunately, the public interest to "listen in" on radios after this broadcast created a new business model for Westinghouse, although it took more than a year for the business to materialize. Westinghouse made broadcasts daily, generated interesting programming, erected three more broadcast stations in 1921, and more to the point, began to manufacture and sell a line of radios to satisfy the needs of the average person, who was not interested in building his own radio set.

Westinghouse manufactured a complete receiver that would allow an average family to "tune in" their programs. The agreement to purchase the patent rights of Howard Armstrong became very important. His regenerative patent and later his superheterodyne patent were perfect for the home radios of the 1920s. Dr. Conrad had previously designed a regenerative receiver for use by Westinghouse in communicating with other Westinghouse factory locations within its range. He and his staff modified this radio to make it suitable for use by the general public as a broadcast receiver, and it went on sale in December 1920. This receiver consisted of two units: the Model RA tuner and the DA detector/amplifier, which when sold together in one cabinet was designated the Model RC receiver. Manufacturing was initially set up at the Shadyside Works in East Pittsburgh and later moved to East Springfield.[4]

Although a combined total of 1,700 RA tuners and DA amplifier/detectors were produced in East Pittsburgh,[5] it is important to recognize that these broadcast radios were an insignificant part of the business of a company the size of the Westinghouse Electric and Manufacturing Company in 1921 (see Fig. 2). At that time, Westinghouse controlled 104 companies and was working full speed to electrify America. This effort required manufacturing everything from dynamos and power stations to light bulbs and small appliances. Much of this equipment, which was constructed in East Pittsburgh, was huge, and the demands of production must have put a strain on the facility

Fig. 2. Postcard depicting a general view of the Westinghouse Electric & Manufacturing Co. and Machine Co. in East Pittsburgh. (Author's collection)

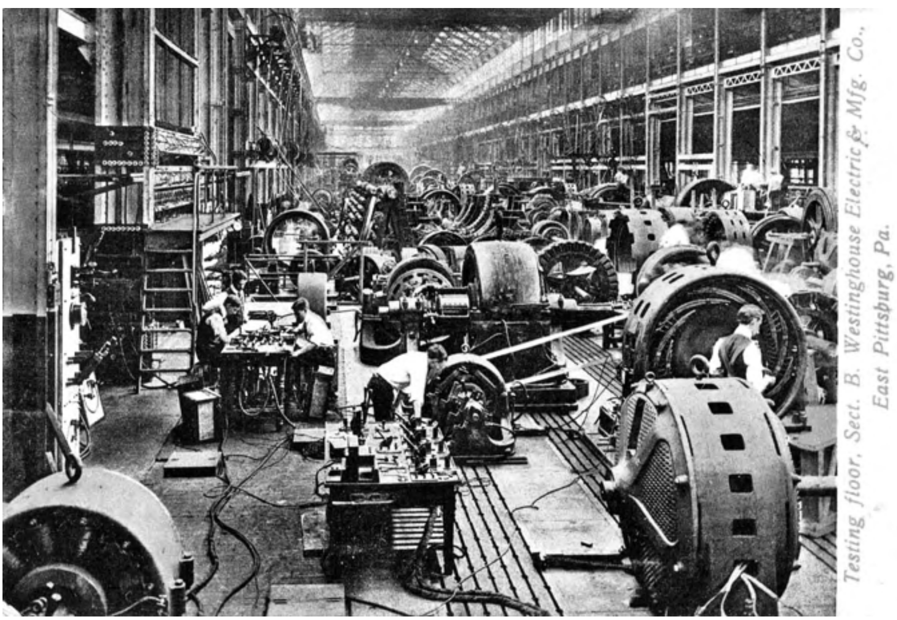

Fig. 3. Postcard depicting Testing Floor in the East Pittsburgh Westinghouse facility where dynamos were tested. (Author's collection)

as well as the available labor force (see Fig. 3). This complex covered 75 acres and had over nine miles of railroad track within the buildings.[6] Therefore, it is not too surprising that Westinghouse needed a new location for the radio portion of its business.

The Move to East Springfield, MA

During World War I, the various divisions of Westinghouse had been awarded many contracts to fill war-related orders. One such contract called for manufacturing components for over one million rifles for the Russian Army. To execute this contract, Westinghouse bought buildings in Massachusetts formerly occupied by an automobile manufacturer, the Stevens-Duryea Company.[7] After war-related contracts ended, Westinghouse redesigned these buildings for other purposes. The site in East Springfield, MA, became home to the Electric Home Appliance Division. The newly created Home Radio Products Division soon left East Pittsburgh, PA, for East Springfield (see Fig. 4). The type of machined parts used for the rifles and the skilled labor that had manufactured them was a good fit for radio work. Westinghouse also produced small motors for automobile starters and sewing machines at the East Springfield facility,[8] and they selected another property for manufacturing small appliances in Chicopee, MA.

To continue the business model calling for the construction of several radio stations in addition to KDKA, the company constructed a second radio station atop the factory in East Springfield. This station was licensed with the call letters WBZ on September 15, 1921. Not all radio work left East Pittsburgh, however. Frank Conrad and the Radio Engineering Department remained there, as did the division that produced small transmitters and radios for government sales.[9]

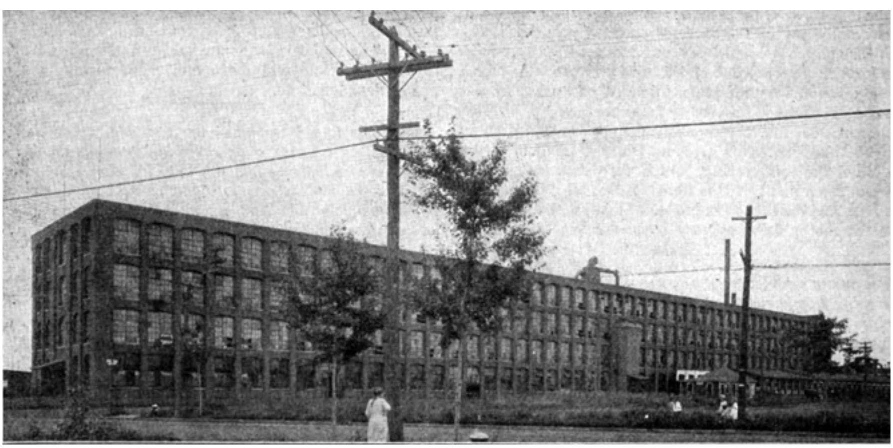

Fig. 4. The Westinghouse facility in East Springfield where most of its consumer radios were manufactured in the 1920s. (*Elect. World*, Vol. 74, p. 620)

During this period, Frank Conrad also experimented with short waves. This work included a demonstration in a London hotel room, where his shortwave receiver with a short antenna received a transmission from East Pittsburgh. Attending the demonstration were both Marconi and David Sarnoff.

Production in East Springfield began with the same RA and DA models that were made in Pittsburgh, but in much greater quantities. Westinghouse combined the RA and DA into a single cabinet and designated it Model RC. They rounded out the offerings the first year by adding two inexpensive models, the Aeriola Junior crystal set and the Aeriola Senior one-tube regenerative receiver.

With the public interest in radio receivers that Westinghouse had kindled in 1921, RCA and GE could no longer ignore the broadcast radio market. It would have been risky for a large corporation to invest substantial resources in radio manufacturing without having a solid patent position. To obtain the licenses for the patents needed to produce competitive receivers, RCA and GE invited Westinghouse Electric, owners of the regenerative patent and others, to join what became known as the "the radio group." RCA, GE and Westinghouse negotiated a deal in which 60% of the broadcast radios sold by RCA would be manufactured by GE and 40% by Westinghouse. A small number of radios made for sale by RCA were actually made by the Wireless Specialty Company; that portion came from GE's 60% share. Under this agreement, neither GE nor Westinghouse would sell broadcast radios directly to the public.

The agreement was signed in June of 1921, but it did not become effective until January 1, 1922,[10] at which time RCA began to advertise the sets. The models produced and marketed by Westinghouse before this agreement became effective are listed in Table 1, while the models made exclusively by Westinghouse and sold by RCA after the agreement became effective are shown in Table 2.[11] Beginning in 1922, RCA also began to sell the models listed in Table 1 that Westinghouse had been selling in 1921. Note that RCA began to market the RC as the Radiola RC in April 1923, but by then, all remaining RC sets sold by RCA had already been manufactured by Westinghouse. As a result, no model RC sets have the Radiola name on the nameplates. The dates in these tables are those when each model first appeared on the market.

Table 1. Broadcast radio models produced and marketed exclusively by Westinghouse before January 1, 1922.

Westinghouse Model Number	Date Introduced
Model RA Tuner*	Dec. 1920
Model DA Det./Amp.*	Dec. 1920
Model RC Receiver	Dec. 1920
Aeriola Junior	July 1921
DB Crystal Detector*	Aug. 1921
Aeriola Senior	Dec. 1921

*An RA tuner when combined with either a DB or DA model formed a complete receiver.

Table 2. Broadcast radio models produced by Westinghouse and marketed exclusively by RCA beginning in 1922 (in addition to holdover sets listed in Table 1).

Westinghouse Model	Date	Westinghouse Model	Date
Aeriola Sr. Amp	Sept. 1922	Radiola Sr. Amp AC	Feb. 1923
Aeriola Grand	Mar. 1922	Radiola III	Feb. 1924
Radiola Grand	Dec. 1922	Balanced Amp.	Mar. 1924
Radiola AR *	Jan. 1923	Radiola III-A	Mar. 1924
Radiola RT *	Jan. 1923	Radiola RC	Apr. 1923
Radiola RS	Jan. 1923	Radiola Regenoflex	Apr. 1924
Radiola Jr.	Feb. 1923	Radiola X	Mar. 1924
Radiola Senior	Feb. 1923	Radiola 26	June 1925

*Used with RA and DA sets in various combinations

Standardization of Receiver Manufacturing

While the 60%–40% agreement between GE and Westinghouse for manufacturing sets had been in place since 1922, the actual ratios depended on consumer demand, and demand greatly favored Westinghouse receivers in the first few years. The agreement was informally modified to make the percentage cumulative over several years, and GE finally evened it up in 1924 with the sale of the first mass-produced superheterodyne receiver. In 1925, it was decided that each model would be manufactured to exactly the same specifications by both companies in the ratio of 60%–40%. The first standardized model manufactured by both companies was the Radiola 28 released in August 1925. Models manufactured to the same standard between August 1925 and the end of 1929 are listed in Table 3.[12]

Unification and Production in Camden, New Jersey

As the size of radio transmitters grew and government orders for receivers increased, more space was needed than was available in East Pittsburgh. In 1925, production of radios for the government was relocated to Chicopee Falls, MA, and the Radio Research and Engineering Department moved there later in 1927. The evolution of the technology during this period was more than impressive. Home receivers progressed from simple crystal sets to regenerative sets, all of which were soon replaced by superheterodyne and tuned-radio frequency (TRF) sets. Sets with headphones, multiple dials, a number of batteries, and long outdoor antennas were soon replaced by single dial tuning sets that only needed to be plugged into a wall outlet. While the radios from East Springfield were produced in larger and larger quantities, that

Table 3. Each model produced to the same standard for RCA by both General Electric (Schenectady) and Westinghouse (E. Springfield) in the ratio of 60% to 40%.

Model	Date	Model	Date
Radiola 16	Aug-1927	Radiola 33 DC	July-1929
Radiola 17	Sept-1927	Radiola 41	Dec-1928
Radiola 18	Apr-1928	Radiola 41 DC	Mar-1929
Radiola 18 DC	Dec-1928	Radiola 44	May-1929
Radiola 20	Nov-1925	Radiola 46	May-1929
Radiola 21	Oct-1929	Radiola 46 DC	Nov-1929
Radiola 22	Nov-1929	Radiola 47	Oct-1929
Radiola 25	Sept-1925	Radiola 50	Mar-1928
Radiola 28	Aug-1925	Radiola 51	Jun-1928
Radiola 28 AC	Sept-1925	Radiola 51 DC	Dec-1928
Radiola 30	Nov-1925	Radiola 60	Aug-1928
Radiola 30A	Aug-1927	Radiola 62	Sept-1928
Radiola 30A DC	Sept-1927	Radiola 64	Oct-1928
Radiola 32	July-1927	Radiola 66	July-1929
Radiola 32 DC	Sept-1927	Radiola 67	Sept-1929
Radiola 33	Mar-1929		

would come to a sudden stop in 1929. Production was not stopped by product issues, lack of demand, or labor problems, but by management decisions involving a change in direction for RCA and the radio group.

David Sarnoff had long recognized the problems of manufacturing and marketing radios under the 60%–40% agreement. In October 1927, he headed a committee at RCA charged with investigating unification of radio manufacturing. Managing the 60%–40% agreement was cumbersome at best because it required that sets be designed and manufactured in a fixed ratio by two different suppliers, which made RCA slow to respond to changes in the marketplace. Engineering and research was not coordinated between the two entities, and production had to be adjusted up or down to stay within the 60%–40% production ratio. These difficulties allowed independent manufacturers to take the lead in radio production and sales.

Sarnoff worked methodically to change this situation. In April 1928, the committee recommended to proceed with unification. RCA had an ongoing relationship with the Victor Talking Machine Company whereby RCA provided radio chassis and amplification hardware for installation in Victor phonographs. Sarnoff developed a plan for the Victor manufacturing facilities in Camden, NJ, to become the manufacturing center for RCA radio products. In a July 1928 meeting with Victor, Sarnoff proposed an RCA plan to purchase the Victor Talking Machine Company.[13]

In addition to manufacturing phonographs and cabinets, Victor also had an extensive marketing network and produced phonograph records using a stable of recording artists under contract—the latter being a new business for RCA. The stockholders of RCA approved the plan on February 27, 1929, and the acquisition of Victor by RCA was completed on March 15, 1929. A new company was soon formed to take over the manufacturing responsibility. On April 29, 1929, a new Audio Vision Appliance (AVA) Company was incorporated, and the assets and manufacturing operations of the Victor Company were transferred to this new company. The AVA Company was owned by GE and Westinghouse in the same 60%–40% ratio as the previous manufacturing agreement.

David Sarnoff soon found that this arrangement, combined with a clumsy marketing arrangement, was a step backwards. Within months he was lobbying at the highest levels of RCA for complete unification. To implement this plan, the RCA Victor Company, Inc. was formed on December 26, 1929. The new AVA Company was dissolved and radio research, manufacturing, and marketing operations were then placed under the control of this new company. Many assets and personnel were transferred to Camden, and GE and Westinghouse became major shareholders of RCA. The radio business for Westinghouse was now upside down. In the 1920s, Westinghouse manufactured radios marketed by RCA, but beginning in 1930, Westinghouse and GE began to market radios made by RCA.[14]

Westinghouse and GE Divest Themselves of RCA

The unification period did not last long. As 1930 started, David Sarnoff was named president of RCA, and his unification plans were put into action. Before unification, many viewed the "radio group" as the "radio trust," and to many, the new RCA looked like a stronger trust than before. Also, the 1930s brought on stronger antitrust actions against monopolies as the U.S. Justice Department investigated big business in the United States. At this time, the federal government was prosecuting a case against Standard Oil, and it was winning the case to break up this monopoly. So by May of 1930, the Justice Department became bullish about prosecuting monopolies just at the time David Sarnoff was waving the red cape with his new company. Preliminary talks were being held between the principal members of the radio group and the Justice Department before any actions had been taken, and these talks dragged on for some time. Again, Sarnoff took the lead for RCA. Finally, as trial dates approached, talks continued at an accelerated pace, and trials were repeatedly postponed. Shortly before yet another trial date, all parties in the radio group reached a settlement with the Justice Department.

The agreement was signed on November 21, 1932, whereby Westinghouse and General Electric agreed to completely divest themselves of all connections with RCA, and management officials from GE and Westinghouse were removed from the RCA board of directors. As part of this settlement, Westinghouse and GE agreed not to compete with RCA in radio production or sales for a two-and-a-half year period. This would allow RCA time to firmly establish production of consumer radios in Camden and gain a market foothold without GE or Westinghouse manufacturing competing broadcast radio receiver lines.[15] The non-compete agreement would end in May of 1935, at which time both Westinghouse and GE were free to manufacture competing consumer radio products.

RCA Victor Manufactures Westinghouse Home Receivers (1930–1935)

From 1930 to 1935, Westinghouse marketed radios manufactured by RCA Victor Co. in Camden, NJ. These Westinghouse radios had equivalent RCA models, which are listed in Table 4. The model years for radios marketed during this decade were from mid-year to mid-year, so that most of the sets first manufactured in 1930 were generally sold through mid-1931, and likewise, most of the sets manufactured in 1934 were sold though midyear 1935, at which time the RCA agreement to make radios for Westinghouse ended. The model number equivalents in Table 4 were taken from the *RCA Victor Service Data* book published in 1944,[16] and the year that each model was first manufactured was taken from the *RCA Victor Service Notes* for the year 1935, which contains a cumulative list of sets made each model year beginning in the model year 1930–1931.[17]

One of the first ads announcing the new line of radios for sale by Westinghouse was a four-page ad that appeared in the July 1930 issue of *Radio Retailing*. The ad featured the WR-5 lowboy, WR-6 screen-grid superheterodyne, and WR-7 combination phonograph-radio.[18] The ad was circumspect about who manufactured the radios: "Westinghouse Radio . . . the product of the finest radio engineering and manufacturing talent ever assembled . . . made in modern factories on a mass-production basis." They certainly told the truth, but they avoided naming any manufacturer at all.

When RCA began manufacturing radios for Westinghouse in mid-1930, the nametags on Westinghouse radios stated, "Manufactured for Westinghouse Electric & Mfg. Company by RCA Victor Company, Inc." One such tag from a WR-10-A receiver that was first manufactured in 1931 is shown in Fig. 5. However, by 1932 the company name appearing on the tags had changed to "Westinghouse Electric Supply Co., Inc. New York, N. Y." The only reference to RCA was as a licensor (see Fig. 6). While the tag in this figure is from a Model WR-28 made in 1933,

Table 4. Westinghouse WR series radios made between 1930 and mid-1935 by RCA Victor Co. in Camden, NJ, with equivalent RCA models (dates are years first marketed).

Westinghouse Model No.	Equivalent RCA Victor Model	First Year Mfd.	Westinghouse Model No.	Equivalent RCA Victor Model	First Year Mfd.
WR-4	Radiola 48	1930	WR-25	RE-80-SW	1933
WR-5	Radiola 80	1930	WR-26	R-27	1933
WR-6	Radiola 82	1930	WR-26-M	R-17-M	1933
WR-6-R	Radiola 82-R	1930	WR-27	R-28-B	1933
WR-7	Radiola 86	1930	WR-27-P	R-28-PB	1933
WR-7-R	Radiola 86-R	1930	WR-28	R-37-P	1933
WR-8	WR-6 chassis	1931	WR-29	RE-40-P	1933
WR-8-R	WR-6R ch	1931	WR-30	140, 141	1933
WR-9	T-5	1931	WR-31	140-E, 141-E	1933
WR-10 (DC)	R-7	1931	WR-32	100	1933
WR-10A	R-7-A	1931	WR-33	M-34	1933
WR-12	R-9	1931	WR-34	112	1933
WR-12 (DC)	R-9 (DC)	1931	WR-35	111	1933
WR-13	RE-16	1931	WR-36	120	1933
WR-13-A	RE-16-A	1931	WR-37	121	1933
WR-14	R-5	1931	WR-38	340	1934
WR-14 (CR)	R-5-X	1931	WR-39	340-E	1934
WR-14 (DC)	R-5 (DC)	1931	WR-41	M-105	1934
WR-15	R-11	1931	WR-42	M-116	1934
WR-15-A	R-10	1931	WR-45	143	1934
WR-16	RO-23	1932	WR-45-A	143 (Mod)	1934
WR-17	R-4	1932	WR-46	128	1934
WR-18	R-8	1932	WR-46-A	128 (Mod)	1934
WR-18 (DC)	R-8 (DC)	1932	WR-47	135-B	1934
WR-19	R-70	1932	WR-48	118	1934
WR-20	R-74	1932	WR-48-A	118 (Mod)	1934
WR-21	R-70, R-70-N	1932	WR-50	128-E	1934
WR-22	R-73	1932	WR-53	125	1934
WR-23	RE-80	1933	WR-93	R-93	1934
WR-24	R-24-A	1933			

the tag on a Model WR-24 made in 1932 has been observed to be virtually identical to the tag on the WR-28 (except for the model number). The Westinghouse Electric Supply Company (WESCO) had been established as a wholly owned subsidiary company of the Westinghouse Electric & Mfg. Company in 1922 for the purpose of distributing electrical products through jobbers, distributors, and eventually retail stores. A WESCO catalog prepared by WESCO for its wholesale distributors clearly stated that it was "A National Distributing Organization" with many branches—clearly, not a manufacturer (see Fig. 7).

It would appear that by 1932, Westinghouse decided it did not want the consumer to know that RCA made their sets. The status quo persisted until mid-1935 when the manufacturing agreement between Westinghouse and RCA expired—and without any mention of the agreement or its expiration in the press. What happened next is something of a mystery. Read on.

Fig. 5. A Model WR-10A radio with nametag indicating it was manufactured by RCA. (Author's collection)

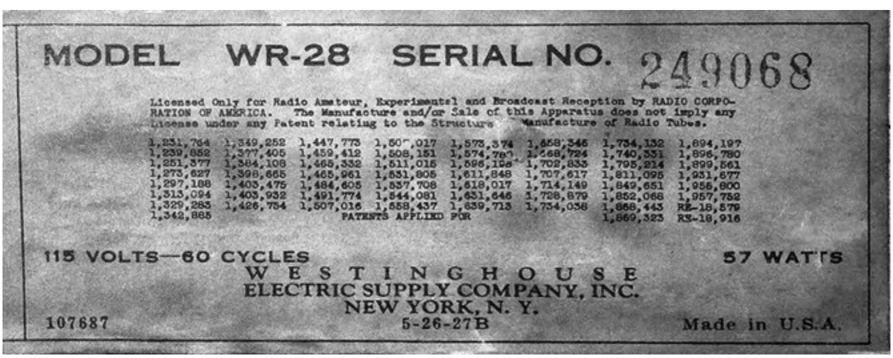

Fig. 6. A nametag from a Westinghouse Model WR-28 made in 1933 no longer reveals that is was manufactured by RCA.

Fig. 7. A Westinghouse Supply Company (WESCO) sales catalog clearly indicates that it was a national distributing organization, not a manufacturer. (Author's collection)

Westinghouse Home Radios Mid-1935 to Mid-1937, or *"The Mystery of the Manufacturer"*

The radio business had changed dramatically during the period from mid-1930 through mid-1935 when Westinghouse marketed radios made by RCA. The United States was well into the Great Depression, and radio buyers had less cash in their pockets. The radio industry had answered with new technology. The many individual components of 1920s radios, often placed in separate cabinets, were replaced with self-contained AC tabletop sets shaped like cathedrals and tombstones. These radios cost less to produce, sold for much less, and as a result, generated much less revenue per sale. Westinghouse radio sales fell from $800,000 per year to $235,000 for 1934, and during this same period other competing companies such as Atwater Kent, Majestic, and Philco became dominant in the marketplace.

In order for Westinghouse to continue selling radios in the post-RCA manufacturing era (beginning in mid-1935), they had two choices—manufacture their own sets or outsource them. In order to design and manufacture their own sets, Westinghouse would have to gamble a huge investment in start-up costs associated with designing new radios and setting up a new manufacturing line. Alternatively, with little risk they could continue to outsource radios using manufacturers of their own choice.

Westinghouse clearly made the decision to continue selling radios under their own brand, because an ad appeared in the August 1935 issue of *Radio Retailing* (once again) announcing the new Westinghouse models for the 1935–36 model year, but this time with little fanfare.[19] The ad was a single page and unassuming with small images of fourteen sets, including the model WR-100—an inexpensive AC/DC receiver. This receiver had the lowest "WR" model number of any set made after the RCA Victor agreement with Westinghouse expired. The WR-100 is a key model number because all radios with a WR number less than 100 were manufactured by RCA under the earlier Westinghouse–RCA agreement, while all radios with WR numbers of 100 and greater were manufactured under other arrangements.

The distribution of Westinghouse radios sold between mid-1935 and 1942 (when the sales of all consumer radios stopped because of World War II) were handled once again by WESCO. Westinghouse radios sold in this time frame had nametags labeled with "Westinghouse Electric Supply Company," many of which were followed by a street address—either 150 Varick St. in New York or 1101 Race St. in Philadelphia, PA. One such nametag found on a WR-272 has the Varick street address (see Fig. 8).

The addresses on these tags were of sales offices that were responsible for marketing the radios, not those of a factory. So, do we know where these radios were manufactured? Do we know if Westinghouse was really the manufacturer? Very few obvious clues have been found. It is likely that Westinghouse, knowing that their name had great appeal to radio buyers, decided to stay in the market by outsourcing the manufacturing. It also appears that considerable effort was made to hide the fact that radio production was subcontracted to other manufacturers. All service information, including tags, schematic diagrams, ads and such, was supplied under the WESCO name.

One of the first clues that manufacturing was outsourced is an ID tag for a Westinghouse Model WR-262, Chassis Model 232E (see Fig. 9), which stated that it was manufactured for

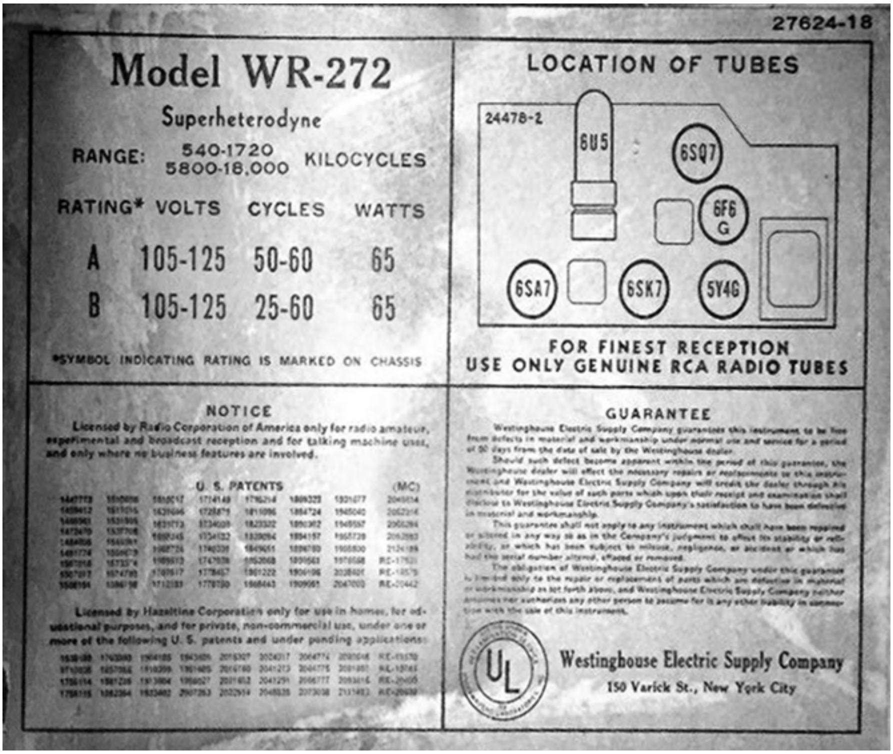

Fig. 8. A Westinghouse WR-28 nametag indicates is was distributed by a WESCO office on 150 Varick St. in New York City.

Westinghouse by "D. Company, Detroit Michigan." This company was almost certainly the Detrola Corporation of Detroit, Michigan. A search of many model tags did not uncover any other clues to actual manufacturers, although collectors have reported WR series radios that were likely made by companies other than Westinghouse.

Another line of investigation began with the fact that all the WR numbers assigned after mid-1935 had an initial digit between 1 and 6. It was first postulated that the first number represented one of six different manufacturers, but investigations of buyers' guides and advertisements in radio magazines pointed to a different meaning. *Radio Today* in particular listed the complete Westinghouse line by year for 1935 to 1939, characterizing each radio by type.[20] The six types are shown in Table 5 for each of the six different series of numbers. The numbers actually indicate sets with different features. For example, the 100 series designates AC/DC table radios, while the 200 series designates AC table radios—that is, radios with power transformers using tubes of equal voltage ratings wired in parallel. (AC/DC radios used tubes with different voltage ratings

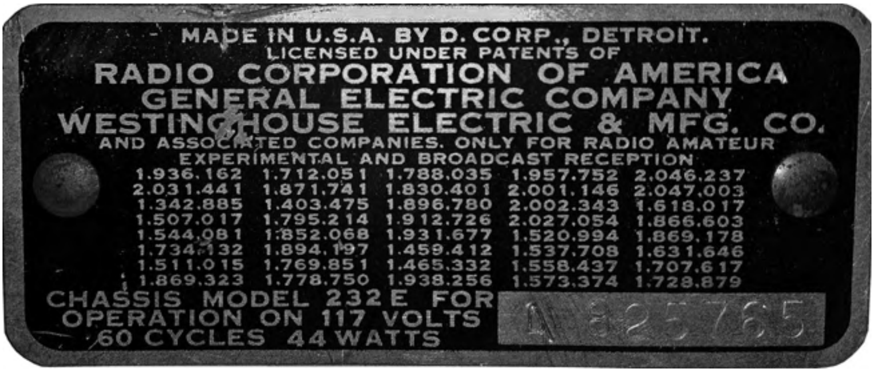

Fig. 9. A license tag found on a Westinghouse WR-262 indicates it was manufactured by Detrola Corp. of Detroit. (Courtesy of eBay advertisements)

wired in series to add up to the power line voltage.) The 100 series sets were the least expensive radios of the lineup. It appeared that the search to identify individual manufacturers would not be easy.

A third line of investigation was to search the 23 volumes of the Rider Manuals to determine if there were any manufacturers with models whose chassis layouts or schematic diagrams were identical to those of Westinghouse models. A great deal of detective work is needed to find matching schematics or chassis layouts in the six or so volumes of Rider's covering 1935 to 1940, each with about 1500 to 1600 pages. Unfortunately, the 23 volumes of the Rider's manual are not research-friendly. In all fairness, it was never Rider's intention to provide accurate material for a researcher some eighty years later.

Table 5. Westinghouse WR Model Numbering Scheme.

Series	Model Types
WR-100 to199	AC/DC Table Radios
WR-200 to 200	AC Table Radios
WR-300 to 399	Console Radios
WR-400 to 499	Radio /Phono Combos
WR-500 to 599	Auto Radios
WR-600to 699	Portable/Farms Radios

To begin the search, it was logical to assume that a manufacturer supplying radios for sale by Westinghouse would provide a radio with a circuit diagram and chassis identical to one of its own models—and in the same year. However, the year of manufacture in Rider's does not generally correspond to the year the manual published. The different indexes are inaccurate or incomplete, the diagrams in each volume are not in numerical order, and bits and pieces of information for the same model may appear in different volumes. Also, the amount of information provided for each radio model varies, and often the major component layout is not included. This makes the search reminiscent of finding the proverbial needle in a haystack, or the challenge of putting together a jigsaw puzzle where you don't know what to expect as the final picture. Thankfully, a hardworking, strong-willed radio historian achieved success for the years 1935 and 1936 and provided the information appearing in the next two tables.

The first step was to accurately date the Westinghouse models to the first year manufactured and then focus on the Westinghouse models manufactured by unknown manufacturers in the first two years beginning with the 100 series. The model years were accurately dated by finding the first year each model appeared in the magazine *Radio Today*. The results of this effort are summarized in Table 6.[21] This table is not entirely complete—but then neither are the Rider's manuals. There are a small number of models listed here, highlighted in gray in the table, that do not appear in Rider's manuals. There are also models listed here with an asterisk that do not appear in the Rider's indexes but can be found in the manuals anyway.

Finally, there are a small number of models listed in Rider's that do not appear in the table. However, most of those sets can be accurately dated using this table by recognizing that the WR model number for each of the six series of models in Table 5 monotonically increases over time. Therefore, it

Table 6. Westinghouse WR Radio Models by Year Introduced (1935–1942).

1935	1936	1937	1938	1939	1940	1941-42
WR-100	WR-102	WR-116	WR-150	WR-165M	WR-168/B	WR-12X3
WR-101	WR-103	WR-120	WR-150W	WR-165I	WR-173	WR-12X4
WR-201	WR-116	WR-217	WR-152	WR-165W	WR-175/I	WR-12X8
WR-203	WR-207	WR-222	WR-154	WR-166A	WR-177	WR-12X10
WR-204	WR-208	WR-224	WR-158	WR-168	WR-179	WR-12X12
WR-205	WR-209	WR-226	WR-256	WR-169	WR-182	WR-12X14
WR-303*	WR-210	WR-228	WR-258	WR-170	WR-184	WR-12X15
WR-304*	WR-211	WR-326	WR-260	WR-172	WR-186	WR-12X16
WR-305*	WR-212	WR-328	WR-262	WR-270	WR-272L	WR-42X1
WR-306	WR-214	WR-330	WR-264	WR-272	WR-288	WR-42X3
WR-500	WR-310	WR-332	WR-366	WR-274	WR-290	WR-42X4
WR-501	WR-311	WR-334	WR-368	WR-372	WR-375	WR-42X7
WR-601	WR-312	WR-336	WR-370	WR-373	WR-388	WR-62K1
WR-602	WR-314	WR-338	WR-472	WR-373Y	WR-475	WR-62K2
-	WR-315	WR-610	-	WR-374	WR-476	WR-62K3
-	WR-316	-	-	WR-468	WR-478	-
-	WR-502	-	-	WR-470	WR-480	-
-	WR-503	-	-	WR-473	WR-482	-
-	WR-603	-	-	WR-474	WR-484	-
-	WR-604	-	-	WR-675/A	WR-486	-
-	WR-605	-	-	WR-676	WR-678	-
-	WR-606	-	-	WR-677	WR-679	-
-	WR-607	-	-	-	WR-680	-
-	WR-608	-	-	-	WR-682	-

*Models in the table that do not appear in Rider's manuals are highlighted in gray. Models with asterisks are in Rider's manuals but do not appear in the Riders index.

is only necessary to determine where the missing model numbers fit in the appropriate six numerical sequences in the table. For example, WR-176 appears in the Rider's index but not in this table. Model WR-176 fits into the 100-series sequence in the year 1940 column between WR-175/I and WR-177, and so it would have been first manufactured in 1940. Note that for some reason, the Westinghouse model numbering system changed for the Westinghouse models beginning with the model year 1940–1941.

The next step was to make a copy of all the Westinghouse models in the Rider's manuals for 1935, 1936 and 1937 and go through all three Rider's volumes for those years trying to match schematics or chassis. After an extended period of time, all the Westinghouse models in the Rider's manuals for the first two years were matched to either Emerson or United American Bosch models (see Table 7). The Emerson and Bosch models in bold were found to have schematic diagrams that exactly duplicate the corresponding Westinghouse models. The schematics for models not in bold were close enough to those of the Westinghouse models to confirm a match, although the diagrams were not exact duplicates.

It is of interest to see how the radios made by Emerson for sale to the public compared to the equivalent models they made for Westinghouse. A Westinghouse WR-201 is compared with an Emerson Model 36 in Fig. 10, and a Westinghouse WR-101 is compared with Emerson Model 107 in Fig. 11. While the cabinets are slightly different, all the shapes are the same, and the controls and speakers are in the same locations.

Emerson all but stopped making sets for Westinghouse after the first year. They made only one in the second year, and no others matches have been

Table 7. Manufacturers of Westinghouse WR Radio Models (1935–1936).

Yr.	Model	Emerson	Bosch
1935	WR-100	**108,110**	-
	WR-101	**107,111**	-
	WR-201	**36**	-
	WR-203	**340, 101**	-
	WR-204	-	**575F, 575Q**
	WR-205	-	**585Y, 585Z**
	WR-303*	**340, 101**	-
	WR-304*	-	**575F, 575Q**
	WR-305*	-	**585Y, 585Z**
	WR-306	-	**595M, 595P**
	WR-500	-	634A
	WR-501	**E128**	-
	WR-601	**103**	-
	WR-602	Not in Rider's	
1936	WR-102	-	**604**
	WR-103	-	**610**
	WR-116	-	620,625
	WR-207	Not in Rider's	
	WR-208	**117**	-
	WR-209	-	**515**
	WR-210	-	**605, 605C**
	WR-211	-	640,650
	WR-212	Not in Rider's	
	WR-214	-	207A
	WR-310	-	**605, 605C**
	WR-311	-	**650**
	WR-312	Not in Rider's	
	WR-314	Not in Rider's	
	WR-315	-	680
	WR-316	-	620,625
	WR-603	-	**600**
	WR-604	-	**601**
	WR-605	-	**602**
	WR-606	-	**600**
	WR-607	-	**601**
	WR-608	-	**602**

found. It appears that Bosch became the favorite supplier for Westinghouse in 1936. Then in 1937, Bosch suddenly stopped making domestic radios for sale in the in the United States,[22] and no more Bosch radios appeared in Rider's. The trail of suppliers went cold.

Westinghouse Home Radios 1937 to 1942, or *"Unsolved Mysteries"*

Searching for identical chassis becomes more difficult beginning in 1937. The model WR-262 tag that refers only to the D. Corp., Detroit may be telling us something (see Fig. 9). Was there

Fig. 10. Emerson Model 36 matches the shape of the WR-201 as well as and the location of the controls and speakers. (Courtesy of Radiomuseum.org)

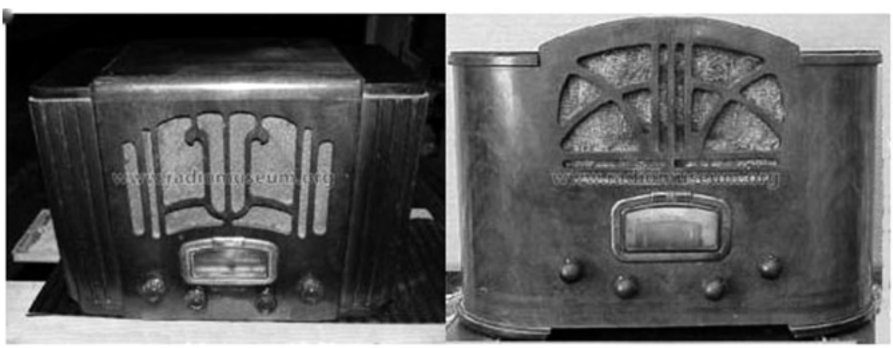

Fig. 11. Emerson Model 107 matches the shape of the WR-101 as well as the location of the controls and speakers. (Courtesy of Radiomuseum.org)

a new effort to hide the subcontracting scheme? Was this subcontracting information being used by other manufacturers to sour buyers against Westinghouse? Was this all done under orders from Westinghouse? There is only a reference on this tag to a chassis 232E. No picture or schematic could be found of an identical set. In the case of the WR-262, a search of the Rider's manuals revealed that many of the three- and four-digit part numbers for parts used on the Westinghouse WR-262 match the part numbers used on the Detrola Model Series 175, 190, and 193. The only difference is that the Westinghouse four-digit part numbers are preceded by the letter "D," while the Detrola part numbers have no initial letter. For example, the part number for a .02 mfd. capacitor used on the Westinghouse Model WR-262 is D576,[23] while the number for the same part type used on the Detrola series is 576.[24] This duplication is repeated many times with many different parts. Obviously, the D refers to Detrola, and Detrola manufactured the WR-262 for Westinghouse using Detrola parts. While the schematics and chassis of the Detrola sets were close to those of the WR-262, they were not nearly as close as the Emerson and Bosch models had been to corresponding Westinghouse models as in earlier years.

Another possibility is that Bosch continued manufacturing some radios for Westinghouse based on sets produced outside the United States. Under those circumstances, no additional Bosch diagrams would have appeared in the Rider's manuals after Volume 9, published in 1938. But did Bosch continue its subcontracting activities? Perhaps that is why the number of identical diagrams has dropped off. Did they keep a contract with Westinghouse for most of the models until World War II stopped all production? So far, no evidence has been found to prove or disprove this theory. Now the jigsaw puzzle box is also filled with a pile of blank pieces.

The frustrations involved in finding additional subcontracted sets became evident when the search of Rider's Manuals produced another possible subcontractor. The schematic diagram for a DeWald Model 408R matched the schematic diagram for Westinghouse WR-677 almost exactly, except for the output tube. Also, the schematic diagrams were both drawn in a very unusual print style. The Westinghouse set used a 1Q5, whereas the DeWald model used a 1C5. By 1937, radio technology had developed to a point where very similar complements of tubes were used in many radios, and the design for many sets had nearly the same schematic diagram. But a check of the 408R and the WR-677 for matching component layouts or physical appearance bore no positive results. Therefore, it is only likely, but not proven, that the WR-677 was made by DeWald. It is possible that additional searching through the Rider's Manuals might find an even more direct link to Westinghouse sets made by DeWald.

Westinghouse in Baltimore During World War II

In 1938, Westinghouse transferred 250 radio research employees working at plants in Chicopee, MA, and Pittsburgh, PA, to a radio division at a Westinghouse facility in Baltimore. This site, not too far from Washington D.C., was chosen so that Westinghouse could pursue its business with the federal government and the military more effectively. It was staffed with personnel who not only could design and build radio communications equipment, but also secretly begin work on the earliest radar systems. In that location, Westinghouse built the first mobile radar system to be deployed, the SCR 270, which used the Westinghouse radar tube WL 530. It was placed on duty near Pearl Harbor, HI, just prior to the attack on the fleet there. On December 7, 1941, this installation reported the incoming Japanese planes that commanders unfortunately decided were friendly aircraft. Throughout the 1930s, the workload of filling government orders kept growing. Westinghouse management stated that during this period they produced a greater number of radios for the war effort than were produced in the entire time the company built broadcast radios in Springfield.[25]

Early Television at Westinghouse Electric and Manufacturing

The Westinghouse Electric and Manufacturing Co. was a leader in early television research. It can be said that television research at Westinghouse began in 1920 when they hired Vladimir Zworykin, who left his then-current job, took a pay cut, and relocated his family to East Pittsburgh. Although his first projects at Westinghouse included developing the WD-11 triode tube for radio, the seed for developing electronic television was germinating. Born to an upper-class family in Russia in 1889, Zworykin was educated in science and engineering and studied under Boris Rosing, who is credited in Russian histories as the inventor of television. At this time in 1911, with Zworykin as his lab assistant, Rosing worked to develop his idea for an electronic system using both a pickup tube and a cold-cathode display tube. Soon the Russian Revolution and World War I caused Zworykin to leave Russia and begin the long path that would take him to East Pittsburgh.[26]

At Westinghouse, Zworykin convinced management to allow him to begin research on television. Zworykin started this arrangement in 1923, a time when broadcast radio was just beginning. While Westinghouse engineer Frank Conrad experimented with mechanical television, Zworykin focused on electronic television. As the 1920s progressed, Zworykin produced crude experiments, first showing a line on a screen and soon sending more geometric shapes. By 1928, Zworykin had built and demonstrated several test receivers using a cathode ray tube (see Fig. 12). As part of the Westinghouse association with RCA, David Sarnoff was one of the RCA officials attending the demonstration. When Westinghouse consolidated its radio manufacturing with RCA, the interest to fund this television research had diminished. By April 1930, Sarnoff would have Zworykin and his team fully transferred to RCA in Camden.

As the depression years continued, Westinghouse did not want to miss out on the sales boom from the predicted shift in the consumer electronics market from inexpensive, low-margin radios to expensive and more profitable television sets. As the 1930s ended, regular television broadcasting was beginning. With the inauguration of scheduled television broadcasting at the 1939 World's Fair, it was expected that TV receiver sales would quickly follow. For Westinghouse, with no television research staff or a manufacturing establishment, gearing up to offer television sets would be slow and expensive. Instead, they decided to make use of the same approach that had been successful for them with radios. Arrangements were made with RCA to supply Westinghouse with four TV models similar to the models offered by RCA, which were produced in Camden, NJ (see Fig. 13). The Westinghouse model numbers and RCA equivalent model numbers are listed in Table 8. And similar they were, right down to the RCA decal on the cabinets. A few subtle differences can be identified by experienced collectors—for example, the three console TVs used a built-in

Fig. 12. Zworykin demonstrates a television receiver with a cathode-ray tube in 1928. (http://www.earlytelevision.org/zworykin_receiver.html)

radio chassis to receive the TV audio portion and AM radio. The radio chassis used by Westinghouse is different from the chassis in the corresponding RCA models. Small cabinet changes can also be noted. However, the oncoming war effort would soon put an end to all TV broadcasting, and television production was also stopped.[27]

After the war, as television broadcasting had started in major cities, Westinghouse experimented with a

Fig. 13. Four televisions appeared in a Westinghouse appliance catalog for 1939. ("Electrical Household Appliance," catalog, 1939, p. 28)

Table 8. Westinghouse TV models produced by RCA in Camden, NJ, and RCA equivalents.

Description	Westinghouse	RCA
5" Tabletop (no audio)	WRT-700	TT-5
5" Console (direct view)	WRT-701	TRK-5
9" Console (direct view)	WRT-702	TRK-9
12" Console (mirror in lid)	WRT-703	TRK-12

system called Stratovision to bring television to more rural areas. In the period before broadcasters could send signals long distances by coaxial cables or microwave relays, there was no way to send programming out from the big metropolitan areas where the programs originated. Stratovision was a plan to have aircraft in the air with receivers to pick up the signal and transmitters to rebroadcast down to rural areas. As other transmission technology improved, the plan for Stratovision was dropped.

Westinghouse in Sunbury, PA

By 1942, war-related orders had overloaded the Baltimore facility. It was urgent that Westinghouse search for available space that could quickly be converted to help with the national war effort. They found a suitable vacant plant in Sunbury, PA, a town with adequate transportation facilities that was centrally located in the foothills near the Susquehanna River (see Fig. 14). There was also a capable local workforce that could outfit the plant in a few weeks, and so Westinghouse was able to staff the plant with an initial workforce of 400. As Walter Evans, Westinghouse Electric and Mfg. Co.

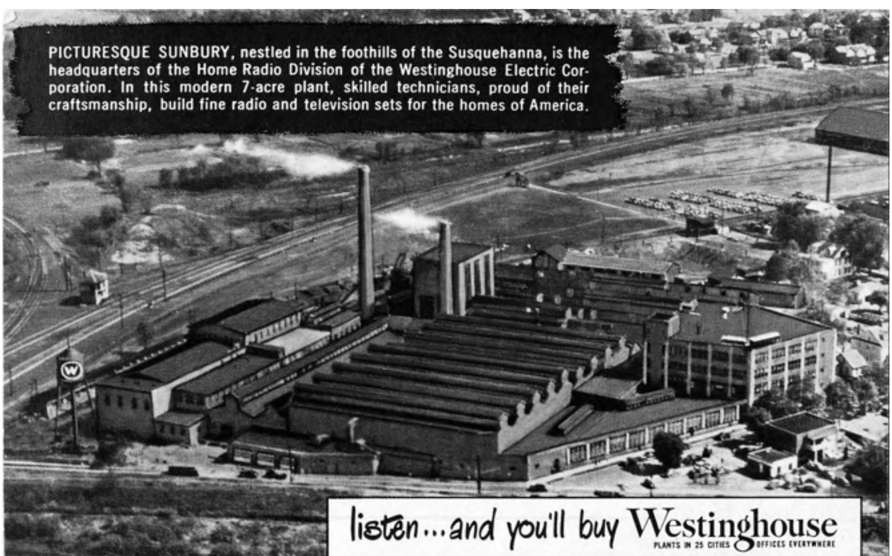

Fig. 14. Postcard of the Westinghouse Sunbury, PA plant. (Author's collection)

General Manager, stated at the time, the plant would turn out "bulkier types of communication equipment."[28] This was deliberately misleading, because the Sunbury Plant was secretly producing radar equipment. During the war, the Baltimore and Sunbury plants produced a combined total of 104,000 radar units.[29]

This plant became the location for the Receiver Division, and during the war, workers in Sunbury continued filling defense orders. In an interview in 1944, General Manager Evans stated that Westinghouse Electric and Mfg. Company was preparing for a conversion to postwar domestic sales. He announced that the company had taken out a Hazeltine license, which was needed in addition to an RCA license, to produce quality radios during this period.[30] He also announced that Westinghouse Company planned to construct three television stations and produce television receivers. In the same announcement, he acknowledged that Westinghouse would manufacture its own line of home radios for the first time since 1928. They predicted a huge demand, as some 50 million home radios were outdated and ready for replacement.[31]

As Westinghouse management continued to position itself for the expected postwar boom, they announced on February 22, 1945, that the Receiver Division would be renamed the Home Radio Division. The Sunbury plant would soon phase out the production of military devices and re-tool for the manufacture of home radios. After the war ended, new Westinghouse radios were on the market for the many new households popping up around the country. These models can be recognized by their serial numbers that started with the letter "H." Models H-103 and H-104 were the first. The Sunbury plant also produced the company's first FM radio, and Westinghouse announced that the first orders for the model H-161 were leaving the factory in early 1948. This introduction occurred at the time the Westinghouse radio station KDKA was beginning early tests of FM broadcasting.

As radio production grew and television receivers were added to the product line, Westinghouse took more actions. A supply line was created to produce some of their own components to feed the Sunbury production line. From the early days of television production, Corning Glass Works, situated along the southern tier of New York in the city of Corning, produced the glass used in TV picture tubes and receiving tubes. Corning became the source at the beginning of a supply chain. In 1952, Westinghouse opened a receiving tube factory in Bath, NY, and a factory for picture tube production in Elmira, NY (see Fig. 15). At these locations, the Westinghouse Electronic Tube Division produced the Reliatron brand of receiving tubes, television picture tubes, transmitter tubes, and special purpose tubes. These facilities would ship components 100 miles or so down to Sunbury on U.S. Highway 15. In comparison to other companies producing radios and televisions at that time, Westinghouse products contained a very high percentage of components manufactured "in house."

When the United States became involved in the Korean War in 1950, critical materials were directed to this effort, which caused supply problems

Fig. 15. Advertisement for the Westinghouse Electronic Tube Division. (*Radio & Television News*, Nov. 1952, p. 11)

for most domestic manufacturers. Other divisions of Westinghouse that were producing products for the military effort would have priority over consumer electronic products. By 1952, supplies began to increase, so production was also increased to meet the demand for television. Westinghouse introduced their first postwar TV, the model H-196 in 1948, but management had already recognized that when demand increased, the Sunbury plant would not be able to produce enough sets. This old factory had been quickly adapted for electronic production during the war, and the decision was made to move to a modern electronics manufacturing facility to provide sets in the 1950s. It was also decided that Sunbury would not be the location for this facility.

As Westinghouse began to phase out the factory in Sunbury, they faced a problem. They had no further plans for this location, and that would mean laying off a workforce that had grown to well over a thousand. To solve this problem, Westinghouse contracted with an industrial realty firm to find a company to take over the factory. Westinghouse offered to pay the rent for over two years if a company could be found to move into the old facility and employ the workforce of one thousand.[32]

Television and Radio Division Moves to Metuchen, NJ

The search for a location to build a modern TV and Radio factory led the Westinghouse Electric Company east to Metuchen, NJ. A large 50-acre lot was purchased in Raritan Township, later renamed Edison Township. Since the area was not well developed, the mailing address was Metuchen, and this new factory became known as the Metuchen plant. This small town, only a short 22 miles to New York City, with a railroad station for commuters, was established in 1900, when Thomas Edison's Menlo Park Laboratory was just a few miles down the road. Construction of the new Westinghouse building was begun in September of 1950. It was the start of a huge $1.5 million dollar project with the main building covering 10 acres (see Fig. 16).[33] A modern straight-line TV production line was built to take advantage of a 450,000 sq. ft. production area.

In his announcement, division manager F. M. Sloan listed a number of the factors that made this site a smart choice. A rail line passed through the

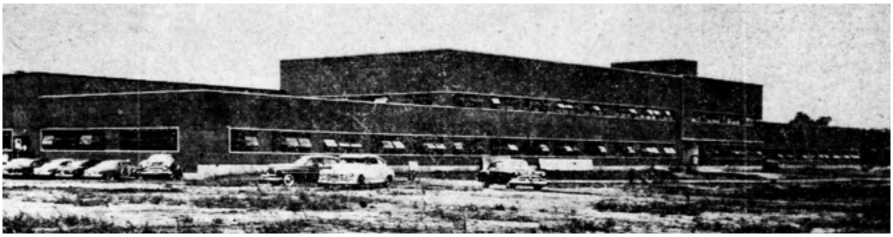

Fig. 16. The new Metuchen plant. (Courier News, Aug. 27, 1951, p. 4)

lot, and there was easy access to major highways, including the recently completed New Jersey Turnpike. He stated that the talented labor force available locally was capable of staffing the completed facility with 3,000 employees. He noted that other leading research facilities were in the area. Metuchen was not far from RCA in Camden and Princeton, Hazeltine Labs in New York, Philco in Philadelphia, and other companies. The potential to recruit talent from these facilities must have been a consideration. He also noted that the location was suitable for reception of color TV test broadcasts from New York. Westinghouse needed to be prepared for this next advance in television.[34]

Construction of this new modern factory proceeded quickly. Opening was set for September 1, 1951, just one year after breaking ground. With just a few management personnel transferred from Sunbury, work began to fulfill ongoing defense contracts with 200 employees. The restrictions that directed certain materials to the Korean War effort slowed the company's transition to television production in Metuchen. By 1952, as materials became available again, the new Westinghouse Electronic Tube Division in Elmira, NY, was able to begin shipping receiving tubes and picture tubes to Metuchen, and the new assembly line went into production. By 1953, about 2,500 people were employed using what was now being called "The Miracle Mile Assembly Line" (see Fig. 17), and they were shipping Westinghouse radios and TVs to a network of 123 franchised distributors.[35]

While Westinghouse was organizing a modern assembly line to produce black and white TVs, they also had to prepare for color TV. Not long after black and white TV production started, Westinghouse engineers began to make good use of the New York test signals broadcast by RCA. In 1953, they produced some early prototype models. Then in March of 1954, Westinghouse was the first company to place a color TV set, Model H840CK15, on sale in 60 stores (see Fig. 18). Unfortunately for Westinghouse, potential customers were aware that color programming in 1954 averaged only about an hour per week. Also, due to the high initial price of $ 1,295 and the small 15" screen, sales were disappointing. Only 30 sets were sold in the first month, and a price reduction in April to $1,100 did not help. RCA kept the price of its CT 100 color set under $1,000, and with its larger production and distribution of televisions, RCA is most often credited as having sold the first color TVs. In all, Westinghouse produced about 500 of these color sets and it is believed many went unsold. Fewer than 20 of these TVs are known to survive today.[36] The company stopped color TV production until the market was ready, but monochrome TV sales were booming. As the 1950s progressed, TV prices dropped and a second wave of sales came in as portable TVs were introduced (see Fig. 19), and families began buy a second set. When color TV prices dropped and programming increased, Westinghouse restarted color TV production.

The announcement of the 1966 television models included another innovation from Westinghouse—the introduction of "instant-on" television.

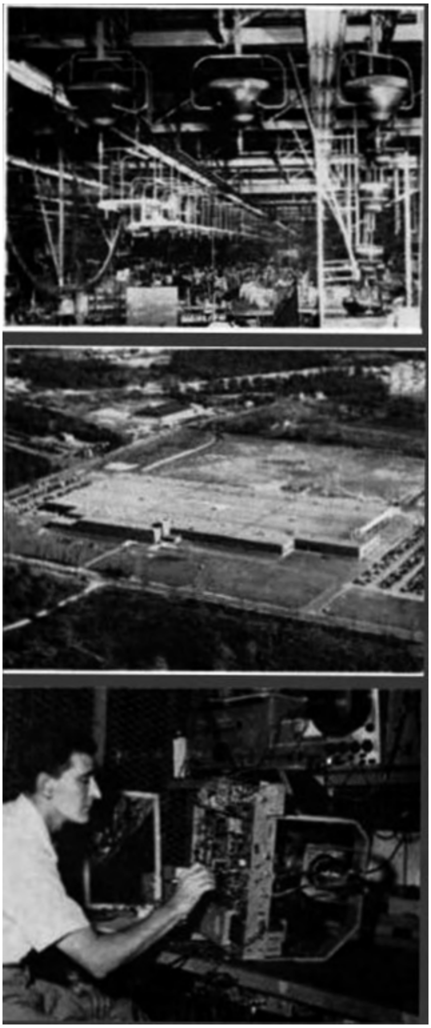

Fig. 17. The "Miracle Mile" Assembly Line at the Westinghouse Metuchen plant (top), Westinghouse plant at Metuchen (middle), and final inspection station (bottom). (*Music Trade Review*, Nov. 1953, p. 22)

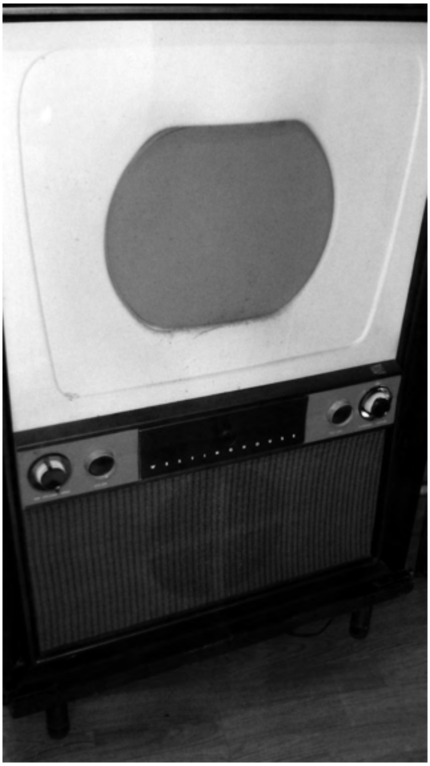

Fig. 18. Westinghouse was the first to place a color TV on the market, namely this Model H840CK15. (Author's collection)

Fig. 19. Westinghouse Portable TV model H14T172. (Author's collection)

Vacuum tube warm up time was reduced to a few seconds by applying a small heater current whenever the TV was plugged into power line. Other industry-wide color TV improvements were announced, including 40% brighter pictures. Production was strong enough that on January 28, 1954, the new division manager, T. J. Newcomb, announced that Westinghouse would start a one-million dollar expansion, including a 150,000 sq. ft. warehouse.[37]

Westinghouse was also an early leader in the production of transistor radios. Their first transistor models were introduced in 1957 with model numbers starting with H-587 and extending up to the H-900s. The earliest models, like the H-622 made in 1957, exhibited the characteristics of many early transistor sets (see Fig. 20). A large case was required to house many of the components that were only minimally modified from those used in portable tube model design. Early hand-populated and soldered printed circuit boards are common in these models. One unusual characteristic in Westinghouse sets was the use of their own brand of transistors (see Fig. 21). As time passed, other related products were introduced, including walkie-talkies, small phonographs, and tape recorders. While the transistors were labeled with the Metuchen tag, construction techniques made domestic production seem unlikely. Later, when the tags were labeled Portable Product Division, the products were clearly imported.

Westinghouse: The Final Chapter

In a 1912 speech, George Westinghouse stated: "Unquestionably, the history of Westinghouse Electric is one of tremendous achievement. Even in so brief

Fig. 20. Westinghouse Transistor Radio model H622P6. (Author's collection)

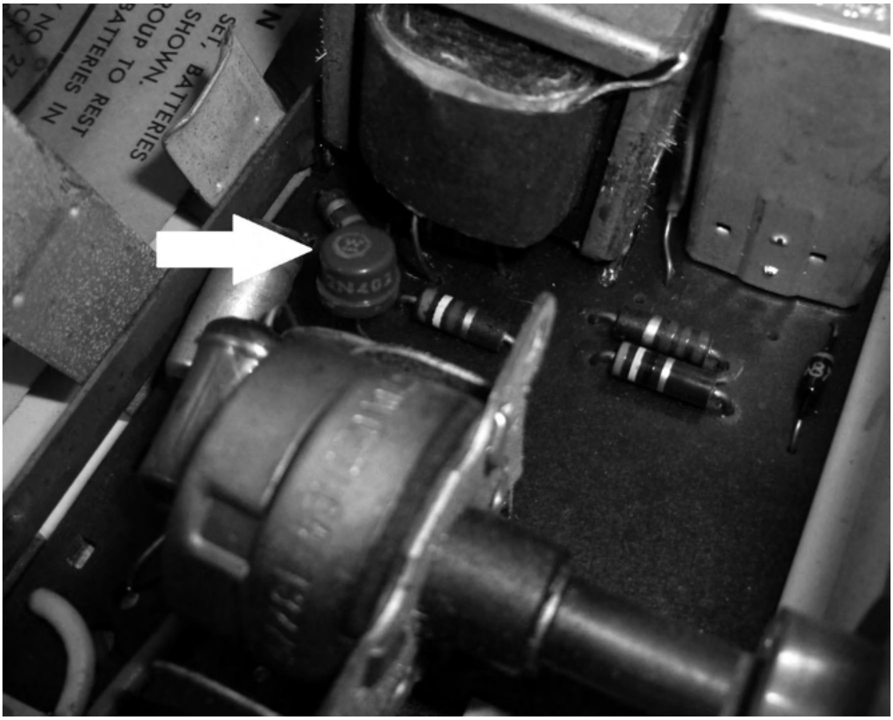

Fig. 21. Westinghouse transistor mounted on a chassis. (Author's collection)

a time, there is abundant evidence of the breadth and depth of contributions made by the company to the nation and the world. All of us in the Westinghouse family—no matter what our span of service—can be proud of these achievements."[38] Indeed, by the 1970s, Westinghouse was a big company with a multitude of products. During the 1970s, the Westinghouse Corporation was represented at an International Exposition in Saudi Arabia where they displayed over 1,000 products from 100 divisions. By 1984 Westinghouse had 150,000 employees and an annual income of over $10.2 billion. At that time, the Westinghouse Radio and Television Division was a small part of a big conglomerate. The Radio and Television Division reported to corporate headquarters through three separate major organizations (see Fig. 22).[39] The future of this division would be driven more by the fortunes of the company at large rather than by the performance of the division itself.[40]

Many Westinghouse divisions were world leaders that pioneered the manufacturing of products as diverse as radar and defense systems, U.S. land-based nuclear power plants, and the first nuclear power plant for submarines. They also built the radar systems that helped the Gemini 6 and Gemini 7 spacecraft dock in orbit and the TV cameras that Apollo astronauts used

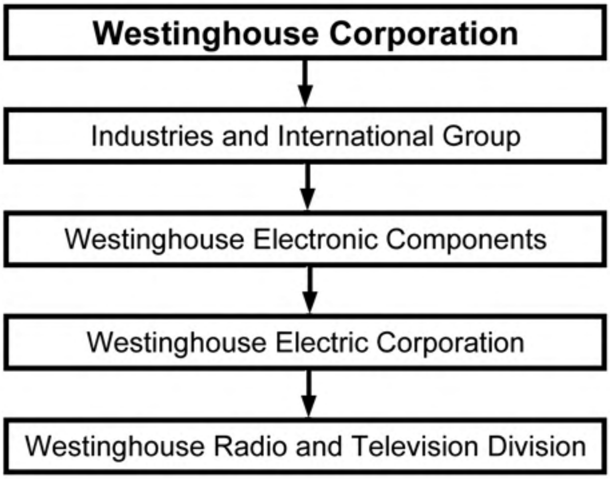

Fig. 22. Position of the Radio and Television Division in the corporate ladder in the 1970s.

on the Moon. There were still more divisions with products as diverse as office furniture to power plants and light bulbs to financial services. Unfortunately, some of these divisions proved to be a huge financial drain. The first big loss came when company contracts to supply fuel to Westinghouse-built nuclear power stations sustained huge cost overruns as the price of uranium skyrocketed. Many lawsuits were filed when Westinghouse could not deliver fuel at the contract price, which ultimately resulted in a two billion dollar loss. A second big loss came several years later when a dip in the economy caused the Financial Services Division to sustain three billion dollars in bad loans.

Neither was the Westinghouse Television and Radio Division itself immune to price competition from foreign companies. During the late 1960s and early 1970s, the "Made in Japan" tag would appear more and more on Westinghouse products as the manufacturing of those goods in the United States was being phased out. An examination of TV listings by Sam's Photofact Service shows that the last TV diagram was published in the late 1960s. Curiously, in the 1970s many TV dealers had showrooms filled with televisions owned by Westinghouse but not made by Westinghouse. As the company had moved into financial services, they provided "floor plan financing" so that the TV dealer did not pay up front for the inventory. Instead, distributors were paid by Westinghouse Credit Corporation, and the TV dealer was paid by Westinghouse Credit Corp. for the products, plus interest, after they were sold from the store's stock.

Overall, the company had many manufacturing divisions. But in the

1990s, management made a major change in direction. This new management brought in to rescue the company systematically sold off manufacturing concerns and bought up media companies. An article in the November 27, 1997 issue of the *Economist* entitled "Westinghouse RIP" posed the question, "Why would a company that enjoyed a century of success in manufacturing make a complete change to media and broadcasting?" There was no clear answer, but it was noted that Group W, the Westinghouse broadcasting division, had the company's highest profit margin of 40%. From 1994 to 1997, Westinghouse Corporation would sell $9.52 billion in manufacturing companies and spend $15.75 billion to buy media companies. Ultimately, Westinghouse would buy the Columbia Broadcasting System (CBS) and, on completion of the deal, change the company name from Westinghouse to CBS. As a result the 111-year-old Westinghouse Corporation and its WX stock symbol disappeared.[41]

Afterword

While the Westinghouse Corporation was a huge concern, the radio part of this business was actually a small fraction of the business. Over the years it was shuffled between divisions at various locations around the country (see Tables 9 and 10). Westinghouse nametags, many of which are shown in Fig. 23, bear witness to a number of divisions and companies of Westinghouse listed in Table 9 that manufactured radios and televisions in many different locations over the years.

The management at large, which was outside the purview of the radio divisions, made decisions that affected the profitability and performance of the consumer radio divisions. For example, they decided who manufactured what type of radios and televisions and how the business was financed. In the end, foreign competition and a management philosophy that focused on businesses with a higher return would end the radio and TV business at Westinghouse forever.

Table 9. Product divisions that manufactured radios and televisions.

Dates	Divisions and Locations of Radio and Television Manufacturing
1920 to 1921	Westinghouse Electric & Manufacturing Co., E. Pittsburgh, PA
1921 to 1929	Westinghouse Home Radio Products Dept., E. Springfield, MA
1930 to 1935	Production outsourced: RCA Victor Company, Camden, NJ
1935 to 1942	Production outsourced: Emerson, Bosch, Detrola, RCA, et al.
1942 to 1945	No production of consumer products during WWII
1945	Parent becomes Westinghouse Electric Corp.
1946 to 1952	Home Radio Products Division, Sunbury, PA
1953 to 1954	Television and Radio Products Division, Sunbury, PA
1954 to 1974	Television and Radio Division, Metuchen, NJ Name change in July 1967: Portable Products Division, Edison, NJ
1975	Sold to White Consolidated Industries, becomes White-Westinghouse

Table 10. Commercial and government radio divisions. (Complied from Barron's)

Dates	Commercial and Government Radio Divisions
1912 to 1915	Experimental Radio Section (no production)
1915 to 1918	Westinghouse Radio Engineering Section, Pittsburgh, PA
1918 to 1920	Westinghouse Newark Works, Newark, NJ
1920 to 1927	Radio Engineering Dept., East Pittsburgh, PA
1920 to 1925	Government and Commercial Radio Products Division, East Pittsburgh, PA
1925 to 1938	Government and Commercial Radio Products Division, Chicopee Falls, MA
1927 to 1938	Radio Division (formerly Radio Engineering Dept.), Chicopee Falls, MA
1938 to 1945	Radio Division, Baltimore, MD
1945 to 1946	Radio Division, Sunbury, PA, becomes Home Radio Products
1946	Radio Division, Baltimore, MD, becomes Industrial Electronics Division

Fig. 23. Assorted Westinghouse ID tags. (Author's collection)

Today, a company with the Westinghouse name is either a company that was bought from the original Westinghouse or a name licensed from CBS to exploit the name recognition of Westinghouse. Even that name recognition is fading over time. For example, while I was researching this article, a call to the library in Sunbury, PA, required an explanation of who and what Westinghouse was and a request to spell the name.

The brick and mortar part of Westinghouse is also disappearing. Buildings that constituted the Metuchen plant, the last Westinghouse consumer electronics manufacturing facility, were used by other companies for many years, and in 2016 the facility was torn down to construct a huge warehouse complex. The bricks making up the buildings were actually ground up on site to create a fill material around the foundation. With the help of a friend, I was able to rescue two bricks, now the last surviving fossils of this last facility for consumer electronics produced by the Westinghouse Electric Corporation.

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Acknowledgements

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About the Author

Mike Molnar started Diagnostic Services Inc. in 1983, and it still keeps him busy building nuclear medicine gamma cameras for veterinary clinics. Thanks to Pam, his understanding wife, Mike also finds time for the care and feeding of a 40-year collection of electronic fossils. This year, with the help of his assistant Lila, two bricks from the last Westinghouse consumer electronics plant joined the other fossils.

Mike Molnar

The Wireless News

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For well over a century, radio has provided ships at sea and their well-off passengers with current news of the world (and at times, war news), market data and sports. From Marconi's wireless telegraph to satellite delivery, the wireless news has been indispensible to voyagers of many sorts, especially on transoceanic routes. Steamship lines saw money to be made in providing this amenity. The technologies of communications and of the printing of newspapers at sea paced each other. Many of these seagoing "newspapers" themselves tell nautical tales and social stories about their readers. But they also illumine their producers in Europe, North America, and Asia, including the shipping lines, the shoreside press, and the radiomen at sea. The radio technology evolved from long waves to satellites, and from spark sets to vacuum tube gear and then to modern solid-state circuits. A demand for current information at sea, far from its sources, created an important maritime revenue stream. The economics of news at sea and the higher socio-economic class of the passengers helped to further the development of the radio art.

Introduction – Young Marconi Started It

News for passengers and crew at sea, sent through the ether by "wireless telegraphy," started with Marconi, as did so much else in radio (see Fig. 1). His daughter Degna Marconi wrote about her then-young father's return from the United States to England via the SS *St. Paul* in 1899:

> "There is a sequel to that epochal [1899] transatlantic crossing. When the *St. Paul* was less than 50 miles from the Needles [near to the Isle of Wight in Southern England], for an hour and a half dispatches reached the vessel about the progress of the South African War. The ship's captain, J. C. Jamison, felt that these should be preserved and a special edition of *The Transatlantic Times* was run off for the benefit of the Seamen's Fund at a dollar a copy. 'Through the courtesy of Mr. G. Marconi,' it said, 'the passengers on board the *St. Paul* are accorded a rare privilege, that of receiving news several hours before landing. . . . As we all know, this is the first time that such a venture as this has been undertaken. A Newspaper published at Sea with Wireless Telegraph messages received and printed on a ship going twenty knots. . . .' Marconi cheerfully autographed the copies. Before the *St. Paul* docked at Southampton, readers knew:
>
> "3·30 [p.m.] 40 miles. Ladysmith, Kimberley, and Mafeking holding

out well. No big battle. 15,000 men recently landed.

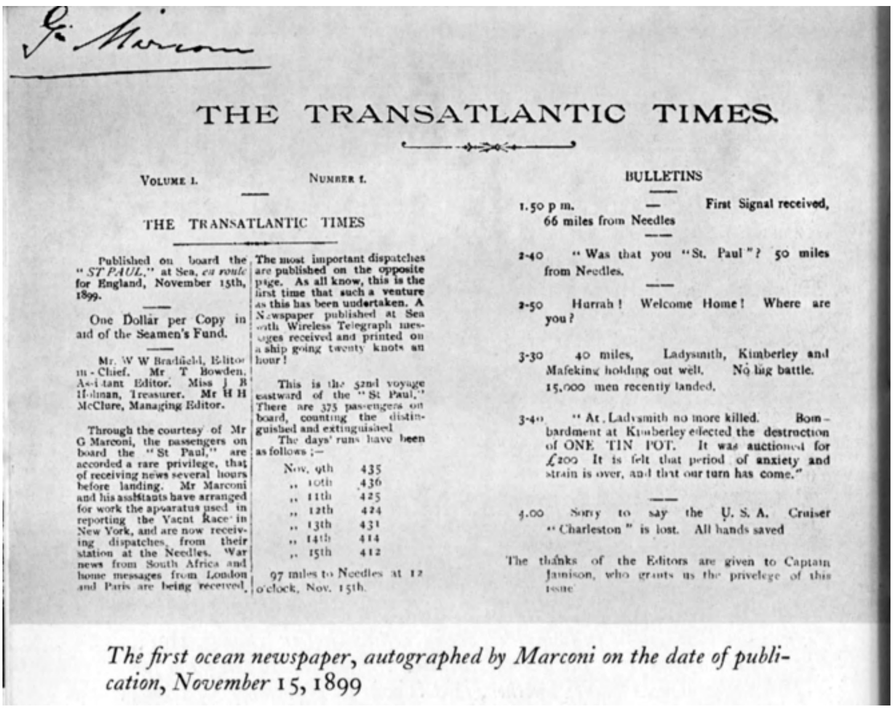
"3·40 [p.m.] At Ladysmith no more killed. Bombardment at Kimberley effected the destruction of *One Tin Pot*. It was auctioned for £200. It is felt that period of anxiety and strain is over, and that our turn has come."[1]

Fig. 1. This image is an enhanced and cropped version of the cover of the company magazine *Wireless World* published by the Marconi Press Agency, Ltd. as Volume 1 for February 1914. The Morse code spells out Marconi, and the station is the reconstructed Poldhu, Cornwall ZZ. Worldwide coverage suggested by the cover, which was then aspirational, had to await the short wave "Beam System" developed a decade later. (Author's collection)

These messages about the Boer War are some of the first recorded wireless telegraphy traffic. A graphic of the *Transatlantic Times* as printed on the SS *St. Paul* is reproduced as Fig. 2.

Ship newspapers of the 19th century, until the coming of the wireless news, primarily allayed boredom on the long voyages from one continent to another:

> "While to date there is little information as to how common the production of ship newspapers on board long-distance passenger steamers in the late nineteenth century was, we do know that it was certainly not a rare thing. The passages between Great Britain and its Australasian colonies could last weeks or months at a time and were notorious for their dullness . . . . [T]he passengers on many journeys got organised and elected a committee 'for promoting the entertainment of the passengers during the voyage.' Besides organising social activities like sports or musical events, such a committee often pushed for the compilation of a ship newspaper, i.e. a newspaper produced by passengers for passengers only with the means available on board—and thus concentrated exclusively on topics that were of interest to the travellers."[2]



G. Marconi

THE TRANSATLANTIC TIMES.

VOLUME I. NUMBER 1.

THE TRANSATLANTIC TIMES

Published on board the "*ST PAUL*," at Sea, *en route* for England, November 15th, 1899.

One Dollar per Copy in aid of the Seamen's Fund.

Mr. W W Bradfield, Editor-in-Chief. Mr T Bowden, Assistant Editor. Miss J B Holman, Treasurer. Mr H H McClure, Managing Editor.

Through the courtesy of Mr G Marconi, the passengers on board the "St Paul," are accorded a rare privilege, that of receiving news several hours before landing. Mr Marconi and his assistants have arranged for work the apparatus used in reporting the Yacht Race in New York, and are now receiving dispatches from their station at the Needles. War news from South Africa and home messages from London and Paris are being received.

The most important dispatches are published on the opposite page. As all know, this is the first time that such a venture as this has been undertaken. A Newspaper published at Sea with Wireless Telegraph messages received and printed on a ship going twenty knots an hour!

This is the 52nd voyage eastward of the "St Paul." There are 375 passengers on board, counting the distinguished and extinguished.

The days' runs have been as follows ;—

Nov. 9th	435
,, 10th	436
,, 11th	425
,, 12th	424
,, 13th	431
,, 14th	414
,, 15th	412

97 miles to Needles at 12 o'clock, Nov. 15th.

BULLETINS

1.50 p m. — First Signal received, 66 miles from Needles

2-40 "Was that you "St. Paul"? 50 miles from Needles.

2-50 Hurrah! Welcome Home! Where are you?

3-30 40 miles, Ladysmith, Kimberley and Mafeking holding out well. No big battle. 15,000 men recently landed.

3-40 "At Ladysmith no more killed. Bombardment at Kimberley effected the destruction of ONE TIN POT. It was auctioned for £200 It is felt that period of anxiety and strain is over, and that our turn has come."

4.00 Sorry to say the U. S. A. Cruiser "Charleston" is lost. All hands saved

The thanks of the Editors are given to Captain Jamison, who grants us the privelege of this issue

The first ocean newspaper, autographed by Marconi on the date of publication, November 15, 1899

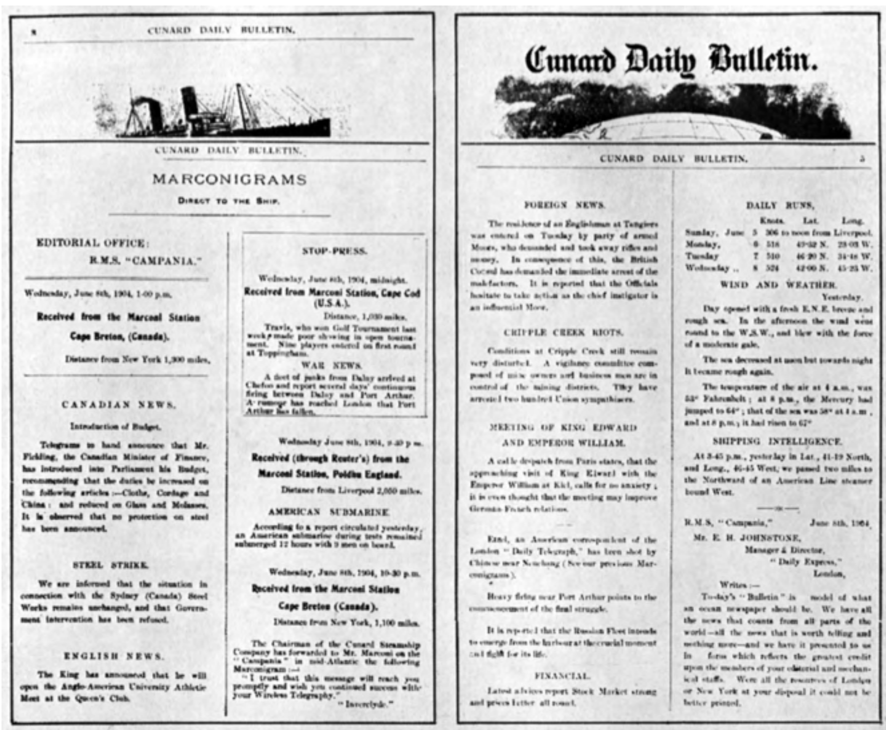
Fig. 2. Marconi's first newspaper at sea, the *Transatlantic Times*; his new technology put to a new use immediately. (Courtesy of David Barlow, Lizard Museum)

Early Evolution of Wireless News at Sea — Sparks at Work

Wireless Signals for Distraction If Not Distress

Wireless signals were early used for distress and later for distraction in the form of wireless news. At the beginning of the 20th century, the maritime industry quickly adopted "the wireless" for signals of distress. (This was at first CQD then by 1910 SOS. CQD is said to have meant Come Quick Danger.) Management equally and quickly saw the advantages of wireless to control vessels—and even senior captains. Passenger convenience (and related revenues) entered the picture as well, and thereby hangs the present tale.

British maritime wireless operations enjoyed staffing from the Marconi Company, which also leased the equipment to the vessel owners. The company trained the operators and largely invented the equipment, especially the low frequency, long wave transmitters. Generally, vessels used the shorter 600-meter wavelength at sea because ships' masts would not support any longer antennas for longer wavelengths.



CUNARD DAILY BULLETIN.

CUNARD DAILY BULLETIN.

MARCONIGRAMS

DIRECT TO THE SHIP.

EDITORIAL OFFICE:
R.M.S. "CAMPANIA."

Wednesday, June 8th, 1904, 1·00 p.m.

Received from the Marconi Station Cape Breton, (Canada).

Distance from New York 1,300 miles.

CANADIAN NEWS.

Introduction of Budget.

Telegrams to hand announce that Mr. Fielding, the Canadian Minister of Finance, has introduced into Parliament his Budget, recommending that the duties be increased on the following articles:—Cloths, Cordage and China: and reduced on Glass and Molasses. It is observed that no protection on steel has been announced.

STEEL STRIKE.

We are informed that the situation in connection with the Sydney (Canada) Steel Works remains unchanged, and that Government intervention has been refused.

ENGLISH NEWS.

The King has announced that he will open the Anglo-American University Athletic Meet at the Queen's Club.

STOP-PRESS.

Wednesday, June 8th, 1904, midnight.

Received from Marconi Station, Cape Cod (U.S.A.).

Distance, 1,030 miles.

Travis, who won Golf Tournament last week, made poor showing in open tournament. Nine players entered on first round at Toppingham.

WAR NEWS.

A fleet of junks from Dalny arrived at Chefoo and report several days' continuous firing between Dalny and Port Arthur. A rumour has reached London that Port Arthur has fallen.

Wednesday June 8th, 1904, 9·40 p.m.

Received (through Reuter's) from the Marconi Station, Poldhu England.

Distance from Liverpool 2,000 miles.

AMERICAN SUBMARINE.

According to a report circulated yesterday, an American submarine during tests remained submerged 12 hours with 9 men on board.

Wednesday, June 8th, 1904, 10·30 p.m.

Received from the Marconi Station Cape Breton (Canada).

Distance from New York, 1,100 miles.

The Chairman of the Cunard Steamship Company has forwarded to Mr. Marconi on the "Campania" in mid-Atlantic the following Marconigram:—

"I trust that this message will reach you promptly and wish you continued success with your Wireless Telegraphy."

"Inverclyde."

Cunard Daily Bulletin.

CUNARD DAILY BULLETIN. 3

FOREIGN NEWS.

The residence of an Englishman at Tangiers was entered on Tuesday by party of armed Moors, who demanded and took away rifles and money. In consequence of this, the British Consul has demanded the immediate arrest of the malefactors. It is reported that the Officials hesitate to take action as the chief instigator is an influential Moor.

CRIPPLE CREEK RIOTS.

Conditions at Cripple Creek still remain very disturbed. A vigilance committee composed of mine owners and business men are in control of the mining districts. They have arrested two hundred Union sympathisers.

MEETING OF KING EDWARD AND EMPEROR WILLIAM.

A cable despatch from Paris states, that the approaching visit of King Edward with the Emperor William at Kiel, calls for no anxiety; it is even thought that the meeting may improve German-French relations.

Etzel, an American correspondent of the London "Daily Telegraph," has been shot by Chinese near Newchang (See our previous Marconigrams).

Heavy firing near Port Arthur points to the commencement of the final struggle.

It is reported that the Russian Fleet intends to emerge from the harbour at the crucial moment and fight for its life.

FINANCIAL.

Latest advices report Stock Market strong and prices better all round.

DAILY RUNS.

		Knots.	Lat.	Long.
Sunday, June	5	306	to noon from Liverpool.	
Monday,	6	518	49·52 N.	23·03 W.
Tuesday	7	510	46·20 N.	34·48 W.
Wednesday ..	8	524	42·00 N.	45·25 W.

WIND AND WEATHER.

Yesterday.

Day opened with a fresh E.N.E. breeze and rough sea. In the afternoon the wind went round to the W.S.W., and blew with the force of a moderate gale.

The sea decreased at noon but towards night it became rough again.

The temperature of the air at 4 a.m., was 53° Fahrenheit; at 8 p.m., the Mercury had jumped to 64°; that of the sea was 58° at 4 a.m., and at 8 p.m., it had risen to 67°

SHIPPING INTELLIGENCE.

At 3·45 p.m., yesterday in Lat., 41·19 North, and Long., 46·45 West, we passed two miles to the Northward of an American Line steamer bound West.

R.M.S. "Campania," June 8th, 1904.

Mr. E. H. JOHNSTONE,
Manager & Director,
"Daily Express,"
London,

Writes:—

To-day's "Bulletin" is model of what an ocean newspaper should be. We have all the news that counts from all parts of the world—all the news that is worth telling and nothing more—and we have it presented to us in form which reflects the greatest credit upon the members of your editorial and mechanical staffs. Were all the resources of London or New York at your disposal it could not be better printed.

Fig. 3. The Marconi Company's Cuthbert Hall in 1903 foresaw a profitable line of business in the wireless news and contracted with Cunard to make it so. Hence, the wireless news on the Cunard line's RMS *Campania* in 1904. (Courtesy of David Barlow, Lizard Museum)

A passenger diary of 1902 refers to this sort of vessel communication by noting:

> "Yesterday we met *Compania*. Messages were sent back and forth by means of wireless telegraphy until they were about ninety miles apart. *Compania* is a much faster boat requiring almost two days less than this boat to cross the ocean. . . ."[3]

The Cunard Line (UK) contracted with the Marconi company in 1903 to broadcast news daily so its vessels could provide it to passengers. One such shipboard publication, also involving the *Campania*, is shown in Fig. 3. These transmissions enabled the first regular "Wireless News" at sea, according to David Barlow, G3PLE, curator of the Lizard Marconi Wireless Station "LD" in Cornwall (UK).[4]

London newspapers and press associations aggregated news stories, and much of that got across the Atlantic by cable. From either shore of the Atlantic, wireless (and then radio), got the stories of the day to vessels plying the pond. See, for example, Fig. 4 with a map of the North Atlantic bracketed by Marconi towers on the first page of a 1908 Cunard Daily Bulletin.

Fig. 4. The Cunard line's RMS *Lusitania* made for travel at its best before World War One—for rich people anyway. Stupidity doomed the passenger liner Lusitania during the war when the Germans torpedoed her because she carried contraband munitions. At least 1,198 people thus died in May 1915, including many Americans. (Courtesy of David Barlow, Lizard Museum)

Marconi Initiates Regular "Press" Broadcasts (circa 1904)

The Marconi high power station ZZ at Poldhu, in Cornwall, had sent out the three clicks of the first transatlantic signal in 1901. Barlow notes its role in press operations, the first "*Ocean News*":

> "I have heard it said that Poldhu was only an experimental and development station and was not involved in commercial activities. This was not the case as in 1903 the Marconi Company came to an agreement with Cunard to send the Cunard Daily Bulletin from Poldhu and Glace Bay [Canada] daily. The first idea for a ships newspaper came from Marconi himself while returning from New York on board the SS *St. Paul* in 1899. The ship received news of the progress of the Boer War . . .
>
> "In October 1903 the first ship's daily newspaper was published on board the SS *Lucania*. This may well have been sent from Poldhu because an agreement had been reached with the Cunard Company that the Cunard Daily Bulletin would be sent from Poldhu and Glace Bay in an attempt to cover the Atlantic Ocean. . . .
>
> "By 1910 it is known that from one AM for 45 minutes Poldhu was sending *Ocean News,* the nightly news bulletin. This is known because the Poldhu signal jammed the SOS between the Lizard station and the SS *Minnehaha*. The log of the Lizard station also indicates that Poldhu also sent out a weather report or forecast for merchant ships. The call sign used was ZZ.
>
> "Poldhu was used for sending ships' newspapers because of its high power and significantly greater range than the coast stations such as the Lizard. It should also be noted that this traffic was sent at night to take advantage of night effect."[5]

As early as 1904,[6] the Marconi Company supplied each ship that offered its *Oceanic News* with an on-board printer and pressman, in the employ of the company, to produce it by letterpress. According to the 1904 report, financial houses, railroads, steamship companies, and any "good house" could buy an advertisement for a minimum $100 "card." The first issue of the *Oceanic News* was expected to cost $14,000 to produce. (Both amounts were relatively princely sums in those days.) The expenditures would permit the advertisers and producers of the news to reach the well-off "salon" travelers on the Atlantic run, some 125,000 in 1903. Among other items for them, daily market quotations for 43 "universal stocks" would appear. Relays from ship to ship updated the data and news. The Marconi Company founded this 1904 project on the successful tests of wireless for news at sea undertaken by the company and the Reuters press agency. The Lizard wireless station sent the press out to an incoming ship, to the delight of all concerned.[7]

Station KPH in California Sends "Press" for the Pacific (circa 1912)

In California, the possibility of transmitting news to ships at sea at the turn of the last century made for a business opportunity for the Pacific routes as well. In 1905, the projected Mt. Tamalpais wireless station (as it happens, sabotage kept it off the air) saw a maritime news service as a revenue source:

> "Wireless Station On Tamalpais [—] Communication To Be Had With Ships 2000 Miles Out At Sea[:] The Pacific Wireless Telegraph Company has the project in hand. It expects to have this wireless plant and a similar one on a high mountain peak near Honolulu, in complete working order inside of a few months. The officers of the company feel confident of their ability to make the wireless plant a complete success in every way. It is believed that it will be possible to communicate with all the wireless equipped vessels with a radius of 2000 or more miles. It is expected that every one of the Oriental and Australian Mail Steamships will be equipped with wireless telegraph apparatus, and that on these ships a daily newspaper of a few pages containing the condensed doings of the world furnished from the Tamalpais station will be published."[8]

Marconi's Poldhu station in 1901 had bridged the approximately 2,000 miles to Newfoundland. The high-power "Mt Tam" station replicated its structure with a vertical fan antenna. Thus, it was well within the realm of technical and commercial possibility to reach Hawaii *circa* 1905 (it did happen in 1910).

An extant audio recording of a press spark transmission *circa* 1910, likely intended to be heard at sea, has been unearthed by David Ring, N1EA, a principal of the Radio Officers Group. This Morse code transmission was probably recorded shoreside in San Francisco on an Edison cylinder machine, and perhaps at the sending station, callsign "TG." A Nevada boxing match is its subject (Nevada permitted betting, then and now). It reads:

> "Joe Jeffries owes Jack Johnson a good deal of money. That is he has made a fortune through his relations with the colored champion. In fact the Californian has cleaned up $62218.28 since Nov 17 all because the negro fighter insisted that the retired champion agree to meet him in a fistic contest . . ."[9]

Earle Ennis, a western wireless pioneer, owned and operated San Francisco's Western Wireless Equipment Company and its wireless station TG (see Fig. 5).[10] It broadcast from the Adam Grant building on Market Street in San Francisco. The entire 15-round prizefight in Reno got on the air via station TG, especially for nearby ships at sea. (That's where most professional wireless receivers were floating around at the time.) Ellery W.

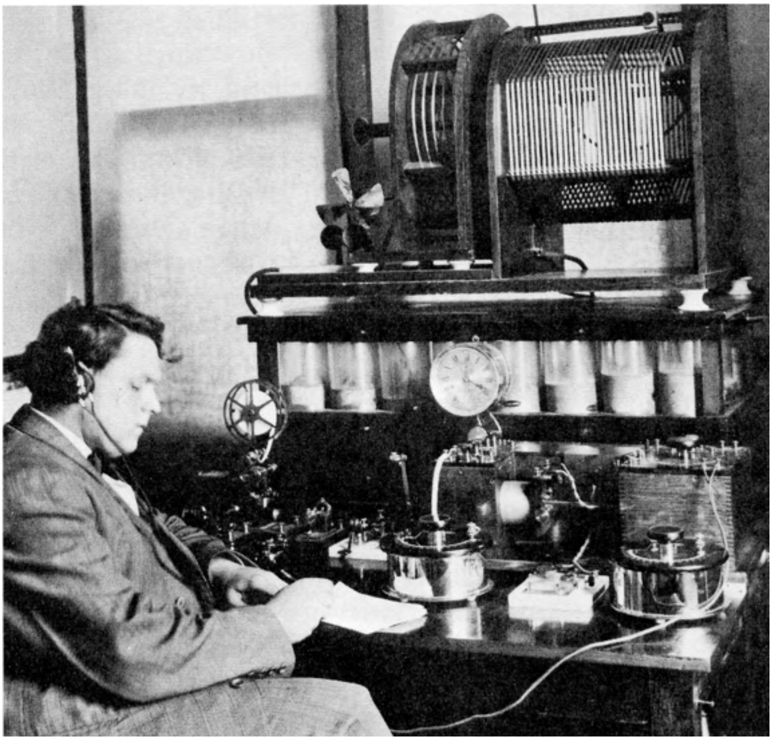


Fig. 5. Earle Ennis pioneered radio with his San Francisco station TG in 1910. He also first communicated by wireless with an aircraft that same year. (Jane Morgan, *Electronics in the West*, 1967, p. 35)

Stone, later the assistant radio inspector for the U.S. Department of Commerce at San Francisco recognized the importance of the story of the radio art and reported this to *Modern Electrics*:

> "The returns were also received by several ships out at sea, among them being the Oceanic Steamship Company's liner '*Sierra*' on her way to San Francisco from Honolulu, whose operator gave out the fight bulletins to the passengers as soon as they were received. . . . later Hillcrest [PH] the U.W. [United Wireless] Co.'s big 15 K.W. station at San Francisco, sent out the news of Johnson's victory."[11]

The *San Francisco Chronicle* employed wireless to hear *from* ships about to come into port. This was known to all as "the shipping news" when the newspapers published this information. The vessels then, it is a fair inference, wanted to hear from their ports of call and homeports if feasible about the news of the day, financial ups and downs, and sporting events. The *Chronicle* used a spark station *circa* 1910 with the call letters "CH." Also in San Francisco, the United Wireless Company used station callsign PH for its initial location at the Palace Hotel in 1905, which it vacated as a result of the San Francisco earthquake in 1906. PH became KPH and migrated to what is now Daly City, on a hill south of San Francisco, around 1912. KPH soon became the main West Coast maritime station. American Marconi assumed ownership of this station in 1912 after United Wireless went bankrupt. While United Wireless first exploited this business opportunity up to 1912, American Marconi extended it thereafter. KPH migrated north *circa* 1920 to the then RCA, high power, transpacific locations at Bolinas and Pt. Reyes, California in Marin County.

Circa 1912, Station KPH sent out "press" daily at midnight on 600 meters from a hilltop south of San Francisco in what is now Daly City. The press had been aggregated earlier from the San Francisco newspapers. Shipboard operators in the Pacific would then turn this traffic into the *Ocean Wireless News*. If a ship's radioman did not get all the detail from the 00:30 Morse code broadcast, other shipboard operators nearby would supply fill-ins. Richard Johnstone, who went to work as a young wireless operator in 1912 (and who much later served as a principal of the Society of Wireless Pioneers, after retiring from RCA and then the Navy) so reported many years later:

> "The daily press aboard ship was just as important and exciting as the arrival of the daily train in a small town. Press was sent by station KPH at 12:30 every morning. All ships copied the press. If you missed a portion, it was always possible to get a fill-in from some other ship, sooner or later. On passenger ships the news was mimeographed on an insert sheet, placed in a magazine section called the "OCEAN WIRELESS NEWS" and sold for ten cents a copy. The wireless company supplied the mimeograph, ink, stencils, magazine section, and the inserts. A different magazine section was used each day. This section contained advertisements from merchants on the Pacific Coast, Hawaiian Islands, Australia, and the Orient. It was a good profitable source of income for the Marconi Wireless Telegraph Co. Besides, they received half of the proceeds of the ten cents per copy obtained by selling the paper aboard ship. Multiply this by thousands of passengers and hundreds of ships and it was good business.
>
> "However, the ship's operators had requested consideration of a more equitable division of the profits, and they were right. This request was under consideration, but it was also under a slow bell. Some of the boys improvised a method of duplicating inserts to bolster their share of the profit, without the approval of the Marconi Company, and the requested increase was never granted. If the ship was to sell 300 papers, the amount to turn in to the wireless company was fifteen dollars. The other fifteen dollars was divided between the two operators making their total salary

for the month $47.50. Apparently everything was in favor of the Marconi Co."[12]

New York Herald *Station WHB Provides Press in the Near Atlantic (as Early as 1909)*

A 1915 Morse code spark signal press broadcast to ships resides on a recording in the AWA archives. The *New York Herald* station WHB transmitted this press traffic in 1915 to ships at sea. The late Jim Maxwell, W6CF, analyzed it in a note for the California Historical Radio Society about copying WHB, as recorded by Charles Apgar, 2MN, in 1915:

> "Here's the text of the WHB transmission: 'Mny k bt investigation shows missing bank clerk Henry Bradley merchants natl bank short hundred fifty thousand played races plunged stox.'"[13]

Maxwell noted that this Morse was hand sent and that the recording starts in the middle of a transmission:

> "It isn't clear what was going on prior to the BT (break or pause). MNY is a common abbreviation for 'many' and K is an invitation to transmit. It is possible that this represents a fragment of a conversation between the operators prior to going on with the news. The entire transmission seems somewhat informal—note the use of the abbreviation NATL for National, and STOX probably for STOCKS. In the word MERCHANTS the two letters CH were sent using the Morse sequence '----' (four dashes). This is not commonly used these days except among Spanish speaking operators. The word PLUNGED is actually somewhat ambiguous. The manual sending was good throughout, with a slight swing, but easy to copy. Only PLUNGED makes any sense here, referring to 'Plunging' (investing heavily) into the stock market or stocks plunging in value."

Maxwell concluded: "Overall, it seems as if a report was being given of a missing bank clerk who had been playing the races and the stock market. Too bad we don't have more information on it." Of course, such a story coming out of the wireless cabin would also alert the captain and the purser of a potential fugitive aboard, irrespective of any on-board newspaper. All such officers surely remembered Dr. Crippin's capture by wireless in 1910.

The *New York Herald* wireless station has been an interest of Professor Noah Arceneaux in the School of Journalism and Media Studies at San Diego State University:

> "Station WHB[:] . . . the [*New York*] *Herald* established a permanent station in 1909 . . . . The station, known first as OHX, broadcast news twice a day, with each transmission lasting approximately fifteen to twenty minutes, and claimed that its signal extended 1,500 miles. Following the Radio Act of 1912, the government began to assign call letters to stations,

and WHB became the new moniker. (The H did not stand for the *Herald,* however, as other New York stations were also assigned call letters that began with the WH prefix.)"[14]

Professor Noah Arceneaux adds: "A book on wireless telegraphy published in 1912 contains two photos of the *Herald* station."[15] One shows an unnamed operator inside the control room; another shows the exterior of the station, located at the Battery, the southern tip of Manhattan. Two massive horizontal antennas dominate the skyline. The book provides no additional information on the *Herald,* although one paragraph citing Alfred P. Morgan addresses the general phenomenon of wireless stations operated by the press:

"'Several enterprising newspapers have recognized the value of wireless telegraphy in collecting shipping news and have installed outfits for the assistance of their reporting bureau. This innovation in modern journalism has quickly developed into a useful feature of those publications who have seen fit to adopt it. When the baseball season is under way every steamship within calling distance wants the latest baseball scores or sporting results.'"[16]

In the years before World War One, the *Ocean Wireless News*,[17] published by Marconi Publishing, New York, had laid in a folded sheet with "News Received Direct by Marconi Wireless," including a weather forecast and press news (and a passenger list). One such sheet is dated March 19th, 1914. The front cover for the booklet carrying the sheet displays a color picture of an ocean liner at sea with a tugboat alongside, signed by the artist "O'Malley" at the bottom of picture. The *News* carried many advertisements, mostly for hotels, suggesting that at least some passengers did not make hotel reservations until well underway. It was likely cheaper to do so by ship's wireless than transoceanic cable.

Around 1914, the regular at-sea newspaper with wireless traffic content evolved. The noted radio authority, Dr. Adrian Peterson of Adventist World Radio (AWR), writes on this development:

"In the very early years, there was a ship newspaper with the title 'Aerogram.' In 1915, due to commercial buy-outs in the United States, the name was changed to 'Ocean Wireless News' and this was made available to many ships plying the coastal passenger trade along the eastern seaboard of North America."[18]

The Conrad Archive notes about its 1915 copy of the *Ocean Wireless News*:

"A colour monthly containing travel articles, marine items, and light humour, supplemented by daily news inserted by wireless operators, *The Ocean Wireless News: A Journal for Travellers* was published by the Wireless Press Company of New York between 1899 and 1925, when it merged with *Popular Radio*. The magazine, which advertised itself as 'The First Wireless Newspaper,' was available on American steamship lines as well as by subscription."[19] As of 1915, it sold for ten cents a copy. (As of 1931, with the advent of the depression, it went out of business.)

An elegant lady passenger of the day appeared on a cover of the *Ocean*

Fig. 6. A uniformed Marconi messenger boy appears, winged like Mercury, the messenger of the gods. A lady of elegance and means glances at him from the corner of her eye as he salutes her and says: "Marconigram for you, Miss." Her valise looks full. Is she about to embark? Is she on board? Is the message from her husband? Perhaps her *fiance'* ? (Courtesy of Joe Knight)

Wireless News in this pre-war era (see Fig. 6). This undated cover exemplifies the era of first class travel and service before World War One, in the decade of the *Lusitania* and the *Titanic*. The cover is itself a droll advertisement for the pleasing convenience of receiving (and sending) Marconigrams at sea, facilitated by a winged boy-Mercury messenger. The Marconi Company was ever alive to the prospects of revenue from its new technology, which enhanced both performance and its bottom line.

Short Wave Radio, Powered by Vacuum Tubes, Became the Etheric Medium for Wireless News at Sea

The Transition From Spark to Continuous Waves ("CW")

The exigencies of the Great War had accelerated vacuum tube technology. After the war, amateurs explored wavelengths "two hundred meters and down," *i.e.*, the short waves above 1,500 KHz. Marconi also turned to short wave radio. The radio art, especially in its maritime aspects, took advantage of these developments. Transoceanic and even worldwide range became routine as a result of ionospheric propagation. Morse code communication to ships at sea became much more reliable. Shore stations automated traffic such as press and weather. Short wave radio, powered by vacuum tubes, became the etheric medium for wireless news at sea in the decades after World War One. Vacuum tube transmitters became the state of the art in the mid-1920s for maritime stations and most others. These evacuated "bottles" powered the antennas that then sent the "press" winging through the ether. Smaller vacuum tubes had already made possible the regenerative receivers that could copy traffic from very far away, especially on the shorter wavelengths. Then the later stable superheterodyne circuit radios predominated after the mid-1930s, for voice as well as Morse code. Until the 1920s, spark was king; after that it was only a technological ghost.

Various styles of wireless news continued to inform passengers of the "press" on almost every shipping line. For a while after World War One, the news traveled through the ether on spark signals, as did almost all the other wireless traffic. (The U.S. Navy used Federal Telegraph Company arcs of up to a million watts of peak power after the first working arc was used at Federal's San Francisco station FS in 1912.)[20] Federal also saw the revenue opportunities in providing the wireless news to passengers on Federal-equipped vessels (see Fig. 7). Beginning in the 1920s, short wave CW transmitters and receivers using vacuum tubes provided the wireless news for passenger liners. Wireless news, particularly about the markets and sporting events of interest to the well-off, was a perquisite and told of luxury travel in the Roaring Twenties. Mundane news of the day also circulated in the same way. These magazines or newspaper-like sheets of inserts also generated revenue from advertisements and in many cases from sales.

Federal Radio News

A DAILY NEWS JOURNAL FOR OCEAN TRAVELERS 3-24-1921

A Canal of Ceylon.

Courtesy Pacific Mail Magazine.

Fig. 7. The Federal Telegraph Company contracted with shipping lines in the Pacific to provide wireless telegraph service to ships at sea using its Poulson arc system. Federal appears to have sent wireless news on a daily basis for shipboard publication in its *Federal Radio News* publication for passengers. Dating from 1921, this cover shows a Ceylonese canal, perhaps to encourage travel on that route. (Courtesy of History San Jose and Joe Knight who found it in the Archives there)

Colorful Newspapers Please Passengers and Generate Revenues

Dr. Peterson describes the format of post-war wireless news publications, which is consistent with wireless news publications discussed in the following paragraphs:

> "In those days, a cover was printed on land, often in color and with lots of advertising, and this was made available in bulk to ships equipped with a wireless receiver and some form of printing press. The inside section of the ship newspaper was compiled from up to date reports received on the wireless equipment, it was inserted into the color cover, and the newspaper was sold to passengers."[21]

The Australian vessel RMS *Makura* published one such edition of the *Wireless News*. The cover of this land-printed 1927 *Wireless News* was graced with a 1926 nautical painting by C. B. Norton (see Fig. 8). Amalgamated Wireless Australasia, Ltd. provided this 36-page booklet aboard the *Makura*. The following words ran as a footer on the cover advertising Amalgamated Wireless: "An Ocean Newspaper Published On Board By Amalgamated Wireless (Australasia) Ltd, Sydney." The crew inserted the news reports aboard. An internal advertisement for the news with the words, "The Morning News of Sea Travel," is reproduced in Fig. 9. The internal logo for the *Wireless News* appears as Fig. 10.

The wireless operators sourced the news from the Australian Press Association and from the *Sydney Evening Post*. This vessel and its sister ships plied the sea-routes to San Francisco via Tahiti from Sydney. The radio-room stayed tuned to Australia even on the Tahiti to San Francisco leg of the voyage. The relevant time zones are shown on the back cover of the *Wireless News* in Fig. 11; this would be particularly useful, perhaps, in sending a wireless message for a hotel reservation. It is likely that the passengers hailed mostly from Australia. The news of the day shows up on the last pages of the magazine (see Fig. 12).

For these booklets, wireless operators on the vessels took down "the press" from one or more shore stations,

Fig. 8. Colorful covers, here a painting from nautical artist C. B. Norton, and pre-printed advertisements enveloped the few pages of this 1927 edition of the *Wireless News*; the news insert was prepared from received radio transmission of "press." (Author's collection)

paragraph by paragraph. This booklet also lists all of the passengers (early "networking" perhaps), and it advertises goods and services. It notices shipboard events and gives port information. Only radio could reach the ships at sea and garner the revenue derived from the demand for current news, especially financial reports, although cables might still supplement radio internationally. Shore stations competed with each other by providing "press" to ships at sea. With "press" reliably anticipated, the passenger lines could sell advertisements in their booklets from businesses in ports of call.

Another edition of the *Wireless News* resides in the collections of the Australian Victoria Museum (see Fig. 13). This is a "Souvenir Edition" of the *Wireless News* published for the Australian Commonwealth Line of Steamers, specifically the TSS *Jervis Bay*, according to the museum. As this

Fig. 9. The 1927 *Wireless News* as printed carried this internal advertisement. These vessels steam along under their 600-meter wavelength antennas. Note inset map of worldwide routes. (Author's collection)

Fig. 10. This logo within the 1927 *Wireless News* perhaps illustrates the company's passenger liners coming and going. In those days only a boat could get in or out of Australia. The mineral and other wealth of the island continent sustained luxury travel. (Author's collection)

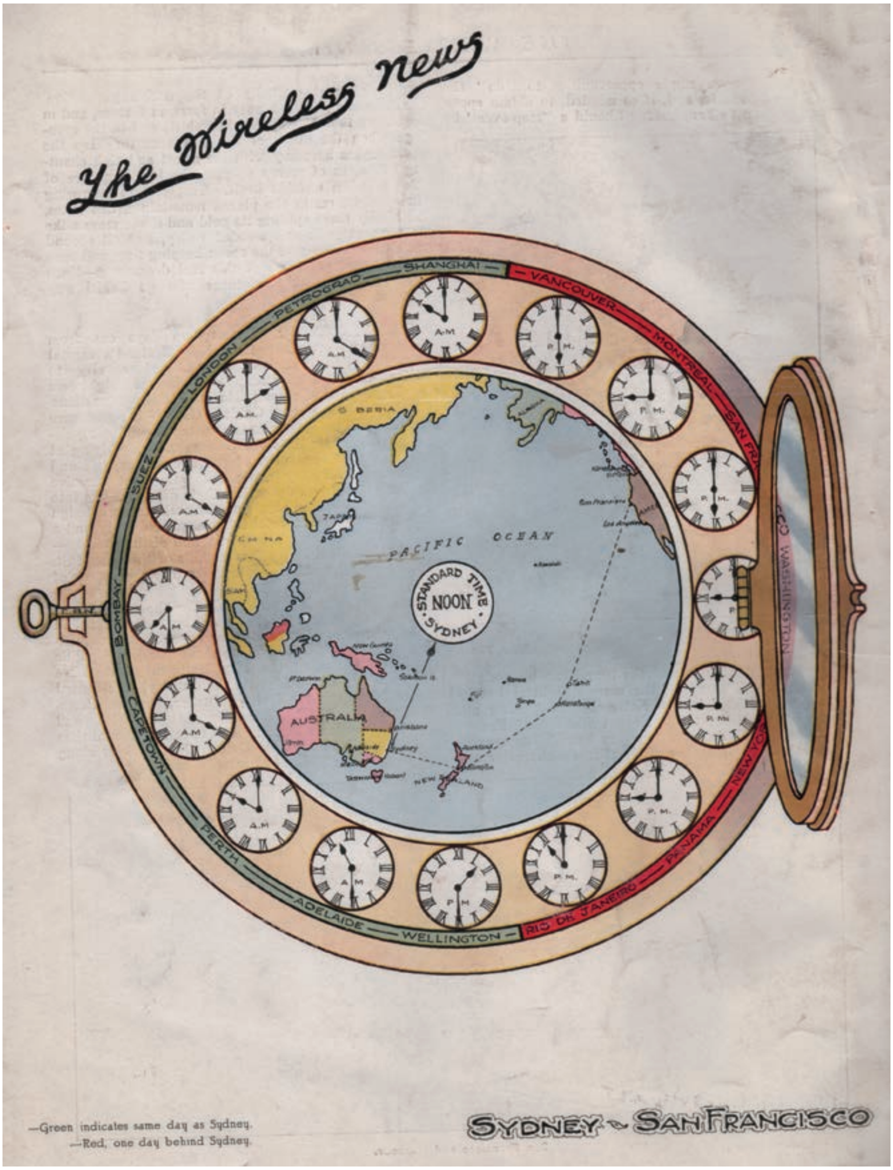


Fig. 11. The back cover on this 1927 *Wireless News* shows time zones around the world. This not only made for a colorful back cover, it also facilitated timing for passenger radio communications to ports. It may be that this was a standard annular back cover illustration with particular routes appearing in the center—why else Bombay, London and Rio clocks? (Author's collection)

The Wireless News

PAPEETE TO SAN FRANCISCO. R.M.S."MAKURA". MAY 11th 27.

LONDON 11th. BISHOP OF LONDON RETURNS.

The Bishop of London returned from Australia and New Zealand to meet a violent attack from Sir William Joyson Hicks. The Home Secretary accused the Bishop of having filled the Diocese, London, with men of disloyal doctrines. (Aust Press Assn)

LONDON 11th. PROBLEM FOR SCOTLAND YARD

Scotland Yard's best brains are concentrating on the mystery of a trunk, which was deposited at Charing Cross station three weeks ago. When opened it was found to contain the decomposed body of a woman (Aust. Press Assn)

NEW YORK 11th. SEARCH FOR NUNGESSER.

The bleak stretches of the stormy Atlantic are being combed today for the missing aviators Captains' Nungesser and Coli, now a full day overdue at New York, on their flight from Paris. Not one authentic word of the planes whereabouts has come from any source.

CANBERRA 11th. IMPRESSIVE BURIAL CEREMONY.

The funeral of flying officer Ewen who was killed at Canberra during Prince of Wale's visit took place today Three aeroplanes flew over the cortege and circled above the cemetry during the burial service (Syd. Evening News)

NOGALES 11th FIGHTING IN MEXICO.

Fighting between Mexican Federals and Yaqui Indians was report-ed as occurring this afternoon, 68 miles south of the International boundary, with heavy casualties suffered by both sides. Four auto-mobiles brought the wounded into Nogales Sonora at 4.30 oclock .

Two machines were dispatched to the scene to bring in addit-ional wounded.

MELBOURNE 11th.. Falls of rain up to three quarters of an inch were recorded in the Mallee and Northern districts where they were badly needed (Syd. Evening News)

Fig. 12. Part of the news of the day from the May 11, 1927, *Wireless News*. Passengers learned among other important news that the Mexican *Federales* fought it out with the Yaqui Indians 60 miles south of the Arizona border; this may have had special import to Australians with mining interests. London, New York, and Australian cities provided other datelines. (Author's collection)

Fig. 13. This 1928 edition of the *Wireless News* also boasts a painting by nautical artist C. B. Norton, and a likely notional clipper ship. Its news issued as the ship transited the Strait of Gibraltar. (Museums Victoria, http://museumvictoria.com.au/collections/items/1125171/magazine-the-wireless-news-the-wireless-press-1928)

vessel passed Gibraltar (April 7, 1928), it printed this particular issue's inserts. A color image of the steamer appears on the blue front cover. One "A. G. Maclaurin," likely a passenger, wrote his name on the cover. Ship interiors, points of interest in ports, results of activities, a passenger list, and a page of signatures from other passengers appear in this issue of the *Wireless News*.[22]

Illustrating the transition to tubes from spark, the Victoria Museum notes: "In September 1926 *Jervis Bay* became the first ship on the UK to Australia route to be equipped with a short-wave radio transmitter—a self-oscillator type using two Marconi T250 valves enabling the ship to be in constant radio-to-shore contact."[23]

C. B. Norton also painted the TSS *Jervis Bay* nautical scene on this cover. A three-masted clipper ship sails off the port side, which must have been quite a sight as late as 1928. The left-side post bindings are probably original, because the RMS *Makura* souvenir booklet is bound similarly.

Dr. Peterson also notes an earlier RMS *Makura* publication of the *Wireless News*:

> "Another example of a ship newspaper was a daily edition of 'The Wireless News' on board the ship '*Makura*,' sailing across the Pacific. This ship was built in Glasgow, Scotland and it was operated by the Union Steamship Company of New Zealand. The outer cover of this paper, in an issue dated in 1923, shows a photo of another vessel plying the Pacific, the '*Niagara*.'"[24]

The RMS *Niagara* mentioned by Dr. Peterson also sailed for the Union Steamship Company on the Vancouver run, so this detail is company advertisement, sort of a "two-fer" in the commissioning of a nautical painting by the steamship line. Dr. Peterson also notes:

> "A 1925 version of the 'Ocean Wireless News' features a color cover, drawn by an artist and showing passengers and crew making ready to depart at the beginning of a voyage. This particular edition was distributed on board the SS *Manchuria* which was built in Camden, New Jersey in 1904 and at the time, it was in passenger service with the Panama Pacific Company in the Americas."[25]

Dr. Peterson's article continues:

> "The Canadian Pacific Company operated a large fleet of passenger and cargo vessels across both the Atlantic and the Pacific. The same name, the 'Wireless Press,' was used for all of their shipboard newspapers regardless of the ship and its service area. For example, the *SS Montcalm* was in the Atlantic passenger service and the '*Duchess of Richmond*' was a cruise ship that voyaged to many destinations; and the name of their shipboard newspapers in both cases, was 'Wireless Press.'"[26]

Examples are known of the Canadian Pacific Line's "Wireless Press" issued aboard the RMS *Montrose* and the RMS *Empress of France* in 1930, probably because a passenger preserved them.[27] The RMS *Montrose* edition identifies its source as "Canadian Pacific News-Radio."

The sorts of news that appeared in the various at-sea publications implies that the passengers were internationalists and cosmopolitans, which could also be inferred just from the price of passage. According to Dr. Peterson:

> "The issue of 'Wireless Press' for Tuesday April 6, 1937 shows that the '*Duchess of Richmond*' was on a Christian World Cruise. The single sheet newspaper, derived again from radio reports, gives an inside view to world events at the time. Among these 1937 news events are the following:
>
> - The weather in London is foggy, and the temperature was just 41 degrees.
> - The Earl of Clarendon arrived in London at the end of a six year term as governor of South Africa.
> - The Crown Prince of Hedjaz, Emir Sand, has just concluded a state visit to Baghdad.
> - Two minutes of silence was observed in Dublin for members of the Irish Brigade killed in Spain.
> - New Delhi reports heavy rains in the North West Frontier and the border regions of Afghanistan.
> - Federal Securities are sold on the open market in the United States at 3% below par.
> - An airplane is taking off for a record flight from Tokyo to London."[28]

Japanese Vessels Provide Passengers with Radio Press

Dr. Peterson also mentions the Japanese N.Y.K. line (Nippon Yusen Kabushiki Kaisha), printing "the information received by radio from Japan." He concludes: "The list of ship newspapers produced from news transmitted in Morse code by wireless and in voice by radio is almost endless."[29]

Before World War Two, Japanese passenger vessels also traversed the Pacific and called at Asian ports. The *Asama Maru*, for example, sailed in the trans-Pacific Orient and California fortnightly service to San Francisco. The N.Y.K. line built her and sister ships in Japan for this route. (N.Y.K. still sails the Pacific.) "The Queen of the Sea" sobriquet applied to the *Asama Maru*; nonetheless, in the war Allied forces sank her (1944) and almost all of the Japanese liners that had served pre-war.[30]

The Japanese *Wireless JiJi Press* from the N.Y.K. line in 1935 provided news and articles. (*Jiji* means "Times.") For example, Figs. 14–15 are mastheads appearing in an issue dated June 24, 1935. The column under the masthead in Japanese is about war. This four-page *Wireless Jiji Press* issued on 11" by 17" newsprint paper in the fourth year of Emperor Hirohito's reign and is so dated in Japanese.[31] Reading from the left, the first two pages are in English. Reading from the right, *those* first two pages are in Japanese. The English content appears to be fill, as does much of the Japanese. In English it says on the first page: "A Newspaper Issued Daily


The Wireless Jiji Press
OCEAN EDITION
A NEWSPAPER ISSUED DAILY ON BOARD N.Y.K. LINERS (無線時事海上版)
AT SEA JUNE 24, 1935.
Annual House-Cleaning is Strictly Observed and Whole Emerges as Clean as New Pin
HOW CAPITOL WOULD BE REMOLDED.

Fig. 14. For the Japanese N.Y.K. line, the *Wireless* Jiji *Press* came out on newsprint, mostly pre-prepared with fill, but issued daily. (*Wireless* Jiji *Press*, June 24, 1935; author's collection)

Fig. 15. The Japanese language predominated in the content of the 1935 *Wireless* Jiji *Press*, although English provided the "fill," perhaps as a way for Japanese passengers to sharpen their language skills. (*Wireless* Jiji *Press*, June 24, 1935; author's collection)

On Board N.Y.K. Liners." A daily sheet of radio news would seem to be missing.

An advertisement in the *Jiji Press* shows maritime traffic to China played a role in N.Y.K.'s revenues (see Fig. 16). Every four days one of the steamers sailed to China. As little as one day on the China Sea (24 hours) put a Japanese businessman in Shanghai. (In those days Japanese imperial ambitions ran high.) The war claimed both of the advertised liners. A mine sank the *Nagasaki Maru* in 1942, and a collision sank the *Shanghai Maru* in 1943. The Japanese navy converted another liner, the *Kashiwara Maru*, into an aircraft carrier (see Fig. 17). The artist has enhanced his image by emphasizing the radio antennas that ordinarily cannot be seen in panoramic photographs of ships.[32] It too did not survive the war.

Radio Press and Shipboard Newspapers in World War Two and After

The "press," in the form of wireless news, went to ships at sea during World War Two. Passengers and crew kept abreast of war developments. The British Wireless Marine Service in World War Two informed British shipping (and anyone within radio range) of war progress. As indicated in the masthead of a message from the Marine Service reproduced in Fig. 18, the Marconi International Marine Communications Company, the Radio Communication

Fig. 16. This sort of advertisement for Chinese travel in the 1935 *Wireless* Jiji *Press* sheds light on Japanese imperial ambitions for China in the 1930s. (*Wireless* Jiji *Press*, June 24, 1935; author's collection)

Fig. 17. The *Kashiwara Maru* never sailed as the 1930s ocean liner of this artist's conception, but this dramatic scene does illustrate the radio antennas of the liners of the day. The vessel ended up as an aircraft carrier and did not make it through the war. (Painting by David "Alan" Urban, Jr. as "carsdude," courtesy DeviantArt.com)

Company, and a third Marconi company had been amalgamated. This fragment of 1939 wireless press reports the defeat of the *Graf Spee* pocket battleship in South America early in the war. Merchant marine radiomen reported the

British Wireless Ma ne Service
Joint Service Departmen of :
The Marconi International Marine Communication Co., Ltd., Radio Communication Company Ltd.
and Marconi Sounding Device Co., Ltd.
Marconi Offices, Electra House, Victoria Embankment,
London, W.C.2.

TO-DAY'S NEWS

S.S. ....

Press message from the Wireless Station at .... Date .... Words ....

Page 2.

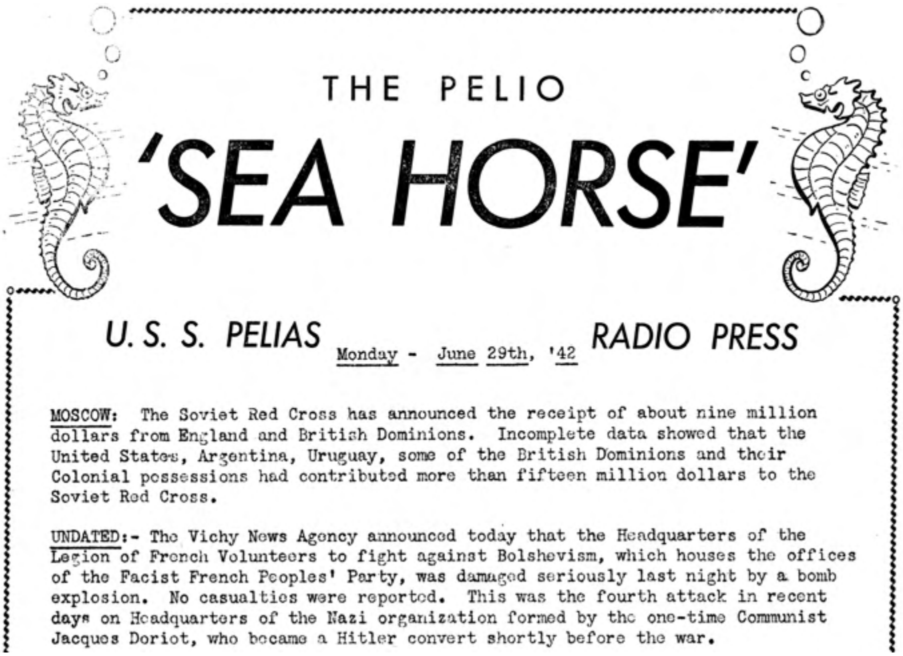
if required, ration commodities in order that all may share and share alike. What I want country to realise is that every restriction which they are asked to accept is just one part of general plan for securing the victory in the shortest possible time.

Fig. 18. "To-Day's News" appears on the 1939 masthead of "press" for newspapers at sea provided by the Marconi British Wireless Marine Service during World War Two. (Courtesy of David Barlow, Lizard museum)

location of *Graf Spee*, at serious risk to themselves and their vessels, enabling the British Navy to find and engage her.

The radiomen on U.S. Navy vessels took a great deal of press and similar traffic, turning it into typed and mimeographed multipage newspapers at sea. One example is *The Pelio 'Sea Horse'*—the "Radio Press" of the USS *Pelias* (see Fig. 19). This submarine tender fought at Pearl Harbor on the first day of the war, "splashing" at least one attacking Japanese aircraft. On Monday, June 29, 1942, she was about to cross the equator on her way to Australia. She supplied her crew with more than six pages of war and national news, including sports, the baseball scores, and commentary. At least 30 paragraphs of war news bear attributions to cities such as Washington, London, Moscow, Bombay, and Cairo. An insert conveyed general orders for the upcoming transit of the equator, known at sea as "Crossing the Line," which was celebrated by "shellbacks," who had done it in various ways before, and usually unpleasant for "polliwogs," who had not. The orders anticipated opposition in the Royal Domain of King Neptune Rex and set a special watch. The survival of this particular at-sea newspaper may owe itself to a then newly christened shellback.

In the 1950s, a sailors' union, the American Radio Association, CIO sent out press for its members at sea in the marine bands, 8 MHz and 17 MHz: "This Press may be copied, free, for posting aboard ship or in Union Halls; may be reproduced if credit is given to: 'Press Broadcast of ARA, CIO,' or just ARA Press."[33] The heading reads: "Note change of West Coast Skeds [,] Switch from 16 MC to 17 MC band[,] Inform all Ships of these Skeds."[34] San Francisco's station KTK covered the



THE PELIO

'SEA HORSE'

U. S. S. PELIAS Monday - June 29th, '42 RADIO PRESS

MOSCOW: The Soviet Red Cross has announced the receipt of about nine million dollars from England and British Dominions. Incomplete data showed that the United States, Argentina, Uruguay, some of the British Dominions and their Colonial possessions had contributed more than fifteen million dollars to the Soviet Red Cross.

UNDATED:- The Vichy News Agency announced today that the Headquarters of the Legion of French Volunteers to fight against Bolshevism, which houses the offices of the Facist French Peoples' Party, was damaged seriously last night by a bomb explosion. No casualties were reported. This was the fourth attack in recent days on Headquarters of the Nazi organization formed by the one-time Communist Jacques Doriot, who became a Hitler convert shortly before the war.

Fig. 19. The "Radio Press" for this Navy subtender in 1942 in its shipboard publication, the *Sea Horse,* provided considerable international information to the officers and crew in the early days of U.S. involvement in the war when the outcome remained in doubt. (Author's collection)

Fig. 20. Unions could hardly count on corporate newspapers to carry union news, or even to treat unions fairly. The merchant marine radio operators' union, the American Radio Association (ARA) in the 1950s, took up the slack with its own ocean-going press broadcast from the East and West Coasts on the marine long-distance bands. (American Radio Association, *ARA Log*, Jan. and Feb. 1953, p. 5)

Pacific, and WCO on Long Island, NY, covered the Atlantic. The logo "ARA On the Air" appearing on the notice is reproduced in Fig. 20.

Linotype Machines Aboard Liners Brought Wireless News to Shoreside Standards

Every significant passenger vessel provided its passengers wireless news every day from the 1920s and thereafter. Popular culture, even in fiction, quickly recognized the importance of the currency of the "wireless news," as did the maritime industries. Alfred Noyes, poet and author, wrote *The Last Voyage*, a sea-going novel in 1930 ringing with drama:

> "*The Last Voyage* begins at night in mid-Atlantic, where an ocean liner, 'a great ship like a lighted city,' is battling through a raging storm. A little girl is mortally ill. The ship's surgeon prepares to operate, but with little hope of success, for the case is complicated and he is no specialist. Luckily, the captain knows from the wireless news that a top specialist from Johns Hopkins is on another liner 400 miles away—within wireless range. The ship's surgeon will be able to consult him, and stay in touch with him throughout the operation. Suddenly, the little girl's chances of survival are much improved."[35]

For the benefit of passengers wanting to keep up with the wireless news, as well as for facilitation of their own hospitality operations, many ships were equipped with printing machines of various types to print wireless newspapers, menus and the like. They also carried press-men and printers (including Marconimen in the early days). But it was the UK *Daily Mail* with its Atlantic edition of 1923 that pioneered the shoreside technology of the linotype machine at sea.

> "The installation of linotype machines on the ships was the technical innovation that made the Atlantic edition possible. Whereas typesetters traditionally set the text by hand—letter-by-letter—a linotype machine allowed the operator to use a keyboard that mechanically selected the letters. After each line of text was assembled, a metal cast of the line, known as a "slug", would be taken and was then used to compose the columns and pages in readiness for printing. Linotype machines had never been used on board a liner before, so that ingenious tests with machines on rollers had to be conducted on land to replicate conditions at sea and ensure the technology would function adequately."[36]

Today, cruise ships (and the few remaining liners) still provide daily newspapers via satellite, complete with full-page images from all over the world. Passenger lines continued to take press traffic from the coast radio stations of Europe, North America, and Asia well into the 1960s.

The coming of satellites made for the replacement of long antennas with squat parabolic dishes, as the frequencies moved up from 500 KHz (600 meters) to the gigahertz ranges at centimeter wavelengths. (Vacuum tubes, too, are long gone.) With the coming of so much bandwidth, the wireless news at sea evolved to near photographic copies of the world's newspapers, local advertisements and all. See Fig. 21 for a current shipboard advertisement for shipboard newspapers. Although the transport of well-off passengers became the business of the airlines, the tourist cruises picked up much of the slack. It still made sense to advertise to them and to cater to the need they felt to stay fully informed, even on luxury vacations.[37]

Fig. 21. This is a copy of a current shipboard advertisement on a cruise ship for newspaper service at sea. Full issues of the major newspapers of the world are available by subscription for the length of the cruise. The data comes down from satellites (although not printed in color). Satellite communication is generally reliable except near the poles where the angle to the equatorial satellites is too low. Perhaps there's something to be said for legacy radio after all. (Author's collection)

Conclusion

The very phrase "the wireless news" came to stand for new knowledge of the events of the day, the only immediate source for which was the radio—or in British parlance, the wireless. A more complete newspaper report of important events came only with the next dawn, at sea as well as ashore. Marconi knew his new wireless telegraphy's primary applications would be maritime, only later to be followed by competition with the transoceanic cables. Maritime interests would pay for immediate communications, and their passenger would pay for news at sea. The economists say supply creates demand but also that demand creates supply. The new technology supplied immediate news of events ashore, and the willingness of passengers to pay for it drove both the radio art and the printing art.

Marconi's new technology gave birth to the wireless news at sea very shortly after wireless telegraphy first itself travelled over water. The then big business of passenger lines sustained its growth for both the Atlantic's and the Pacific's well-off passengers. The various, often colorful issues of the *Wireless News* record for us not only the events of the day, but also tell us of the social world of travel through the decades.

From Marconi's 1899 maritime adventures and the first 1899 wireless transmission in America (in San Francisco from the *Lightship 70* announcing the return of the troopship USS *Sherman* to San Francisco newspapers), radio communications and journalism have quickly informed the world of events worldwide. From its earliest day to the present, radio has also informed otherwise isolated seafarers and passengers of events at home and abroad. Radio and news are a natural marriage. That marriage, now polytechnological, thrives throughout the electromagnetic spectrum, spark long gone but now through satellites above.

Endnotes

1. Degna Marconi, *My Father Marconi* (1962), page 83. The official history of the Marconi International Marine Communications Company, by H. E. Hancock, *Wireless at Sea* (1950) tells the same story and reports the same traffic at page 22 virtually word-for-word and notes the newspaper memorialized by a then-standing monument on the Isle of Wight.
2. Roland Wenzlhuemer and Michael Offermann, "Ship Newspapers and Passenger Life Aboard Transoceanic Steamships in the Late Nineteenth Century" (citations omitted) in the *Journal* [of] *Transcultural Studies*, Number 1, (2012), published by the [University of Heidelberg] Cluster of Excellence 'Asia and Europe in a Global Context: The Dynamics of Transculturality'[!] of the Ruprecht-Karls-Universität Heidelberg. http://heiup.uni-heidelberg.de/journals/index.php/transcultural/index.
3. This quote comes from the 1902 diary of Otelia Langum on a voyage on the Cunard Line's *Saxsonia,* back to America by way of Liverpool, UK. The ships exchanged messages on the third day of her nine-day crossing. Larry Nutting, K7KSW, CHRS, supplied a copy of the relevant part of the diary. His wife, the granddaughter of Ms. Langum, had transcribed the diary.
4. Originally almost all Marconi stations used call signs to show their locations. The Lizard was LD, although nearby Poldhu was ZZ. Marconi stations soon added an "M" prefix. Thus, the Lizard station became MLD. Later post office ownership changed the call sign to GLD. Today the Amateur Radio Club at Lizard uses GB2LD for special events. See Bobby Lyman, "The Lizard Radio Station ~ The Oldest Surviving Wireless Station in the World," Antique Wireless Classified, (Feb. 2009), http://www.antiqueradio.com/Feb09_Lyman_Lizard.html.
5. David Barlow, "Poldhu – ZZ GB100ZZ," *Poldhu Amateur Radio Club, G B 2 G M, Newsletter*, #80, (June 2, 2014), pages 11 ff. See also http://www.lizardwireless.org/. Curator Barlow not only kindly provided a number of the British images appearing in this note but also earlier provided a thorough tour of the reconstructed Lizard Marconi station, for both of which I am grateful.
6. "The First Mid-Ocean Daily," *San Francisco Chronicle*, (May 1, 1904), at page 2. This appears to have been a widely distributed story, with graphics, for later publication in local newspapers, in part because the internal graphic of *The Marconigram* is dated May 21—perhaps the *Chronicle* jumped the journalistic gun.
7. "Wireless News at Sea: Successful Experiment," *Daily Telegraph* [London], (Feb. 11, 1903); reproduced in Papers Past [,] Wireless News

At Sea, from the New Zealand newspaper *Aukland Star*, (April 4, 1904). https://paperspast.natlib.govt.nz/newspapers/all.

8. "Wireless Station On Tamalpais," *Sausalito* [California] *News*, (Sept. 2, 1905), Internet sourced by Barry McMullan, CHRS. https://cdnc.ucr.edu/cgi-bin/cdnc?a=d&d=SN19050902.2.19.
9. See Ellery W. Stone, "Returns From Fight Sent By Wireless," *Modern Electrics*, Volume 3, Number 5, (August 1910), page 257. The text is from the cylinder recording that may be heard at http://www.tinfoil.com/cm-0406.htm; 'Ed' Trump, AL7N, of Fairbanks, Alaska transcribed the then American Morse code. The cylinder recording is in the Frank V. de Bellis collection at San Francisco State University. David Ring, N1EA found this remarkable record. Dr. Adrian M. Peterson of Adventist World Radio found Stone's article. "U.W. Co." refers to United Wireless, operating in the marine service from what is now Daly City. It is possible that the transcribed text emanated from PH, not TG, although Stone seems to be saying PH sent out only the news of the victory at the end of the match. Nonetheless the text appears to be a prepared broadcast and not a wireless operator extemporizing. A series of numbers appears at the end of the message but its intent is unknown now.
10. Jane Morgan, *Electronics in the West*, (1967) page 35.
11. Stone, op cit.
12. Richard Johnstone, Commander, U.S.N.R. (Retired), *My San Francisco Story of the "Waterfront and the Wireless,"* (1965), privately printed and now in the Library of the California Historical Radio Society, page 50.
13. James A. Maxwell, [W6CF], "Copying WHB as Recorded by Charles Apgar, 2MN, in 1915," *Journal of the California Historical Radio Society,* Volume 13, Number 1 (1994). The correct callsigns WHB and W6CF are emended. The audio recording comes from the archives of the Antique Wireless Association in New York, part of an NBC 1934 interview with Charles Apgar during which two of his Edison cylinder recording were played on the air. Apgar also recorded the then-German Sayville, L.I., NY station on Edison cylinders in 1915 for U.S. authorities.
14. Noah Arceneaux, "News on the Air: The New York Herald, Newspapers, and Wireless Telegraphy, 1899–1917," *American Journalism*, Volume 30, Number 2, (2013), page 174.
15. The book that Professor Arceneaux quotes is: Alfred P. Morgan, *Wireless Telegraphy and Telephony Simply Explained*, (Norman Henley Publishing Co., New York, 1913).
16. Ibid., pages 95–96.
17. *Ocean Wireless News*, Volume IX, Number 2, (March, 1914) from a current bookseller's advertisement: https://www.abebooks.com/Ocean-Wireless-News-Volume-Number-Marconi/745749169/bd.
18. Dr. Adrian Peterson, "Radio Newspapers Aboard Ship" from the Adventist World Radio *AWR Wavescan*, posted at http://mt-shortwave.blogspot.com/2010/07/radio-newspapers-aboard-ship.html.
19. Conrad First, The Joseph Conrad Periodical Archive, about the Conrad story "The Brute: A Tale of a Ship That Wouldn't Behave" published in *Ocean Wireless News* for January 1912. The Conrad Archive is a program of the University of Uppsala, Sweden. http://www.conradfirst.net/view/periodical?id=12536.
20. Federal arc transmitters, usually 2 kW, served many ships on the Pacific routes into the 1920s and 300 vessels of the United States Shipping Board. Federal sited its main transmitter in Palo Alto, California. A publication, *Federal Radio News, A Daily News Journal for Ocean Travelers* survives from 1921 in the collection of Joe Knight, CHRS, AWA, with a scene from Ceylon on its cover. A photograph of a federal arc in a ship's radio room is available at: http://www.telegraph-office.com/pages/images/Kdid.jpg. By inference, a ship equipped with Federal equipment took its press from Federal stations primarily. The arc technology did not, however, long survive the development of power vacuum tubes.
21. Peterson, "Radio Newspapers Aboard Ship," op cit.
22. http://museumvictoria.com.au/collections/items/1125171/magazine-the-wireless-news-the-wireless-press-1928.
23. http://collections.museumvictoria.com.au/articles/3665. The museum adds: "On 5 November 1940, *HMS Jervis Bay* was sunk in the Atlantic by the German pocket battleship *Admiral Scheer* after the convoy *Jervis Bay* was escorting came under attack. *Jervis Bay* turned toward the *Admiral Scheer* and

diverted her fire while the 38-ship convoy HX84 which included the cargo liner *Rangitiki* escaped. Her captain, E.F.S Fegan (a former commanding officer at the RAN College at Jervis Bay) was killed and the ship sank with the loss of 198 men. Fegan received a posthumous Victoria Cross for his actions during this engagement. . . ."

24. Peterson, "Radio Newspapers Aboard Ship," op cit.
25. Ibid.
26. Ibid.
27. These two issues of the Canadian Pacific line's *Wireless Press* recently appeared for sale on eBay. eBay often provides images and information not otherwise easily available.
28. Peterson, "Radio Newspapers Aboard Ship," op cit.
29. Ibid.
30. According to Wikipedia, which supplies considerable detail about the line and the vessels.
31. I am indebted to my friend Michi Osada for the translations from the Japanese.
32. *Kashiwara-Maru* at sea by "carsdude" (David "Alan" Urban, Jr.) on DeviantArt.com captioned "The Japanese liner as she was intended before being transformed into aircraft carrier *Junyo*" (enhanced here to show antennas), http://carsdude.deviantart.com/art/kashiwara-maru-506523859.
33. Notice in the ARA (American Radio Association, CIO) *ARA Log* for January and February 1953. The logo says: "ARA on the Air" showing a radio tower and a long antenna.
34. Ibid.
35. From the article about Alfred Noyes in Wikipedia, http://en.wikipedia.org/wiki/Alfred_Noyes.
36. Seth Cayley, "Publishing at sea," in *Research Information* [which declares itself to be] The essential link between publishers, librarians and researchers (August 7, 2013). https://www.researchinformation.info/feature/publishing-sea. This article notes that each vessel carried an *Atlantic Times* editor to turn the wireless traffic into newspaper stories. That traffic came from Massachusetts (RCA's Chatam, MA station WCC) and Marconi in England but also directly from U.K. Foreign Office transmissions.
37. For an interesting discussion of technology, even at-sea newspapers, illuminating class differences, see Teresa Breathnach, "If All the World was Paper and All the Sea was Ink: Ships' Printers and Printing 1890–1960 (Draft)" (no date) at https://www.academia.edu/7882257/ . . . The disproportionate survival of the First Class passengers of the RMS *Titanic* tells the same story in starker terms. The *Great Eastern*, laying the Atlantic cable in 1866 took news through the cable it laid down, and provided it as daily summaries of shoreside events. The information thus conveyed by lithograph related primarily to finance in London. http://atlantic-cable.com/Article/GreatEasternDocuments/ (Shipboard Publishing and Printing on Great Eastern).

About the Author

Bart Lee, K6VK, xKV6LEE, WPE2DLT, is a longtime member of AWA and a Fellow of the California Historical Radio Society (CHRS), for which he serves as General Counsel Emeritus and Archivist and an historian. He holds both FCC commercial (GROL with radar endorsement) and amateur extra class licenses. He has enjoyed radio and radio-related activities in many parts of the world. He has in recent years spent a fair amount of time on the high seas and is thus indebted to today's Wireless News. Radio technology and history have fascinated him since he made his first crystal set with a razor blade and pencil lead 60 years ago. He is especially fond of those sets of which it is said: Real Radios Glow in the Dark. Bart is a published author on legal and other subjects and extensively on the history of radio. The AWA presented its Houck Award for documentation to him in 2003, and CHRS presented its 1991 "Doc" Herrold Award to him in connection with his work for the Perham Foundation Electronics Museum. In 2001, during disaster recovery operations in New York after the "9/11" terrorist enormity, he served as the Red Cross deputy communications lead from September 12 to September 21, (the "night shift trick chief"). Bart worked as a litigator by trade, prosecuting and defending civil cases in federal and state courts for 40 years. He is a graduate of St. John's College (the "Great Books School") and the University of Chicago Law School. Bart invites correspondence at KV6LEE@gmail.com.

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Bart Lee

Henry K. Huppert and His Vacuum Tubes

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This is the story of Henry K. Huppert and the four innovative types of thermionic vacuum tubes he designed over his lifetime. Much of what appears in this article is taken from the personal papers of Henry Huppert that have never been published previously. These Huppert papers have been in the possession of his granddaughter, Claudia M. Benish who inherited them from her father, Ralph M. Huppert. The focus of this paper is on the four vacuum tubes he developed—the Solenoid tube, the Two-in-One tube, a tube with the trade name Quadrotron, and a unique thermionic X-ray tube with a control grid that had no trade name. While the Solenoid tube and the Two-in-One tube have been chronicled previously, documents in the Huppert papers provide much interesting background information on how the tubes were designed and how they performed. The unique X-ray tube that he designed has never been chronicled previously. In addition to information on his vacuum tubes, this article also provides interesting details on his life and his work as a radiologist and as a doctor treating patients with radiotherapy techniques.

Introduction

It is not often that a radio collector or historian discovers the unchronicled papers of an early wireless pioneer—in this case, Henry K. Huppert, an engineer who worked for Western Electric, Lee De Forest, and Otis Moorhead in the pre-broadcast era and Moorhead Laboratories, Atlantic-Pacific Supplies Co., A-P Radio Laboratories, Inc. and several other companies manufacturing thermionic vacuum tubes in the broadcast era. Over a ten-year period, he developed four innovative thermionic vacuum tubes as the broadcast era unfolded. I was fortunate enough to make contact with Henry Huppert's granddaughter, Claudia M. Benish, who inherited the files that her father, Ralph Martin Huppert, Sr., had inherited from his father, Henry. The files are complete with pamphlets, photographs, reports, patents, letters, newspaper clippings, awards, and other memorabilia covering Henry's life's work. In addition to Huppert's vacuum tubes, this paper also covers his development of diathermy machines in competition with De Forest and describes his treatment of patients with those machines as a practicing doctor.

Henry Huppert had a number of diverse and colorful vocations: able-bodied seaman, assistant to Moorhead and De Forest designing vacuum tubes, installer of telephone equipment for Western Electric, designer of X-ray equipment for Keystone Electrical Laboratories, radiologist at Preston-Huppert X-Ray Laboratories, Superintendent of manufacturing and sales divisions for A-P Radio Laboratories, designer of X-ray tubes and shortwave radiotherapy equipment at American Electric Co., and self-employed as an electro-therapist and Doctor of Physical Medicine treating patients with diathermy equipment. He also served in the voluntary Naval Communication Reserve (NCR) beginning on October 23, 1926.

Fig. 1. A photograph of Henry K. Huppert taken in 1925 at the time he designed his Two-in-One tube. (Huppert papers)

The main focus of this paper is on the four vacuum tubes Henry Huppert developed during the early broadcast era: the Solenoid, the Two-in-One, the Quadrotron, and a unique thermionic X-ray tube with a control grid that had no trade name. The paper is divided into three parts, the first being a short biography of Henry Karl Huppert, whose photograph appears in Fig. 1. The second part describes the four tubes that he designed—the Solenoid tube, often attributed to Moorhead Labs, a Two-in-One tube, the mysterious and rare tube marketed as the Quadrotron, and an unnamed, three-element, X-ray tube. The third part covers his activities as radiotherapist, first designing a diathermy machine for the American Electric Company of California and then in private practice as a radiologist and Doctor of Physical Medicine.

PART I. BIOGRAPHY OF HENRY KARL HUPPERT

The short biography presented here is abstracted from a longer version prepared by Ralph Martin Huppert, Sr. of Ashburn, Virginia, who died at age 83 on August 20, 2012.[1] Born on November 1, 1928, in San Francisco, Ralph was the son of Henry Karl Huppert and Olga Marie (*née* Kahler) Huppert. Clearly, Ralph Huppert had an interest in his ancestry in general and his father's life in particular, which is evidenced by the number of boxes of material he collected on the life of his father and family. The writings of Ralph

Huppert and the material he collected from his father, Henry, were passed on to his daughter, Claudia Benish (*née* Huppert), who has preserved them for posterity.

The Early Years

Henry Karl Huppert was born Heinrich Friedrich Carl Huppert on September 20, 1893, in Vienenburg, Germany, a small farming community at the northern edge of the Harz Mountains in Lower Saxony (see Fig. 2). He was the son of Heinrich Huppert and Marie (née Kassell) Huppert. According to church records, Henry was baptized on September 22, 1893. He was raised and received his basic education in Vienenburg. Under the Prussian system, elementary school (*Volksschule*) education was compulsory in every town and village from ages six to fourteen, and so he attended *Volksschule* from 1899 to 1907.

He may or may not have received additional education in Germany before immigrating to the United States. Biographic data submitted to the U.S. Navy when he applied for a commission lists apprentice electrical work at a polytechnic high school in Germany from 1907–1910. Although there were ten technical high schools in Germany at this time, one of which was only 22 miles away in Braunschweig, there are no documents among his papers to verify attendance at any school in Germany after graduation from *Volksschule*.

The records indicate that after graduating from *Volksschule* in 1907, he worked in a salt mine owned by his

Fig. 2. A postcard printed circa 1910 depicting the small town of Vienenburg, Germany, where Henry Huppert was born.

uncle, Johann Karl Huppert. Heinrich's father was employed at the same mine, and he collected both of their checks on payday. Heinrich was not satisfied with this situation and persuaded his father to let him work on a farm. Consequently, contractual arrangements were made for him to serve on a farm in Zweidorf for a year. The food was good and he gained size and strength, but the farmer and farmhands were brutal and ignorant, and Heinrich suffered many beatings. Furthermore, he had to put in long hours harvesting crops from three in the morning until ten at night. When life on the farm became unbearable, he fled to an aunt in Braunschweig who found him a job delivering bakery goods under an assumed name. He visited his parents some months later and found that the farmer had brought suit against his father for the loss of his slave. Fortunately for Heinrich, his father had taken a dislike to the man and did not force him to return.

Immigration to the United States

Heinrich had no desire to be a miner or farm laborer like his forebears, and instead he turned to the sea for a livelihood. After several short voyages to English and European ports, he sailed to San Francisco Bay where he deserted his ship, the auxiliary clipper *R. C. Rickmers*, and applied for U.S. citizenship. Heinrich celebrated his 18th birthday by filing a Declaration of Intention in the office of the clerk of the United States District Court, San Francisco, CA, renouncing allegiance to William II, German Emperor, to become a citizen of the United States. Two years later, in the San Francisco office of the Immigration Service, he executed a Certificate of Arrival for Naturalization Purposes showing that he first entered the United States in March 1911 in San Francisco after deserting from the *R. C. Rickmers.* He completed the process five years later in February of 1917 when he filed his Petition for Naturalization. He took the Oath of Allegiance to the United States on June 14, 1917, and at the same time changed his legal name to Henry Karl Huppert. Nevertheless, his wife and in-laws called him "Hein" throughout his life. His Certificate of Naturalization was issued on June 30, 1917.

Henry, who spent the remainder of his life in and around San Francisco, was the first of his branch of the Huppert family to become a citizen of the United States. He was also responsible for bringing his brothers Robert, Herman, Wilhelm, and Karl to America, all of whom became citizens of the United States.

Education in the United States

His personal records list completion of courses in electricity at Heald College, San Francisco, CA, from 1911 to 1914, the International Correspondence School (I.C.S.) in 1914, and radio engineering at University of California Extension. Records of UC Extension show that he took a course in Wireless Telephony in 1921. Some biographical data lists him as an electrical engineer, but there is nothing among his personal papers to verify formal training leading to an E. E. degree.

He matriculated at the San Francisco College of Drugless Physicians, 1122 Sutter Street, on July 26, 1937, and was granted the degree of Doctor of Physical Medicine (DPM) on May 1, 1940. Physical medicine includes electrotherapy, the mechanical manipulation of bones and muscles, and dietetics. His specialty was electrotherapy and diathermy.

Home Life in the United States

Where Henry lived for the first five months after leaving his ship is unknown. Perhaps he lived with one or more of his shipmates. However, in September 1911, when he filed his Declaration of Intention, he listed his residence as 1208 Geary Street, San Francisco, CA, and his occupation as an elevator operator. He is not named in the 1912 or 1913 editions of the Crocker-Langley San Francisco City Directory (SFCD).

On July 3, 1914, the County Clerk of the City and County of San Francisco issued a marriage license to Henry Huppert, 20, and Olga Marie Anna Ida Kahler, 16, both residents of the city. They were married on July 6, 1914, in the City Hall by Justice of the Peace Michael J. Roche in the presence of her parents, Mr. and Mrs. R. Kahler of 723 Baker Street, San Francisco, CA. Henry's name then appeared in the 1914 edition of the Crocker-Langley SFCD at 1729 McAllister Street with Richard M. and Emma Kahler, his in-laws. A picture of Henry and his wife, Olga, taken at a later date is shown in Fig. 3.

Fig. 3. An undated photograph of Henry Huppert with his wife, Olga. (Huppert papers)

The 1915 edition of SFCD shows that Henry and Olga Huppert moved with the Kahlers to 723 Baker Street, San Francisco. According to Herman Kahler, Henry and Olga lived in the top-floor flat at 723 Baker Street for about two years, then moved to a cottage in the Sunset District rented from Mr. Groat, a San Francisco policeman who headed the Chinatown Squad. The 1916 edition lists Henry and Olga Huppert at 1273 23rd Avenue.

The 1917 and 1918 editions show that they moved back to Baker Street with the Kahler family and then to the town of Ross in Marin County. Herman Kahler recalls that his sister Olga and brother-in-law, Hein, rented a house in Ross, Marin County, CA, for a little over a year before moving back to San Francisco. Olga recalls that neighbors in Ross were anti-German and didn't like her Austrian accent. Their neighbors made life so miserable for them that they moved back to the city. The city directories for 1919–1925 list Henry and Olga Huppert at 67 Scott Street. About 1925, they moved to 722 47th Avenue, San Francisco, a few blocks from the cliffs that overlook Seal Rocks and the Pacific Ocean.

In 1927, Henry Jr. was born at St. Joseph's Hospital, and Ralph Huppert was born at the same hospital fourteen months later on November 1, 1928. The damp, foggy climate proved to be injurious to the health of Henry Jr.—he had double pneumonia twice—so they moved south fifteen miles to Millbrae. Henry lived there with his family until his death on July 30, 1947.

Employment History

Henry Huppert had five basic employment situations between the time he entered the United States in March 1911 and the date of his death on July 30, 1947 (see Table 1). He was first employed at Western Electric as a telephone installer of telephone central office equipment between 1912 and 1915. According to a reference letter from Western Electric, his services had been satisfactory and his termination was necessary "to temporarily reduce forces." During this same period (1912–1913) he was also a consultant to Lee De Forest, who was then at Federal Electric in Palo Alto performing experiments on vacuum tubes. From Western Electric he went to Keystone Electrical Laboratories during the years 1915 and 1916. Exactly what he did there is not known, but the Keystone Company manufactured X-ray equipment. The 1916 San Francisco Directory listed Huppert as an engineer.

In 1916, Henry Huppert formed the Preston-Huppert X-Ray Laboratories at 1222 Howard Building, 209 Post Street, San Francisco, in partnership with Myers A. Preston. The 1917 and 1918 editions of the Crocker-Langley San Francisco City Directory list Henry Huppert as a radiographer at this address, but from 1919 to 1931, the same directory listed the Preston-Huppert X-Ray Laboratories at 209 Post Street, San Francisco. Thus, his employment at the Preston-Huppert X-Ray Laboratories covered 16 years from 1916 to 1931. However, during this period he also was a consultant to Moorhead Labs in 1917, and during parts of 1924 and 1925 he was also employed by A-P Radio Laboratories. Huppert was working at the Preston-Huppert X-Ray Laboratories during the time he designed and patented all three of his vacuum tubes intended for use in radios.

After terminating his Preston-Huppert X-Ray Laboratories partnership with Myers Preston in 1931, Huppert went to work for the American Electric Company of California as the general manager developing shortwave radiotherapy equipment. He developed and patented an X-ray tube there before leaving in 1935 to become a self-employed electro-therapist and X-ray technician at 450 Sutter Street, Suite 906, San Francisco, CA. He enrolled at the San Francisco College of Drugless Physicians on July 26, 1937, and earned the degree of Doctor of Physical Medicine on May 1, 1940. He treated patients with radiotherapy equipment for seven years until July

1947, when he died as a result of exposure to X-rays.

Henry applied to the Chief of the Bureau of Navigation for appointment in the voluntary Naval Communication Reserve (NCR) as a Lieutenant for communication duties for Special Service on August 20, 1926.[2] He was accepted as a lieutenant on October 23, 1926, and performed two weeks active duty each fiscal year, during which time he operated a home-made radio transmitter and receiver with his amateur radio operator's license as part of his duties. He remained in the NCR for the remainder of his life.

Table 1. Henry K. Huppert employment history with patents filed

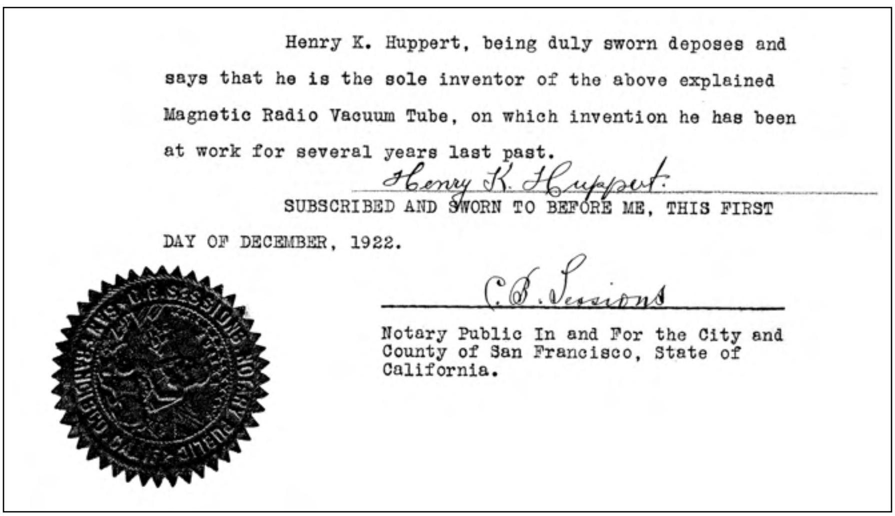
Dates	Employment and Patents Filed
March 7, 1911	Entered the United States
1912-1915	**Western Electric** • 1912-1913: Also a consultant to De Forest at Federal Telegraph Co.
1915-1916	**Keystone Electrical Laboratories**
1916-1931	**Preston-Huppert X-Ray Laboratories** • 1917: Also a consultant to Moorhead • 1923: Filed Solenoid tube patent • 1924-5: Also employed at **A-P Radio Laboratories** • 1924: Filed Two-in-One tube patent • 1925: Filed Quadrotron tube patent
1931-1934	**American Electric Co. of California** • 1931: Filed X-ray Tube patent • 1934: Filed diathermy machine patent
1935-1947	**Self-Employed as Electro-Therapist** • 1937-40: Attended San Francisco College of Drugless Physicians • 1940: Received Doctor of Physical Medicine degree
July 30, 1947	Died at age 54 of aplastic anemia from exposure to X-rays

PART II. HUPPERT'S TUBES

The Solenoid Tube

Gerald Tyne, author of *Saga of the Vacuum Tube*, considered the Solenoid tube to be "the final product of the Moorhead enterprise."[3] However, Tyne did not attribute the design of this tube to Henry Huppert, or any other individual for that matter. That Huppert designed the tube is clear from a sworn deposition that Henry Huppert signed and dated December 1, 1922 (see Fig. 4), which stated that he was the "sole inventor" of the Solenoid tube and that he named it the "Magnetic Radio Vacuum Tube." He further stated that he had been working on the tube for "several years last past." This deposition was signed in conjunction with a patent application he filed for this tube on January 19, 1923. Based on his signed statement, it appears that Huppert alone began to design this tube sometime in 1920.

There is nothing in Huppert's papers to indicate how he became involved in the design of the Solenoid tube. Huppert had been working since 1916 with his partner at their Preston-Huppert Laboratory, and he had no direct contact with Moorhead Laboratories after being a consultant for Moorhead Labs in 1917. However, by early-1920, Moorhead Labs was in desperate need of a vacuum tube that did not infringe on either the Fleming or De Forest patents. RCA, as successor to the American Marconi Company, had canceled agreements effective July 30, 1920, with Moorhead Labs and the De Forest Radio Telephone & Telegraph Company. Those agreements, which


Henry K. Huppert, being duly sworn deposes and says that he is the sole inventor of the above explained Magnetic Radio Vacuum Tube, on which invention he has been at work for several years last past.

Henry K. Huppert

SUBSCRIBED AND SWORN TO BEFORE ME, THIS FIRST DAY OF DECEMBER, 1922.

C. B. Sessions

Notary Public In and For the City and County of San Francisco, State of California.

Fig. 4. A sworn statement by Henry Huppert attesting to the fact that he alone designed the magnetic radio vacuum tube, popularly known as the Solenoid tube. (Huppert papers)

had been in effect since 1919, allowed Moorhead Labs to manufacture tubes under De Forest and Fleming patents for little more than a year.

Thus, one could presume that Huppert's involvement with such a tube was triggered by the cancellation of the contract with Moorhead Laboratories. This conjecture is supported by the fact that the Preston-Huppert Laboratory was located only several blocks away from Moorhead Labs, making it plausible that the two had kept in contact over the years since Huppert's consulting work with Moorhead in 1917. Whether Huppert had been asked to design a non-infringing tube for Moorhead Labs or took it upon himself to design such a tube is unknown, but it appears that he owned all the rights to the tube he eventually designed.

The Solenoid Tube Concept

Huppert reasoned that since De Forest vacuum tube patents covered an internal grid using an electric field to control electron flow from the filament to the plate, he would use an internal solenoid that produced a magnetic field to control the electron flow. Of course, this idea was not entirely new. On August 27, 1906, De Forest had filed a patent for a solenoid external to his audion in an attempt to control the flow of electrons from the filament to the plate (see Fig. 5).[4] De Forest's solenoid was oriented such that the magnetic field along the axis of the tube was

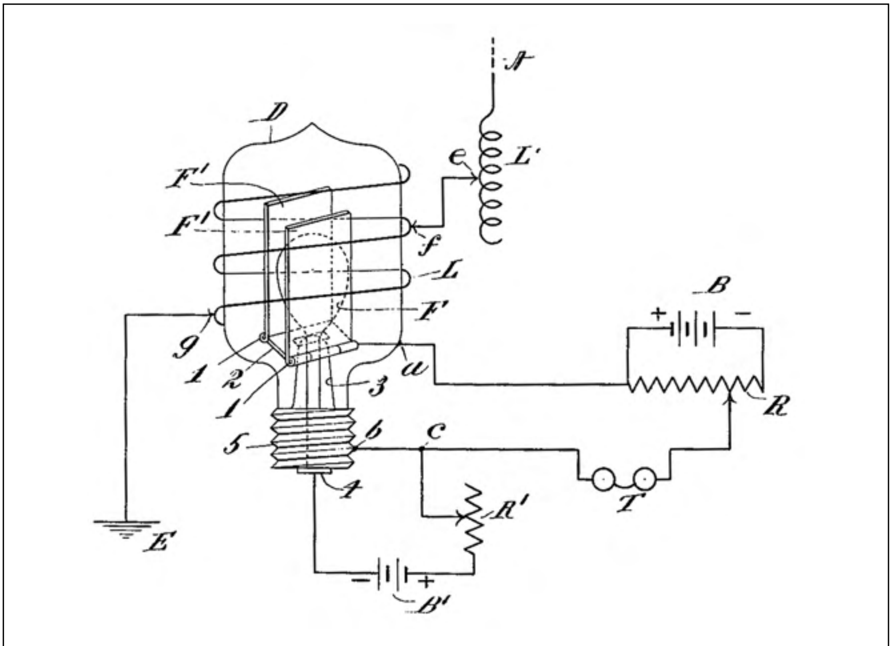


Fig. 5. De Forest's patent U.S. 841,386 issued January 15, 1907, for a magnetically controlled tube using a solenoid external to a vacuum tube.

perpendicular to the direction of electron flow in the radial direction, thereby maximizing the effect of the solenoid on electron motion. However, De Forest never pursued this concept, and since the solenoid was external to the tube, it did not forestall Huppert's patent on a solenoid coil within the tube.

The Mignon Wireless Corporation also had used the solenoid principle in the design of it RBD8 receiver in 1916,[5] although the solenoid in the form of two opposing coils was placed around the outside of a tube with an internal grid. Again, since the solenoid was not part of the tube, it did not forestall a patent on the tube that Huppert was developing with an internal solenoid.

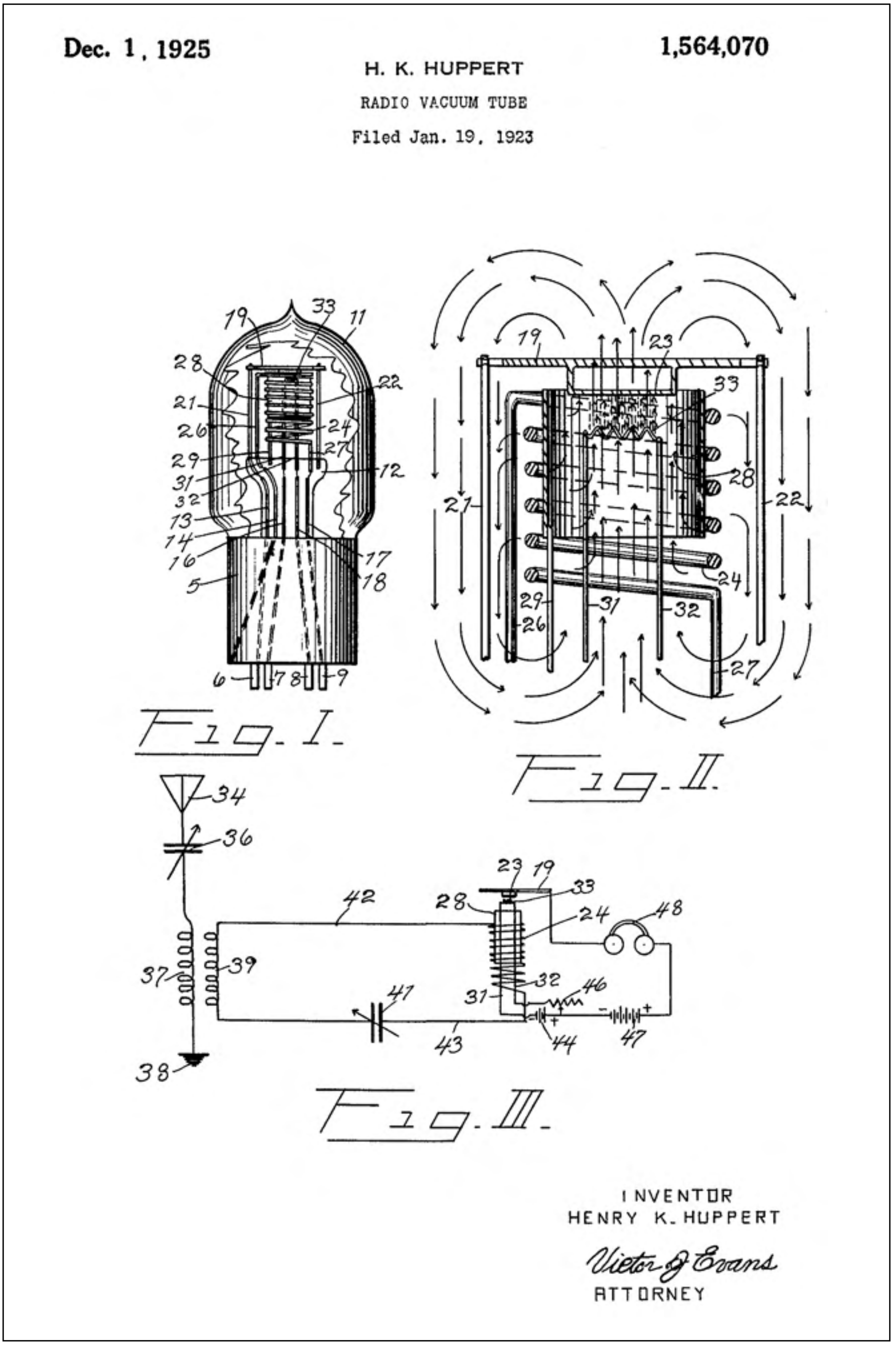
At the same time Huppert was developing his Solenoid tube *circa* 1920, graduate students under the direction of Earle M. Terry, Associate Professor of Physics at the University of Wisconsin, were studying the efficacy of an internal solenoid in controlling electron flow within a vacuum tube.[6] They also oriented their solenoid so that the magnetic field was perpendicular to the electron flow. The students published their results on March 16, 1921, stating that they were unable to get their tube to oscillate. Whether or not Huppert was ever aware of this study is unknown, but since the students reported null results, there is nothing obvious in this study that would have precluded Huppert from patenting his device.

Huppert's Solenoid Tube Patent

Huppert filed a patent entitled "Radio Vacuum Tube" on his Solenoid tube on January 19, 1923, which was issued on December 1, 1925, as U.S. patent 1,564,070 (see Fig. 6). The details of the tube shown in this figure will be explained in the following paragraphs using several documents that Huppert submitted to his attorney enabling him to prepare the patent documents. One of the most interesting documents Huppert provided his attorney was a photograph of four Solenoid tubes that Huppert signed and subsequently had notarized on December 14, 1922 (see Fig. 7). It is clear from the shape of the glass envelopes and the Shaw bases appearing in this photograph that these tubes were fabricated by Moorhead Labs. The Shaw bases used for the Solenoid tubes in this photograph were left over from the stock that Moorhead Labs had been using at the time it ceased tube production.[7]

Note that the construction details of these four early prototype tubes made sometime in 1922 are clearly different from another 38 prototype tubes that Huppert made in 1923, two of which are shown in Fig. 8.

While designs of these 38 tubes will be discussed in more detail later, suffice it to say that the most obvious mechanical differences in the 1923 prototype tubes are twofold—the use of a spool around which the solenoids are wound, and the addition of a metal structure at the base of the tube to support the solenoid spool. The four tubes in Huppert's photograph have neither of these features, but virtually all 38 of the 1923 prototype tubes have both. It is likely that the spool was added to facilitate



Dec. 1, 1925 1,564,070

H. K. HUPPERT

RADIO VACUUM TUBE

Filed Jan. 19, 1923

INVENTOR
HENRY K. HUPPERT

Victor J. Evans
ATTORNEY

Fig. 6. Huppert's patent U.S. 1,564,070 filed on January 19, 1923, for a magnetically controlled tube with a solenoid placed within the vacuum tube.

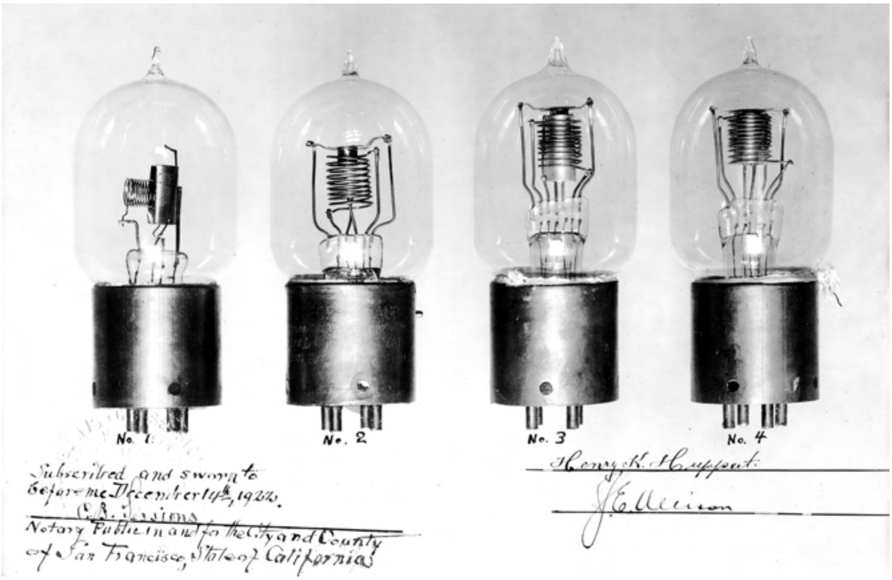


Fig. 7. A notarized photograph of four of the earliest known Solenoid tube prototypes designed by Huppert prior to December 14, 1922, the date appearing on the signed photograph. (Huppert papers)

Fig. 8. Two of 38 Solenoid tubes made in 1923, which were used in an extensive test program to determine the optimum design parameters for a production tube.

Fig. 9. An early prototype Solenoid tube used to test a concept for supporting the solenoid spool by using the glass envelope. (Lauren Peckham Collection)

fabrication of different solenoid diameters, wire dimensions, turn spacing, and number of wire layers.

A strange-looking Solenoid tube surfaced recently in the collection of Loren Peckham that may have been a step in the transition from the earlier prototypes to the later prototypes (see Fig. 9). The solenoid spool and Shaw base identify this tube as one designed by Huppert and manufactured by or in conjunction with Moorhead Labs. The diameter of the upper portion of this tube is reduced so that the solenoid spool fits snugly against the glass, presumably for lateral support. It is likely that this prototype tube was used to explore the possibility of using the glass envelope to support the solenoid structure. Based on later production tubes, which have the metal base, it is clear that a metal base support option was chosen over the glass envelope support option.

The first tube on the left of the Huppert photograph appears to be a variant of the Moorhead VT tube design in which the control grid has been replaced by a solenoid oriented perpendicular to the tube axis. The upright cylindrical plate has a slot that allows the solenoid to extend into the interior. The magnetic field lines produced by the solenoid interior to the plate are canted at various angles to the flow of electrons, which is radially outward from the filament towards the cylindrical plate. Consequently, the force exerted on the moving electrons will depend not only on the speed of the electron and strength of the magnetic field, but also on the angle between the directions of the electron flow and the magnetic fields.[8]

The second prototype tube is substantially different from the first. The cylindrical plate has been replaced by a flat plate located above the filament such that the electron flow is mostly along the axis of the tube and is aligned with the magnetic field produced by the solenoid. When the electron flow is aligned with the magnetic field, there is no force on the electrons; thus the magnetic field from the solenoid would have little influence on the electron flow to the plate. Also, note that the Shaw base on this tube has markings citing both of De Forest's audion patents, which, of course, were superfluous because the tubes did not infringe on the De Forest patents. A base with these markings was intended for use on the tubes manufactured by Moorhead for sale by RCA under the three-party contracts among Moorhead, RCA, and De Forest.

The two remaining tubes are something of an enigma. They clearly have a flat plate similar to that used on the second tube, but they also have a cylindrical structure under the solenoid that does not appear to be part of the plate. Fortunately, Huppert prepared a third document for his attorney that describes the individual elements of his Solenoid tubes and how he believed they worked (see Fig. 10). Referring to Figs. 5 and 6 of his document, he states, "The essential parts of these tubes are a plate, a filament, a metal tubular shield interposed between the filament and a solenoid, or coil of wire, which is wound in such a manner as to generate the greatest density of magnetic flux or lines of force from a minimum electric current." His patent describes this shield as being "constructed of any impervious material, such as glass, mica, fiber, aluminum or other similar

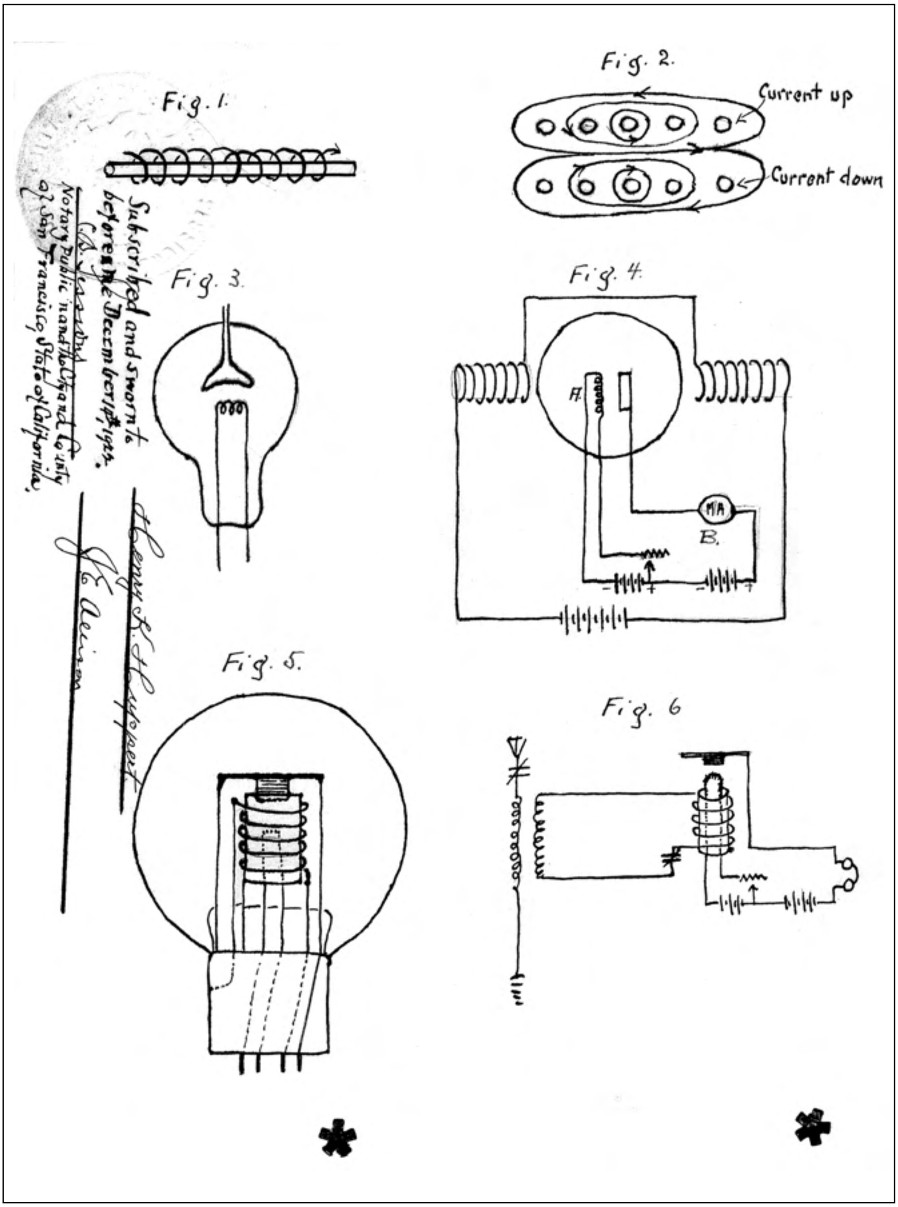


Fig. 10. Figures from a document Huppert prepared for his patent attorney in 1922 to describe the individual elements of his solenoid tubes and how he believed the tube worked. (Huppert papers)

metals." Clearly, the cylindrical structure was intended to shield the solenoid from electron impact. Neither the mechanical drawing of Fig. 5 nor the electrical drawing of Fig. 6 indicates whether or not the shield, if metallic, is electrically connected to the plate. The mechanical drawing indicates the extra lead required for the solenoid is attached to the base of the tube.

Huppert's notarized document goes on to explain how he believed his Solenoid tube worked: "These collective magnetic lines of force [from the solenoid] pass through the space between the filament and plate and affect the flow of electrons from the filament to the plate. If the magnetic field is being built up in the direction with the flow of electrons, it will increase the flow of current in the output circuit; if the magnetic flux is built up in the opposite direction it will decrease the flow of current in the output circuit…Due to the above functions this tube will act as a 'Detector or Amplifier.'" It seems that Huppert believed the motion of an electron was influenced by a magnetic field in the direction of electron flow. In fact, electron motion is influenced only to the extent that the direction of the magnetic field is canted at an angle to the direction of electron motion. When the direction of electron flow is aligned with a magnetic field, the force on the electron is zero, and the solenoid has no effect on the electrons as they move from the filament to the plate. Figure II of Huppert's patent (see Fig. 6) is clearly drawn with the magnetic field lines parallel to the flow of electrons along the axis of the tube from the filament to the plate, in which case the solenoid has no effect.

While Huppert's explanation is not correct, he was correct in stating that the magnetic field in the region between the filament and plate can affect the flow of current to the plate—however, only if the end of the solenoid is placed *below* the region between the filament and plate—as it is shown in Fig. III of his patent (see Fig. 6). In that case, the magnetic field lines of a solenoid have a radial component beginning at the end of the solenoid that can greatly influence electron motion in the region between the filament and plate. Huppert depicts the radial lines at the end of a solenoid in the upper right corner of Fig. 10. Test data, which will be discussed later, clearly showed that the effect of the solenoid was greatest when the end of the solenoid was positioned below the filament and was minimal when the end of the solenoid rested against the plate.

Huppert's 1923 Prototype Tubes

It is not clear why Huppert selected a baseline design in which the magnetic field and direction of electron flow were aligned. It is also not clear to what extent Huppert tested his first four prototype tubes made in 1922 before filing his patent. It is known from correspondence between Elmer Cunningham and RCA attorney L. F. H. Betts that Moorhead Labs postponed plans to manufacture the tube in April of 1923.[9] Instead of manufacturing one of Huppert's early tube designs, they initiated an extensive test and evaluation program, which eventually involved 38 prototype tubes with different solenoid parameters, including variations in dimensions, wire diameter, number of turns, and positions.

Moorhead Laboratories engaged consulting electrical engineer William W. Hanscom to test and evaluate the Solenoid tubes in real time as they were designed by Huppert. Hanscom began on May 23, 1923, by testing three tube samples. He reported that the first three tubes, all with the magnetic field aligned parallel to the flow of electrons, did not work well. After learning of the marginal performance of the first three prototypes, Huppert designed a whole series of tubes with different design details for test and evaluation by Hanscom—approximately 38 different configurations in all. The test results from each group consisting of two to six tubes (except for one group consisting of the last 19 tubes) were used to guide the design of each succeeding group. Each tube was numbered using white labels with red borders (see Fig. 11). It is notable that many of these prototype tubes can be found in tube collections today, complete with their numbers on white labels with red borders. Most of these labels are dated with the date of the test, all of which occurred between May 23 and July 9, 1923.

Fig. 11. One of 38 prototype vacuum tubes made in 1923, each of which had a white sticker with a red border affixed to the glass bearing a number in the order of testing (8), the date it was tested (5.28.23), and a key descriptor (5 contact). (Huppert papers)

Hanscom's test results are recorded in his notebook that can be found in the Perham Collection held by History San Jose. A 14-page report prepared by Hanscom covering tests of the 38 tubes entitled "Huppert Tubes" was found among the Huppert papers. According to the introductory page, this report dated August 14, 1923, contained "the principal results of a series of tests made upon a number of electron tubes constructed in accordance with the ideas of Mr. H. K. Huppert and delivered to me at different times during the periods covered by the dates between May 23rd, 1923 and July 9th, 1923, as follows." Moorhead Laboratories at 648 Mission Street is identified as the recipient of the report, which describes the physical characteristics of each tube, summarizes the test results, and identifies the tubes with the best performance characteristics.

Solenoid Tube Performance

The tubes were tested in a number of different circuits, most notably by measuring the current versus voltage (I-V characteristics) in "static" circuits using both simple detector and regenerative detector configurations, and by evaluating broadcast receptions with Solenoid tubes installed in representative receivers—specifically the Atlantic-Pacific AP-2 and Kennedy 110 regenerative receivers.[10] Both local and distant stations were used as excitation sources for evaluating receiver sensitivity and clarity with Solenoid tubes versus standard tubes of the day in the detector stage. Local stations in the Bay Area cited in the report were KPO (500 watts) and KLS (250 watts) in Oakland, and KUO (150 watts) and KLX (100 watts) in San Francisco. Long distance stations cited were KFI (500 watts) and KHJ (500 watts) in Los Angeles, and NPM, a high-powered Navy station with a 5 kW transmitter in the Honolulu area.

While it is beyond the scope of this article to describe the configurations or performance characteristics of each tube individually, Hanscom's summary of his test report describing the general results is most interesting. He begins by stating, "In summing up the results of the tests so far made, no final conclusion as to the actual operation of the tubes has been reached." He goes on to say, "The exact action of the tube is not clearly understood." Hanscom found that while some of the tubes were good detectors for local stations, none of the tubes would amplify, and only two would oscillate or bring in signals beyond the "bay district" (Nos. 16 and 18). He also found, "Another feature is the lack of effect of regeneration on the new tube." These statements are not surprising, given that the magnetic field of the solenoid had little effect on the electron motion in most of the tubes. Finally, he states, "Tube No. 16, which I rate as the best all around tube of the lot so far received, has one feature different from all of the rest. In addition to having a greater separation between the filament and plate, the winding on the spool has but 21 turns and the top one of these turns stops some distance below the plate, whereas of the other windings extend to the inside of the top flange which brings them in close proximity to the plate."

A tube with the glass envelope missing that matches this description was recently found in Loren Peckham's collection (see Fig. 12). While the top of the solenoid spool rests against the plate, the windings clearly stop some distance below the plate. Furthermore, there are exactly 21 windings on this solenoid spool in two layers. It turns out that this tube also matches a known production tube with the serial number 962, which appears in Fig. 13.

Fig. 12. A close up photograph of a tube without its glass envelope, believed to be a production tube based on the prototype No. 16. (Loren Peckham Collection)

Fig. 13. A production Solenoid tube stamped with the number 962 followed by "A. P. Solenoid" and "Patent Pending."

From the viewpoint of a user, the most interesting results were related to the performance of the Solenoid tube when used as detectors in the two selected radio sets of the day (Atlantic-Pacific AP-2 and Kennedy 110). Since none of the tubes was able to amplify, there was no reason for Hanscom to test them in amplifier stages. The results of Hanscom's tests of the Solenoid tubes as detectors in the two radios are reproduced with minor editorial changes in the Test Report sidebar. Summarizing the entire sidebar in a single sentence, Hanscom wrote, "Owing to its being a detector only, it does not reproduce any of the fringe from the transmitting station but makes the voice and music very clear and in one case, working with a two-step amplifier, the signals from the loud speaker were considerably clearer and better when the standard tube [supplied with each of the two sets] was replaced by one of the new ones [Huppert's Solenoid tube]."

Moorhead and A-P Radio Supplies Companies Cease Operations

The results of these tests must have been a disappointment to both Huppert and the key management of Moorhead Laboratories and its sales organization,

W. W. Hanscom Test Program Report Summary

In summing up the results of the tests so far made, no final conclusion as to the actual operation of the tubes has been reached. Two receiving sets were connected so as to permit the use of the standard regenerative circuit in one and the Huppert circuit in the other, and a double pole, double throw switch permitted connecting either to the head receivers. In this way it was possible to tune both sets to the same station and make a direct comparison between two tubes when both were adjusted to their maximum sensitiveness, and when working as an external grid tube or as a solenoid tube.

The conclusion has been reached that the new tubes work as detectors, it being practically impossible to make them oscillate, with the exception of two tubes previously mentioned (#16 and #18). Regeneration has no effect of any magnitude, sometimes increasing strength of signals and sometimes decreasing it. I have been unable to use any of the tubes as amplifiers, and no appreciable difference has been noted in the operation of the tubes when used in either the standard or Huppert circuits.

When compared with any of the other tubes as a simple detector without oscillation, the best of the new tubes is practically as good, but when regeneration is used in connection with the tubes now on the market, the new tube is from 50% to 85% as good in signal strength. Owing to its being a detector only, it does not reproduce any of the fringe from the transmitting station but makes the voice and music very clear and in one case, working with a two step amplifier, the signals from the loud speaker were considerably clearer and better when the standard tube was replaced by one of the new ones.

The new tube cannot be used to pick up distant stations. It is not good for long distance work on weak signals as it requires an appreciable amount of original signal strength for its operation and also requires closer coupling and more capacity in the grid condenser when used in a standard set. It is a good tube for use with single circuit receiving sets and has a very wide range of both A and B battery adjustments, which are not at all critical.

Local stations, those around the Bay of San Francisco, come in very good; Los Angeles has been heard with about 50% of the strength of a standard tube, as have San Jose and Portland, but in the case of the more distant stations it has not been possible to pick them up without first getting the proper tune with a standard tube and then changing to the new tube and making the final adjustments.

It has been stated that the new tubes are not as sensitive to weak signals as are the standard tubes; it has also been noted during tests that stronger signals give a proportionately greater response in the receivers. Owing to this feature, much of the weaker interference that would otherwise be audible is eliminated and the desired signals are retained without the necessity for loose coupling.

Atlantic-Pacific Radio Supplies Company, referred to hereinafter as A-P Radio Supplies Co. The key decision makers of both companies, President Willis M. Deming and Director Willard F. Williamson, had counted on the Solenoid tube being the future of the A-P Radio Supplies Company. It was intended to be a non-infringing replacement for the infringing Moorhead VT tube that the A-P Radio Supplies Company could no longer legally manufacture or market.

When company executives learned the tube could not amplify and barely oscillated, they realized it would not be a very popular tube. Consequently, they made the decision not to put the Solenoid tube on the market as planned. Instead, they looked again to Henry Huppert to find an alternative solution. According to an entry in Hanscom's notebook dated October 22, 1923, Huppert "brought in several new tubes made by him having thoriated filaments and chemical exhaust (i.e., a getter to enhance the vacuum) with sodium mercury amalgam." He also wrote that one of these tubes "had 2 concentric 3 element structures mounted in parallel with one filament central thru both." He quickly tested it and found it "worked very well, equal to the 201-A," which GE was manufacturing for sale by RCA. This tube would later become known as the Two-in-One tube, which is addressed next.

This new tube had great performance characteristics, but it also had an internal grid structure that would have infringed on De Forest's tube patents. But at that time, it was generally believed that tubes with internal grids could be legally manufactured and sold when the first De Forest tube patent (No. 841,387) expired on January 15, 1924, only six months hence. Clearly, the management of the A-P Radio Supplies Company believed that was the case because in late 1924 they announced to the trade that they would resume manufacturing of the tube in January of 1924 when De Forest's patent expired. This announcement was memorialized in a letter from Elmer Cunningham to L. F. H. Betts dated Dec. 13, 1923, stating:

> "At a recent meeting of the local Radio Trade Association, the sales manager of the Moorhead, Atlantic-Pacific Companies made a public announcement that they would resume manufacture of vacuum tubes in January after the expiration of the DeForest patent. . . . For some time these people have been talking about a new tube that they have, and I have been fortunate in seeing a sample. It is a rather crude looking affair and really possesses no merit. I cannot state at this time whether they contemplate the manufacture of this special tube or a tube with a grid and plate on opposite sides of the filament. I am keeping in close touch with the situation and will advise you of any development."

L. F. H. Betts responded to Cunningham's letter with a letter of his own dated Dec. 19, 1923:

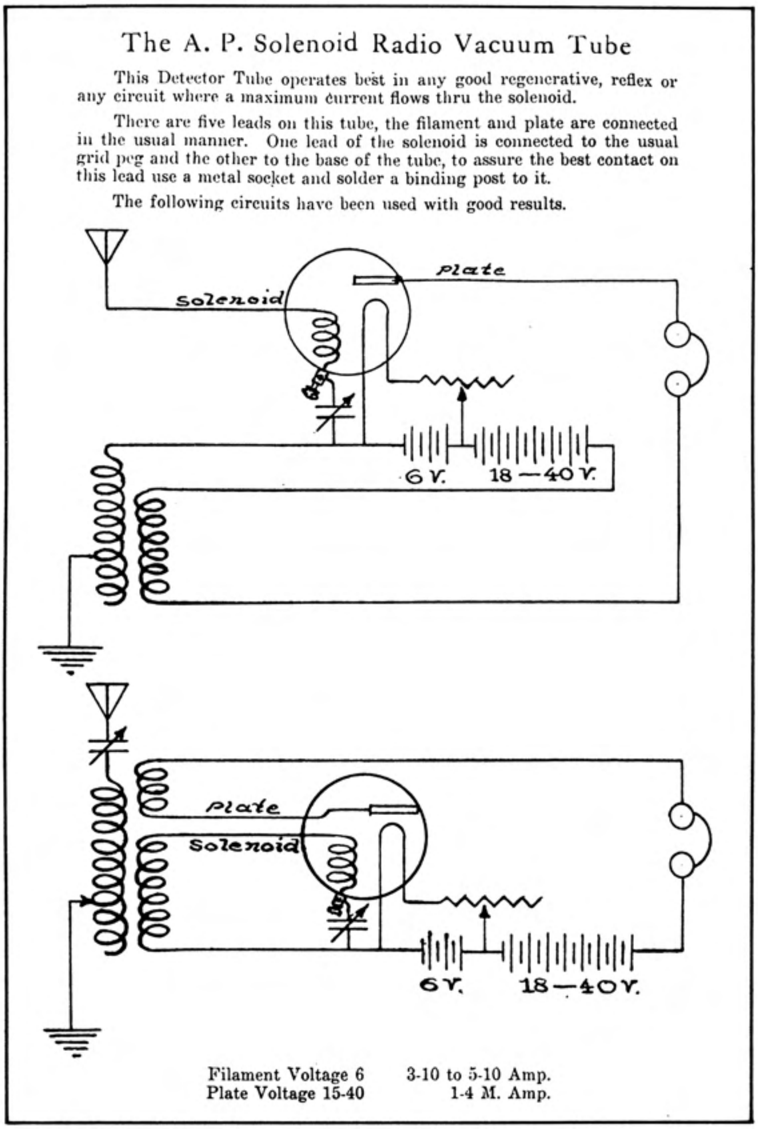
> "Other people evidently have the idea that when the first DeForest patent expires in January 1924, the manufacture of vacuum tubes will be open, but of course you know as well as I do that the second DeForest patent [879,532], which does not expire until February 1925, for the specific form of the three-element tube in which the grid is located between the filament and the plate, effectively controls the vacuum tube situation."

In December 1923, the officers and directors of the Moorhead Labs and A-P Radio Supplies Co. became aware that the second De Forest patent controlled the vacuum tube situation and that the new tube with internal grids would infringe that patent. Williamson, an experienced attorney, was probably the one who realized that if the Moorhead and A-P Radio Supplies Company were to proceed with their plan to manufacture and market this tube in January of 1924, the company and all associated parties who were under the injunction proscribing the manufacture and sales of tubes infringing on the second De Forest patent could be sanctioned quite severely by the court with a simple motion filed by either RCA or AT&T. They not only made a decision not to proceed with the manufacture of either the Solenoid or internal grid tube as originally planned, but they decided to cease operations altogether. Corporate Secretary Williamson testified at the Federal Trade Commission hearings in 1926 that the directors allowed the charter of the Moorhead Laboratories to expire in January 1924, thereby dissolving the company.[11] The A-P Radio Supplies Co. was also abandoned in January of 1924, although in a somewhat circuitous manner. Some historians believe that one or both of these companies were reorganized with a change in name only, but that is not so. Instead, the assets of Moorhead Labs and A-P Radio Supplies Co., including the tube manufacturing equipment and rights to the two tubes, were sold to an entirely new entity, albeit with similar name—the A-P Radio Laboratories Company. This new company would market both the Solenoid tube and the new Two-in-One tube.

Production of the Solenoid Tube

It is not known exactly when the Solenoid tube went into production, but there is strong evidence that there was indeed a production tube and that it was marketed by the new A-P Radio Laboratories Company sometime in 1925. While no ads for the Solenoid tube have been found, Solenoid tubes with serial numbers and instruction sheets intended for users have been found. The Solenoid tube pictured in Fig. 13 has the serial number 962 and the words "A. P. SOLENOID TUBE" followed by "PATENT PENDING" stamped on the base. Two other identical examples of this tube have also been found, one without any marking on the glass and the other described previously with the glass missing. These three tubes match Hanscom's description of Solenoid tube No. 16, which he stated was "the best tube of the lot."

An instruction sheet that came with the tube is shown in Fig. 14. Note that the sheet contains pertinent information on the key operating voltages and currents for this tube. Note also that this tube has five terminal connections rather than the usual four associated with vacuum



The A. P. Solenoid Radio Vacuum Tube

This Detector Tube operates best in any good regenerative, reflex or any circuit where a maximum current flows thru the solenoid.

There are five leads on this tube, the filament and plate are connected in the usual manner. One lead of the solenoid is connected to the usual grid peg and the other to the base of the tube, to assure the best contact on this lead use a metal socket and solder a binding post to it.

The following circuits have been used with good results.

Filament Voltage 6 — 3-10 to 5-10 Amp.
Plate Voltage 15-40 — 1-4 M. Amp.

Fig. 14. A tube carton insert for the Solenoid tube entitled the "A. P. Solenoid Vacuum Tube," which illustrates two detector circuits that "have been used with good results." (*Saga of the Vacuum Tube,* p. 181)

tubes with internal grids that were matched to Shaw bases. The solenoid coil required two connections rather than the single connection needed for an internal grid. Consequently, one end of the solenoid was attached to the base, which formed the fifth terminal. Such an arrangement would make it difficult to use this tube as an exact replacement for three-element tubes with four pins used in virtually all radios of the day. Since some rewiring would have been necessary, amateurs and experimenters were most likely the target customers.

Two-in-One Tubes

History of the A-P Radio Laboratories Company

While Henry Huppert designed both the Solenoid and the Two-in-One tubes for the Atlantic-Pacific Radio Supplies Company (a.k.a. A-P Radio Supplies Co.), both tubes were actually marketed by a completely different entity with a very similar name—the A-P Radio Laboratories Co. It is appropriate to begin this section with a summary of how and why the assets of the old company were transferred to the new company, a story that has been chronicled elsewhere.[12] W. F. Williamson, attorney for both Moorhead Laboratories and A-P Radio Supplies Company (the sales organization for Moorhead Labs) prepared the incorporation papers for the new A-P Radio Laboratories Co., which were filed on March 21, 1924. The Articles of Incorporation for this company mimicked those of the Atlantic-Pacific Radio Supplies Company that Williamson had filed a few years before on August 31, 1921, when it was incorporated. Williamson picked the officers and directors of the new company and also arranged for D. C. Seagrave to be president and D. E. Gunn to become Secretary. Other key employees who subsequently joined the company were Frank Polkinghorn, a prominent engineer who in 1924 joined the company as its chief engineer in charge of tube design, and Henry Huppert, who also joined the company later in 1924 and became the head of the manufacturing and sales departments on February 1, 1925.[13]

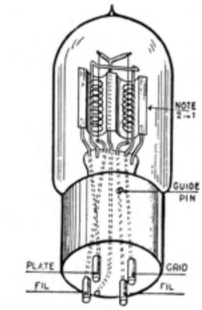
In testimony before the Federal Trade Commission hearings on October 20, 1926,[14] D. E. Gunn, Secretary of A-P Radio Laboratories, revealed some interesting facts about the activities of the company. He stated that the company acquired the manufacturing equipment of Moorhead Labs from an unidentified trustee of the defunct Moorhead Labs Company—which must have been W. F. Williamson, Corporate Secretary for Moorhead Laboratories, who was responsible for liquidating the assets of Moorhead Labs. Second, when asked how the tubes were sold, Gunn testified that they were sold through a sales agent, which at first was Electric Appliance Company and later the Baker-Smith Company. In fact, no ads placed by A-P Radio Laboratories have been found in the literature, but ads placed by the Baker-Smith Company for Two-in-One tubes have been found (see Fig. 15).[15] Note this ad states in fine print: "These tubes are made by the

New A-P Two-in-One Radio Tube

2 grids
2 filaments } *in* { *one tube*
2 plates

Great Sales Advantages

ASSURES INCREASED PROFITS



6 Volt .25 Ampere

A Product that is Made Right

ALL TUBES ARE MATCHED AND BALANCED

This tube is of a new, original and unique design. It is not an infringement or poor imitation of so called Standard tubes, which puts it in a class by itself.

We also feature standard "DRY CELL" Tubes

No. 306P—3 Volt .06 Ampere, with Peanut Base
No. 306A—3 Volt .06 Ampere, with Standard Base.

These Tubes are made by the successors to the makers of the famous "MOORHEAD" tubes used by all the ALLIED GOVERNMENTS during the World War.

BAKER-SMITH CO., *National Distributors*

Also National Distributors for Rola Re*Creators and Phonograph Units

74 NEW MONTGOMERY STREET, SAN FRANCISCO

443 S. San Pedro St., Los Angeles
318 Atlas Block, Salt Lake
427 Henry Bldg., Portland
L. C. Smith Bldg., Seattle
311 Colorado Bldg., Denver
and all principal eastern cities

MANUFACTURED BY

A-P RADIO LABORATORIES, Inc.

650 Mission Street, San Francisco

Reprinted from HARDWARE WORLD, February 1925

Fig. 15. A reprint of an ad placed in 1925 by the Baker-Smith Company (national distributor for A-P Radio Laboratories) for the new A-P Two-in-One Radio Tube. (Huppert papers)

successors to the makers of the famous "Moorhead" tubes . . ." This statement may be useful in advertising, but it is not true in a legal sense. It is clear from testimony and other documents that A-P Radio Laboratories was a separate entity with different officers and directors, and that this new entity purchased the Moorhead manufacturing equipment and had no liabilities associated with the old Atlantic-Pacific Radio Supplies Company.

Gunn mentioned that two advertising circulars had been prepared and distributed, one of which with a date of 1925 has been found among the Huppert papers (see Fig. 16). When asked for the name of the tube that the company was selling, Gunn responded "Two-in-One." He was not asked if there were any other tubes sold by the company, and he did not mention anything about the sale of a Solenoid tube.

Gunn also testified that the company manufactured an average of 3,000 tubes per month until July 1925, at which time the company voluntarily ceased operations. However, he did not say anything about the time frame when the two different tubes were sold. Thus, one can conclude that the company manufactured approximately 39,000 tubes for the thirteen months the company was in business, but one cannot determine how many were Solenoid tubes versus Two-in-One tubes. Both tubes may have been sold simultaneously for the entire period, or the Solenoid tube may have been sold first, thereby delaying the date at which the infringing Two-in-One tube was sold until after the second De Forest audion patent expired, thereby forestalling legal action by either RCA or AT&T.

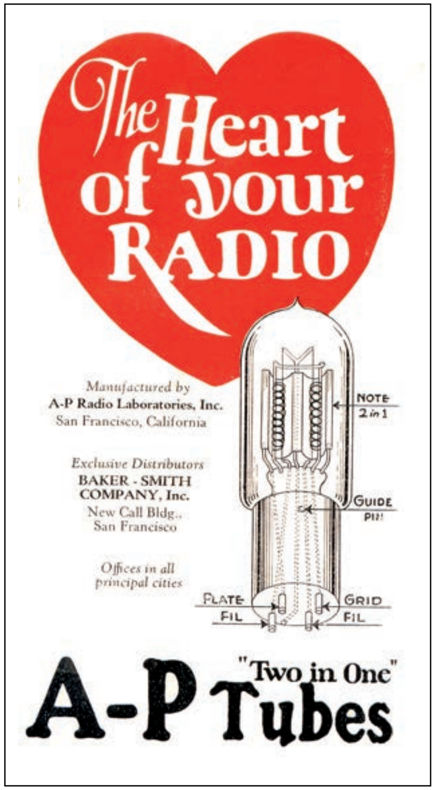


Fig. 16. A sales brochure prepared by Huppert in 1925 describes the advantages of the A-P Radio Laboratories Two-in-One tube. (Huppert papers)

It is interesting to note that Huppert wrote a feature article for *Hardware World* magazine describing the "new A-P 'Two-in-One' tube" in which he identified the Baker-Smith Company as its then current distributor. This article appeared in the February 1925 issue, the very month that the second De Forest patent expired.[16] The only known photograph of Huppert to be published appeared in this article. Huppert's photograph in this publication is so close to the photograph from the Huppert papers appearing at the beginning of this article that both pictures must have been taken at the same sitting.

Two-in-One Tube Design

Huppert filed a patent on the Two-in-One tube on June 11, 1924, shortly after the new A-P Radio Laboratories Company was formed in March (see Fig. 17). This tube was simply two triodes wired together in parallel within a single envelope for the purpose of increasing the power output. The sales brochure published by the company in early 1925 stated the Two-in-One tube would produce more power without distortion and promised that replacing the amplifier tubes in a receiver would mean "less effort to bring in distant stations—greater clarity—easier tuning—greater efficiency of your set."

The two triodes in the Two-in-One tube were contained within a single structure formed by two plates positioned vertically within the glass bulb and attached lengthwise as shown in the cutaway sketch of Fig. 18. An example of this tube without its glass envelope

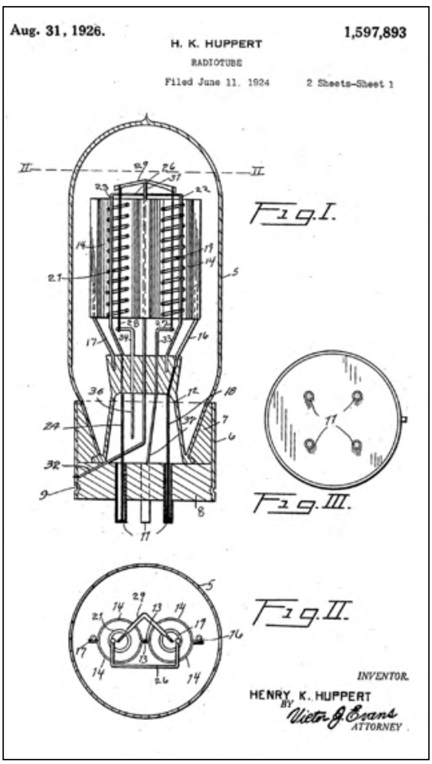


Fig. 17. Huppert's patent U.S. 1,597,893 filed on June 11, 1924, for the Two-in-One tube.

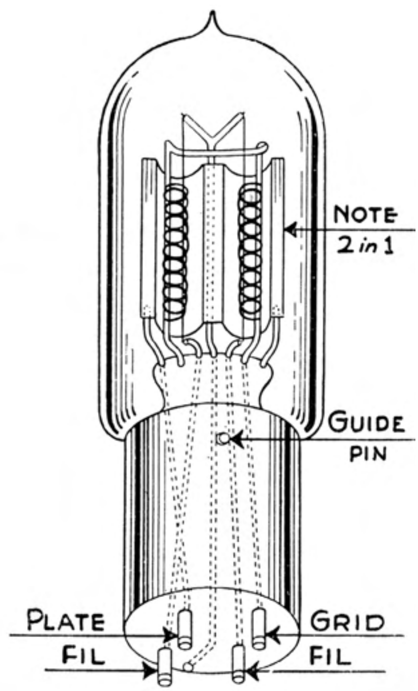


Fig. 18. Drawing of the Two-in-One tube detailing the internal structure of the tube and the five contacts, which consist of four pins on the base and the brass base itself. (Huppert papers)

provides a clear three-dimensional view of the plate structure with two separate but joined cylindrical plates (Fig. 19). Spiral-wound grids were placed in each of the cylindrical plates and connected so they acted in concert. A single filament ran up from a pin in the base, through the center of the grid in one cylinder to the top, over a "Y"-shaped support to the other cylinder, and then down through the other grid to a second pin in the base. A special lead was brought out from a center tap of the filament at the midpoint along the top and connected to the metallic base of the tube without going through either cylinder. Thus, the base of the tube constituted a fifth electrode. With this center tap, the filament could be connected in series or in parallel and could be operated on either 3 or 6 volts.

Fig. 19. A photograph of the interior of a Two-in-One tube that is missing the glass envelope.

The 1925 A-P Radio Labs brochure identified four different types of Two-in-One tubes that are listed in Table 2: a 625A amplifier and a 625D detector operating on 5 volts at .25 amps, and 306A and 306P tubes operating on 3 volts at .025 amps, both of which functioned as either a detector or amplifier. The Type 625A amplifier is stamped "Amplifier" on the Shaw base, while the Type 625D tube is stamped with "Detector" on the base. Both are also stamped with and "6 Volt" and ".25 Amps" (see Fig. 20).[17] Because the Type 625D tube was described as a "new" tube in the brochure, it must have been produced later than the Type 625A—the very first one in the line of Two-in-One tubes.

Many, if not all, of the 625 tubes were also stamped on the opposite side of the base with the following five lines: Two-in-One A. P. Tube/ Made by/ A. P. Radio Laboratories/ San Francisco/ Patents Pending (see Fig. 21). The 625D detector was identical in construction to the 625A except that it was "a gas contained tube." The brochure warned the user that the amplifier tube 625A

Fig. 20. The Type 625A Two-in-One nickel tube base is stamped with "Amplifier" (left), and the Type 625D nickel tube base is stamped with "Detector" (right).

Table 2. Four types of Two-in-One tubes listed in the A-P brochure, "The Heart of Radio," published in 1925.

Tube No.	Base	Use	Glass Shape	Filament	
625A	Shaw	Amplifier (hi-vac)	Moorhead	5V	0.25A
625D	Shaw	Detector (gassy)	Moorhead	5V	0.25A
306A	Shaw	Amp and Detector	Cylindrical	3V	0.07A
306P	UV-199	Amp and Detector	UV-199	3V	0.07A

should not be used as a detector or the tube will "over-sensitize the set and make it microphonic."

The type 306A and 306P had low-current filaments that were designed for use with dry cells, and despite the "A" designation on one, both were designed to function as either a detector or an amplifier. The Type 306A had a Shaw base with a distinctive tubular-shaped glass envelope—unlike the 625A, which had the classic Moorhead glass envelope (see Fig. 22). The 306P had a UV-199 base and a matching glass envelope. Since the tube was described as a "Peanut type" tube, the letter "P" was most likely selected to reflect the fact that it was a much smaller tube than the other three in the Two-in-One tube family. However, in addition to the four tubes described in the brochure, a tube stamped 306M with an appearance

Fig. 21. Many, if not all, 625A and 625D tubes were stamped on the base with the following five lines: Two-in-One A. P. Tube / Made by / A. P. Radio Laboratories / San Francisco / Patents Pending.

Fig. 22. The 625A and 625D with 6-volt filaments had a Shaw base with a classic Moorhead glass envelope (left), but the 306A with 3-volt filaments had a tubular shaped glass envelope (right).

identical to the 306P has also been observed (see Fig. 23). The significance of the letter “M” is not known.

Of all the tubes Huppert designed and patented, the Two-in-One was the one that enjoyed the most commercial success, an assertion supported by the larger number of Two-in-One tubes in collections today as compared to the other types of tubes associated with Huppert. Hugo Gernsback thought enough of this tube to award it the “Certificate of Merit,” which was given by Radio News Laboratory for “passing rigid tests” and possessing “all the high standards adopted for this type of product.” The original certificate was found among the Huppert papers (see Fig. 24).

Despite the initial success of this tube, the company ceased operations in July of 1925. Secretary of A-P Radio Laboratories, D. E. Gunn, gave two

Fig. 23. Evidence that A-P Radio Laboratories made a Type 306M with a UV base in addition to a Type 306P tube, both of which were characterized as a “peanut tube.” (Joe Knight Collection)

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Number 692

RADIO NEWS LABORATORIES

Certificate of Merit

We hereby Certify that this Certificate of Merit has been awarded to A-P RADIO LABORATORIES in connection with their 2 IN 1 A-P TUBE

This TUBE has been subjected to the various rigid tests of our laboratories and has been found to possess all the high standards adopted for this type of DETECTOR AMPLIFIER AND OSCILLATOR

The article complies fully with all modern radio engineering principles of this class.

Awarded the Certificate of Merit.

RADIO NEWS LABORATORIES

Directors

THIS CERTIFICATE IS SUBJECT TO CONDITIONS ON THE REVERSE SIDE

Fig. 24. The original Certificate of Merit awarded to A-P Radio Laboratories by Hugo Gernsback for the 2-in-1 A-P tube. (Huppert papers)

reasons for the company discontinuing business in July 1925, the principal one being that by early 1925 the retail price of tubes dropped to the point that it was no longer profitable for the company to manufacture tubes. The second reason cited was the difficulty the company had in obtaining filament material. While the company stopped producing tubes in mid-1925, it was not until March 8, 1932, that the company was suspended for reasons unknown—possibly for failure to file documents required in the normal course of business. This would have been an inexpensive way of going out of business without having to file dissolution papers.

The Quadrotron Tube

Henry Huppert's Quadrotron tube was first introduced to the public in an article appearing in the April 1926 issue of *Radio News* entitled "A Departure in Radio Tube Design."[18] The Quadrotron pictured in Fig. 25 was a four-element tube with two control grids, one of which was designed to reduce or eliminate the space-charge barrier around the filament, thereby allowing more current to flow to the plate using lower voltages. He also made claims in his patent that the second grid reduced the energy loss in the tube, eliminated self-oscillations produced by feedback from the inter-electrode capacity between the plate and control grid, and increased the amplification factor.

The idea for this tube was almost certainly inspired by an editorial written by Hugo Gernsback in the August 1924 issue of the *Radio News* introducing American readers to both the Solodyne principle and the Solodyne tube,[19] which also used a second grid to dissipate the space-charge barrier. Gernsback's editorial was followed by a number of articles in *Radio News* during the rest of 1924 and into 1925 describing a number of circuits using the Solodyne tube.

It is not known exactly when Huppert started working on this tube, but it is known that he filed a patent on this tube on December 21, 1925, which issued as U.S. patent 1,631,035 on

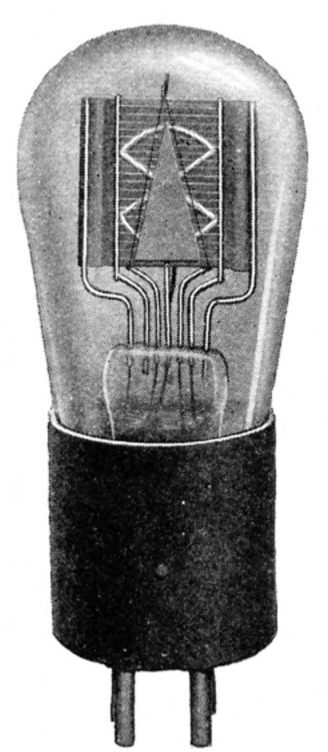


Fig. 25. The Quadrotron with a triangular object mounted in the center constituting a fourth element that was often characterized as a space-charge control grid. (*Radio News*, July 1926, p. 52)

May 31, 1927 (see Fig. 26). He was working for the A-P Radio Laboratories at the time Gernsback published his editorial and was there until the company ceased operations in July of 1925. He was listed as a consultant for the Baker-Smith Company in the article published on the Quadrotron in April of 1926. Recall that Baker-Smith Company was the distributor for Two-In-One tubes made by the A-P Radio Labs until it ceased operations in July 1925, but by December of 1925 the Baker-Smith Company also manufactured equipment including Sylfan vacuum tubes with a bulb shape exactly matching that of the Quadrotron appearing in Huppert's April 1926 article.[20]

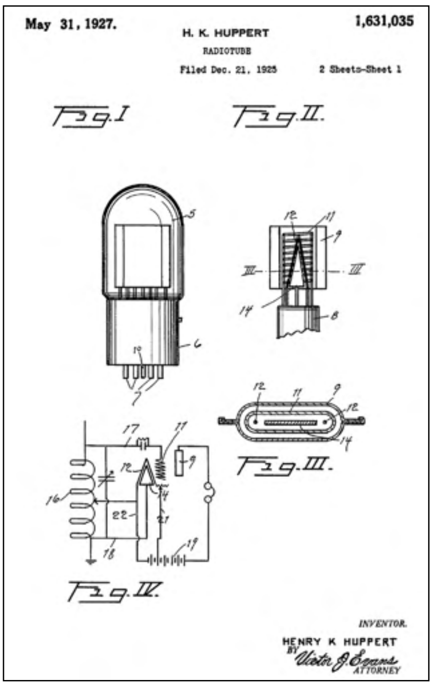


Fig. 26. The first page of Huppert's U.S. patent 1,631,035 for the Quadrotron tube.

Status of Four-Element Tubes in 1925

To appreciate the innovative nature of Huppert's Quadrotron, it is necessary to understand the status of four-element tubes with two grids at the time he designed this tube in the mid-1920s. Tubes with two grids, generally known as tetrodes, were not new at that time. Both Irving Langmuir and Walter Schottky had proposed tubes with two grids well before 1920.[21] Two types of two-grid tubes had been contemplated—one featuring a space-charge suppression grid inserted between the filament and the control grid, and the other with a screen grid inserted between the control grid and the plate. The space-charge suppression grid, when positively charged, neutralized the space charge between the filament and the control grid, thereby permitting a larger current to flow from the filament to the anode for a given plate voltage. The greater the change in plate current for a given change in control-grid voltage, the larger the amplification factor becomes. The screen grid inserted between the control grid and the plate reduced the grid-to-plate capacity, thereby reducing effects of feedback. It also prevented fluctuations in the plate voltage from influencing electron flow to the plate. The tube type with a space-charge grid became known as a "double-grid" tube—as in double control grid—while the second type became known as a "screen-grid" tube, a nomenclature that will be used in the remainder of this article.

Interest in the double-grid tube was heightened in early 1924 when

G. V. Dowding and K. D. Rogers, two technical editors of the *Popular Wireless Weekly* in England, introduced the "Unidyne Principle," which they claimed was a "revolutionary discovery."[22] The Unidyne principle was a circuit concept in which the "B" battery was eliminated in favor of the filament battery, which supplied a lower voltage to the plate in the range of 4 to 6 volts. While the discovery was made using a three-element tube, they found that a double-grid tube "obtained some really first-class results," a statement that increased interest in double-grid tubes. The editors used the available double-grid, four-electrode Thorpe K4 tube for their experiments. This tube had been introduced by the Bower Electric Company of England earlier in 1924 (see Fig. 27).[23] The four electrodes used in this tube are shown in Fig. 28—plate or anode, filament, main control grid, and a smaller space-charge grid located between the filament and control grid.[24] After the Unidyne principle was made public, the Bower Electric Company lost no time in advertising the K4 tube as the one "used by the inventors of the famous 'Unidyne' Circuit during their experiments…"[25]

Fig. 27. The four-electrode K4 tube introduced by the Bower Electric Company of England earlier in 1924 under the Thorpe trade name. (The National Valve Museum)

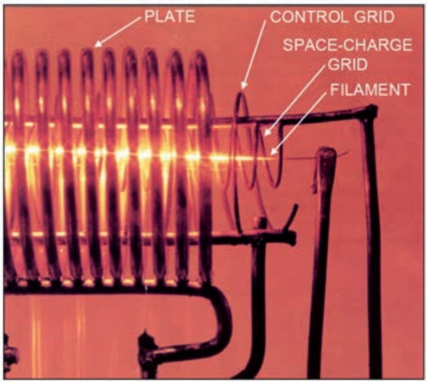


Fig. 28. The four-element K4 bi-grid valve with a space-charge grid located between the filament and the main control grid. (Desmond Thackeray, *Radio Bygones*, April/May 1994)

Interest in the Unidyne Principle spilled over to the United States when Hugo Gernsback made an agreement with editors of the *Popular Wireless Weekly* to gain exclusive rights to the Unidyne principle in America using the trade name "Solodyne." The agreement was announced in the August 1924 issue of *Radio News*. In the same issue of *Radio News*, the Nutron

Manufacturing Company of Passaic, NJ, began to advertise the Solodyne tube, a trade name licensed to the Nutron Company by Gernsback. A number of additional Solodyne circuits were published in subsequent issues of *Radio News* in 1924, most of which featured a double-grid tube.

The Solodyne principle was referenced only occasionally in issues of *Radio News* in 1925, but in the December issue, Theodore H. Nakken wrote a feature article entitled "Multiple Grid Vacuum Tubes and Their Advantages." That Gernsback was still betting on the multiple-grid tube was evident by the following note he placed under the title of the article: "An interesting article is here presented that every true radio fan should read carefully, as it concerns a development which should soon be widespread." However, the article featured not only the double-grid tube but also the screen grid tube, and Nakken never mentioned the Solodyne or Unidyne principle.[26] Nakken showed an unidentified image of a double-grid tube, which was clearly the K4, although he never mentioned it by name. He clearly stated that the extra grid in the double-element tube was located between the filament and the control grid and was designed to nullify the effects of the space charge surrounding the filament. Nakken also provided a representative circuit for the double-grid tube in which the space-charge grid was connected to the positive tap of the "B" battery to provide space-charge neutralization (see Fig. 29).

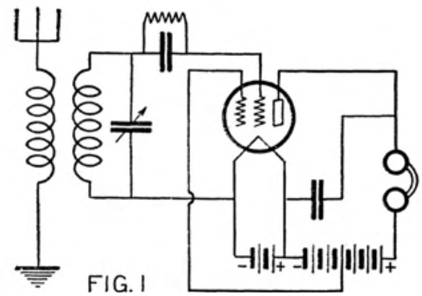


Fig. 29. Nakken's representative circuit for the double-grid tube in which the space-charge grid was connected to the positive tap of the "B" battery. (*Radio News*, Dec. 1925, p. 804)

According to Nakken, the function of the space-charge grid was twofold—to increase the amplification factor, and to reduce the battery voltage requirements for the "B" battery. Note that he never mentioned the concept of *eliminating* the "B" battery—which was the main objective of the Unidyne/Solodyne principle. He cited an increase in the amplification factor "from about 6 or 7 in an ordinary three-element tube to about 20 or more without an increase in the internal output impedance, so that tubes of this kind [double-grid tubes] are also suitable as power tubes."[27]

The Quadrotron Design

Huppert's Quadrotron incorporates the usual V-shaped filament surrounded by a spiral grid structure that in turn is surrounded by a solid cylindrical plate (see Fig. 30). The unique feature of this tube is the solid, flat, triangular plate that is placed under, and in close proximity to the triangular filament. In this figure, it is identified as the "auxiliary

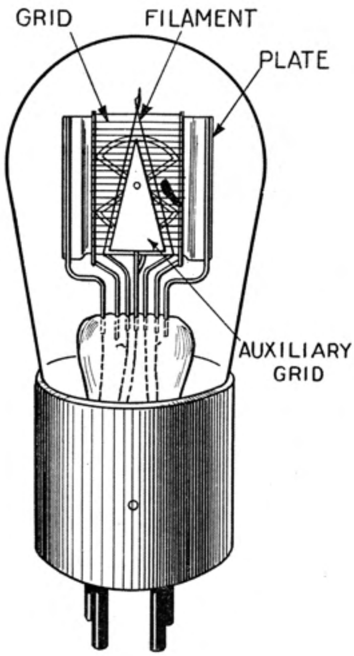


Fig. 30. The unique feature of Huppert's Quadrotron is the auxiliary grid consisting of a solid, flat, triangular plate placed under, and in close proximity to the triangular filament. (*Radio News*, July 1926, p. 51)

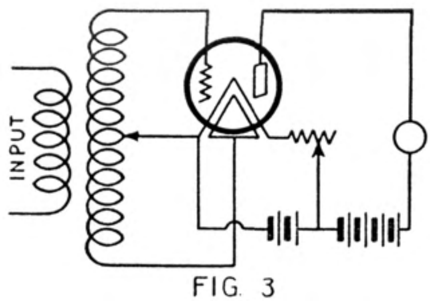


Fig. 31. Huppert's push-pull circuit in which the auxiliary grid absorbs electrons on the negative cycle and assists in the acceleration of electrons towards the plate on positive cycles. (Radio News, July 1926, p. 51)

grid" and constitutes the second control grid. This grid is completely different in both form and function than the second grid appearing in the K4 and other double-grid tubes where the second grid is placed between the filament and primary control grid. Huppert provides a description of how the auxiliary grid works using the circuit shown in Fig. 31. He begins with the following paragraph:

"Figure 3 illustrates how this tube operates as a sort of push-pull amplifier. You will note that there are the usual three elements with a fourth added, so spaced within the tube and circuit that the fourth element will at all times be of opposite polarity from the grid. In this way, both impulses of the received cycle are utilized as a control factor. When the usual grid is charged with a negative potential, no electrons should reach the plate. Those that do leave the filament are absorbed by the fourth element, called the auxiliary grid. During the other half of the cycle, the auxiliary grid is charged negatively and accelerates the flow of electrons to the plate."

Referring to Fig. 32, he then describes how this tube can be used to neutralize the inter-electrode capacity in tuned radio frequency (TRF) amplifiers: "The difficulty of neutralizing the capacity in neutrodynes is easily overcome with this tube; by simply connecting all the fourth elements, or auxiliary grids of the tubes, and taking advantage of the capacity coupling between the auxiliary grids and the other elements."

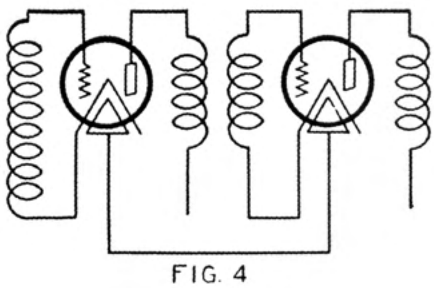


Fig. 32. Huppert's circuit for neutralizing the capacity in neutrodynes by connecting all the fourth elements, or auxiliary grids of the tubes, and "taking advantage of the capacity coupling between the auxiliary grids and the other elements." (*Radio News*, July 1926, p. 51)

He then shows two additional circuits for neutralizing the capacity, neither of which are reproduced here. Finally, referring to Fig. 33, he explains how this grid will eliminate the hum in receivers when an alternating current is used to light the filaments:

> "The reason a hum is caused in the set when operating tubes on alternating current is that the grid return is usually connected directly to one side of the filament; and thereby receives either a negative or positive charge, as shown in Fig. 6, which is amplified in the plate circuit. Fig. 7 illustrates how this difficulty is overcome with this new tube. There is no actual connection of the grid return to the filament, but it goes instead to the auxiliary grid, which is completely surrounded by the filament and is, therefore, uni-potential. The grid-filament circuit is still operative by means of capacity coupling between the filament and auxiliary grid. Should this be insufficient, a condenser of the correct capacity may be connected between the center tap of the filament transformer and the auxiliary grid."

Disposition of the Quadrotron

Huppert ended his article in *Radio News* by stating that "suitable information for all standard sets and circuits will be given by the writer in the near future in *Radio News.* There is no question that this unique development will abridge many gaps in radio." These were

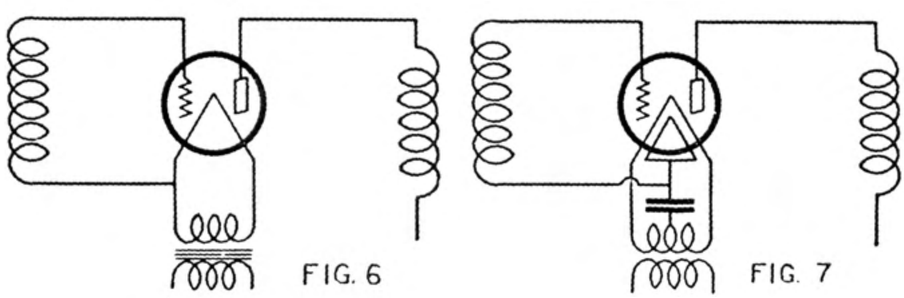


Fig. 33. Huppert's circuit for eliminating hum when operating tubes on A-C power by connecting the grid return, not to the filament as shown in his Fig. 6, but to the auxiliary grid as shown in his Fig. 7, which is completely surrounded by the filament and is, therefore, uni-potential.

the last words Huppert wrote about the Quadrotron. No additional Quadrotron articles written by Huppert or anyone else have been found. However, in 1942 and 1943, the Quadrotron appeared on lists of tubes that collectors were seeking. Thus, it appears that the Quadrotron was in fact manufactured.

With the introduction of the screen grid and the indirectly heated cathode elements in 1927, there was no longer a need for the double-grid tube or the Unidyne/Solodyne principle, and they quickly disappeared from the scene. The obituary of the Unidyne principle and double-grid tubes were chronicled by three separate retrospective articles published in the 1990s.[28]

Thermionic X-ray Tube with Grid

According to family records, Huppert terminated his association with Preston-Huppert X-Ray Laboratories in 1931 and went to work for the American Electric Company of California as the general manager of the Research Staff the same year. However, a letter dated August 31, 1931, found among the Huppert papers indicates that he was working with or for the Thomas Forde Company, a corporation organized under the laws of California in April 1931. The Forde Company, which succeeded the Formell Corporation organized in California in 1929,[29] was advertising the development of a high heat furnace, a mixer vibrator, a line of dental supplies, and a new type of X-ray tube.

It is likely that Huppert was working with Dr. Thomas Forde as a consultant to his company during 1931 while he was still employed at the Preston-Huppert X-Ray Laboratories. Huppert's work at Preston-Huppert most likely entailed the design and maintenance of X-ray tubes and other associated equipment in addition to the normal duties of a roentgenologist.[30] Perhaps Dr. Forde, who had already designed a much simpler type of thermionic X-ray tube without a grid control element,[31] needed the help of Huppert, who was familiar with not only two-element thermionic X-ray tubes but also thermionic tubes using a grid as a control element.

Huppert and Forde filed a patent on their new three-element X-ray tube on December 4, 1931, but after examination by the U.S. Patent Office, the application was rejected, and they had to file a new application, which was not submitted until July 19, 1933. Since family records state that Huppert joined the American Electric Company in 1931, it is likely that Huppert continued to consult for the Forde Company for whatever redesign or rewriting may have been required prior to the 1933 filing. In the end, Huppert was listed as the first inventor on the patent, and the tube was referred to as the Huppert-Forde X-ray tube. The patent was issued on Sept 8, 1936, as U.S. patent 2,053,792 (see Fig. 34).

The new X-ray tube was a thermionic triode with a heated cathode, an anode, and a control element to adjust the energy and intensity of the resulting X-ray beam. The most significant differences between a thermionic X-ray tube and a radio tube are the high

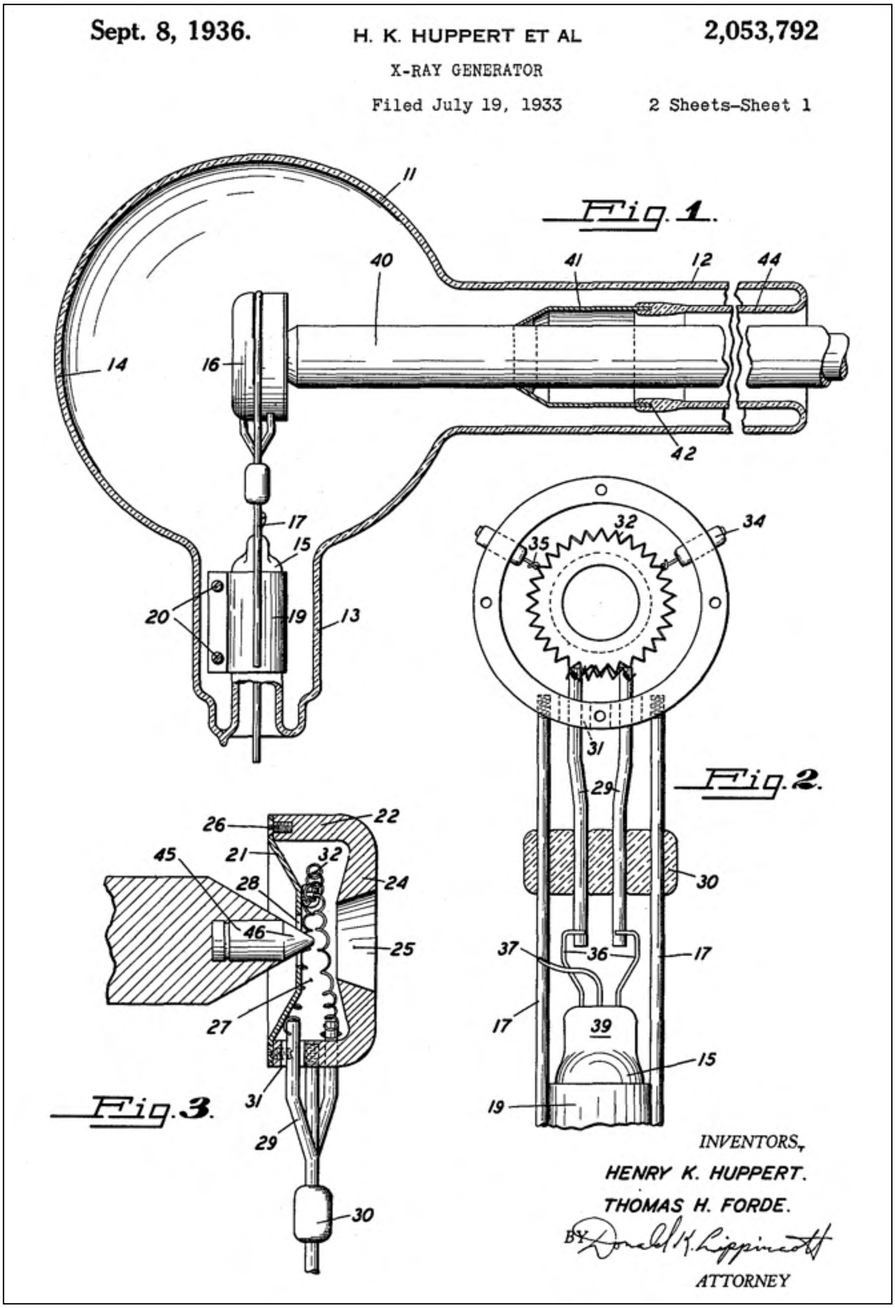


Fig. 34. Huppert's U.S. patent 2,053,792 filed on July 19, 1933, for an X-ray Generator, which was a three-element thermionic tube used to generate X-rays and control their characteristics electrically.

plate voltages capable of producing X-rays when electrons emitted from the hot cathode strike the plate, and a well-defined path for X-rays to exit the evacuated tube in a small parallel beam. It is beyond the scope of this paper to explain how the performance of this X-ray tube differs from previous tubes, but the patent claims the following features: an electron stream that can be controlled independently of the anode and cathode supply, the ability to self-oscillate at high frequencies, a focal spot size and position that can be changed electrically, an envelope that is effectively protected from secondary electron bombardment, increased efficiency, minimal stray X-ray energy outside the main bean, a minimal band of X-ray wavelengths in the main beam (a nearly monoenergetic spectrum), simple construction, an improved X-ray generator, and novel methods of operation. Potential customers were given the following less technical description:

> "Six years of research and development work on X-ray tubes resulted in the perfection of a new three-element type X-ray tube, which operates at a comparatively low voltage and gives the same X-ray output as a large type Coolidge tube [a two-element tube]. Because of this, it has been possible to design a very small compact X-ray unit. This unit has now been on the market three months, and satisfactory demonstrations have been made to more than three hundred physicians and hospitals.
>
> "X-ray work has been in the past considered a highly specialized art. A physician has to learn electrics in order to properly adjust high and low voltage and amperages as well as learn a critical photographic technique.
>
> "All this has become obsolete with the development of our new X-ray unit. A novice can take X-ray pictures with our X-RAY CAMERA. It is absolutely electrically shock proof, automatic in operation and safe. X-rays are emitted through a small metallic window and the operator does not expose himself to continuous radiation.
>
> "Physicians may operate it at a patients bedside on any ordinary lighting circuit. He may take pictures or examine the patient with a fluoroscope. It weighs less than one hundred pounds and is therefore easily portable. This enables the ordinary practitioner to take advantage of this great medical aid without investing thousands of dollars and increasing his office space."[32]

Nothing was found in the Huppert papers or in the open literature indicating whether the new X-ray tube was a success or how long the Thomas Forde Company was in business. After designing this X-ray tube, Huppert began a new career at the American Electric Company in the field of radiotherapy, a career described next.

PART III. HUPPERT'S CAREER IN RADIOTHERAPY

In 1931, Henry Huppert left the Preston-Huppert X-ray Laboratories and went to work for the American Electric Company, which specialized in developmental work on shortwave diathermy machines and dental equipment.[33] This marked a change in his career from working with X-rays to working with short waves. While at American Electric Company, he focused on designing and fabricating radiotherapy equipment. The radiotherapy equipment manufactured by the American Electric Company was not widely accepted by physicians, and so after three years, Huppert left the company in 1935 and opened up a private practice to treat patients with short-wave therapy.

After several years of private practice, Huppert enrolled in the San Francisco College of Drugless Physician, 1122 Sutter Street, San Francisco, while he continued his private practice. He received the degree of Doctor of Drugless Physicians on May 1, 1940, and remained in private practice until he died in 1947. The remainder of this paper will focus on two aspects of his later years—the diathermy equipment he developed while at American Electric, and some highlights from his private practice.

Diathermy Machine and Thermionic Tube Oscillator

In 1931, Henry Huppert was employed by the American Electric Company of California, which, among other medical technologies, specialized in developing shortwave diathermy equipment. Huppert's first major project was to develop a short wave diathermy machine, a technology that had just been introduced to America from Europe circa 1930 and was replacing long-wave machines.

By way of background, diathermy machines were first powered by repetitive spark-discharge sources such as Ruhmkorff coils with spark gaps that discharged into a resonant circuit, thereby producing a sequence of quasi-CW pulses with wavelengths on the order of 300 to 100 meters (1 to 3 MHz). These so-called long-wave machines were capable of delivering upwards of 8–10 kV to electrodes of various shapes and sizes,[34] but required contact with the skin to heat subsurface issue in localized areas of the body. These long-wave machines were undesirable for several reasons. Because they required contact with the skin, they often caused burns and electrical shocks, and because they used spark gaps, they radiated significant broadband electrical energy producing interference with radios and other electrical devices.

Huppert's Diathermy Machine

Short wave machines, which were first introduced in the United States circa 1930, used high frequencies generated by high-power vacuum tubes, which solved most of the problems associated with long-wave machines. The American Electric Company of California was one of the first in the United States to design and manufacture a short wave machine, which was given the trade name "American Radio-Thermy." Huppert applied for a patent on this machine that was assigned an application date August 20, 1934, with the title "Artificial Fever Apparatus." It was issued on March 1, 1938. No technical specifications were given for this machine, and the patent was not specific about its frequency or wavelength. It states only that, "For the purposes of this specification, artificial fever apparatus is defined as apparatus electrical in character adapted to produce high-frequency radio oscillations, preferably below 100 meters in wavelength and preferably adapted to produce a sufficiently high-intensity electrostatic field between opposed electrodes to raise living tissue positioned between the electrodes to a temperature higher than normal."

The artificial fever machine depicted in the patent is shown in Fig. 35, which illustrates a cabinet (1) holding the electrical source, a slanted control panel (2) with dials and an ammeter to monitor current flow, and two articulated electrodes (50) that can be positioned to oppose each other opposite virtually any portion of the body. Figure 3 of the patent is a cross section of the rotating arm joint and Figure 4 is a simplified connection of the vacuum tube oscillator circuit to the applicator plates, or electrodes. A photograph of the machine taken before the articulated electrodes were attached is shown in Fig. 36.

The details of the electrical oscillator and its connection to the electrodes were intended to be the subject of another patent entitled "Thermionic Tube Oscillator" that Henry K. Huppert and Howard D. Lane filed on September 25, 1934, but it was the subject of an interference, and the patent was apparently never issued. However, the original patent application detailing the oscillator circuit and the electrical connections to the electrodes was found among the Huppert papers (see Fig. 37). The two high-power vacuum tubes that Huppert used in the push-pull oscillator circuit he designed to generate short waves are evident in Fig. 36.

Apparently Huppert's diathermy was not a financial success because he wrote a letter dated March 12, 1935, to his attorney, Lippincott & Metcalf, stating in part: "We made many attempts to sell our Radio-Thermy equipment, but when the Noble doctors found what they had to learn to operate this equipment they hesitated and when they heard that the unit cost $650.00 they became disinterested." Huppert continues, "So on the first of the year [January 1935] I took an office at the little shack known at Four-Fifty Sutter Building and by permission of the Medical Association started to treat patients for a fee. The word spread fast from patient to patient and now I am very busy restoring human wrecks. Medical men who hear of these cures come from all over the state to investigate this new science and unconsciously become prospects

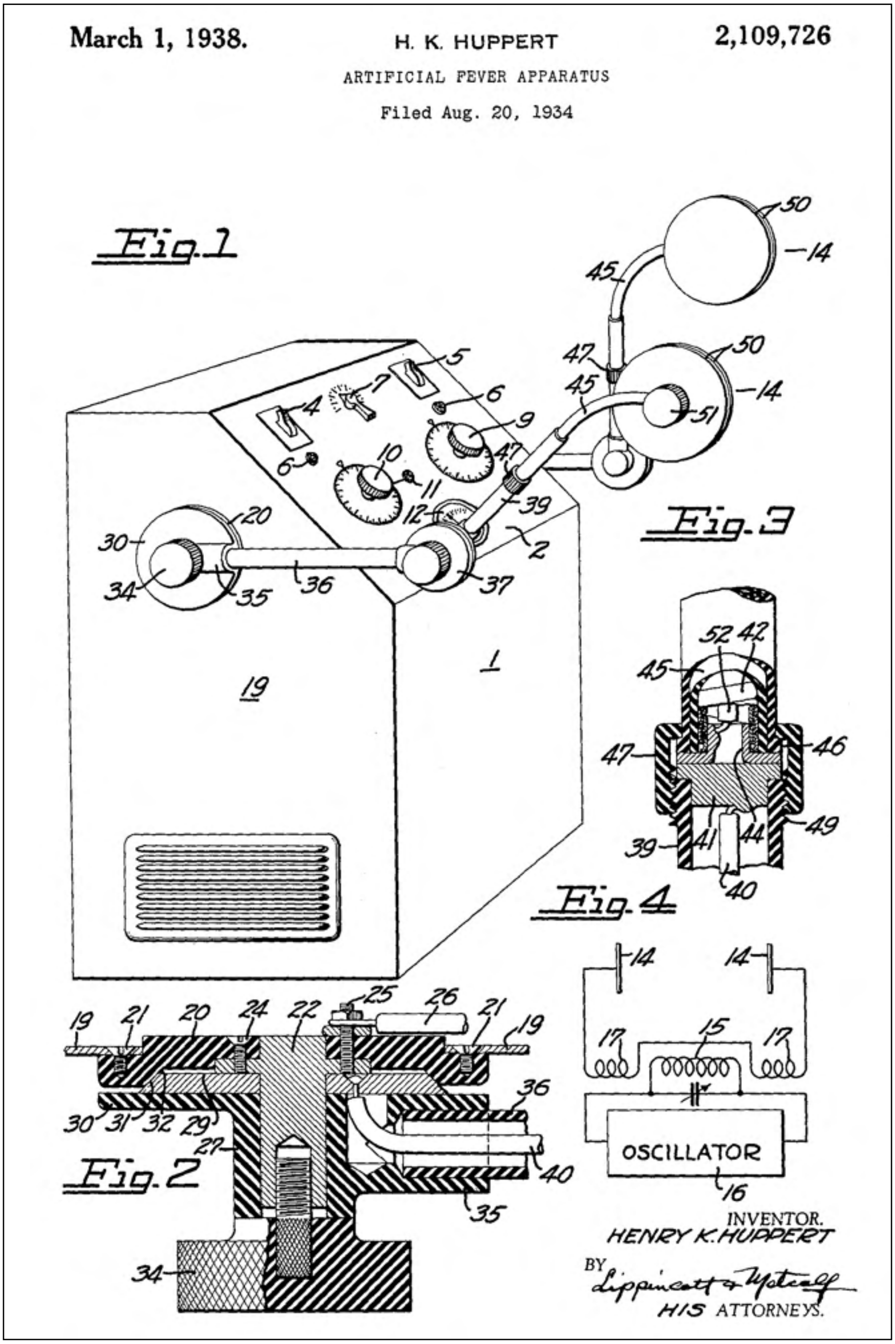


Fig. 35. Huppert's U.S. patent 2,109,726 filed on August 20, 1934, for an Artificial Fever Apparatus, otherwise known as a diathermy machine.

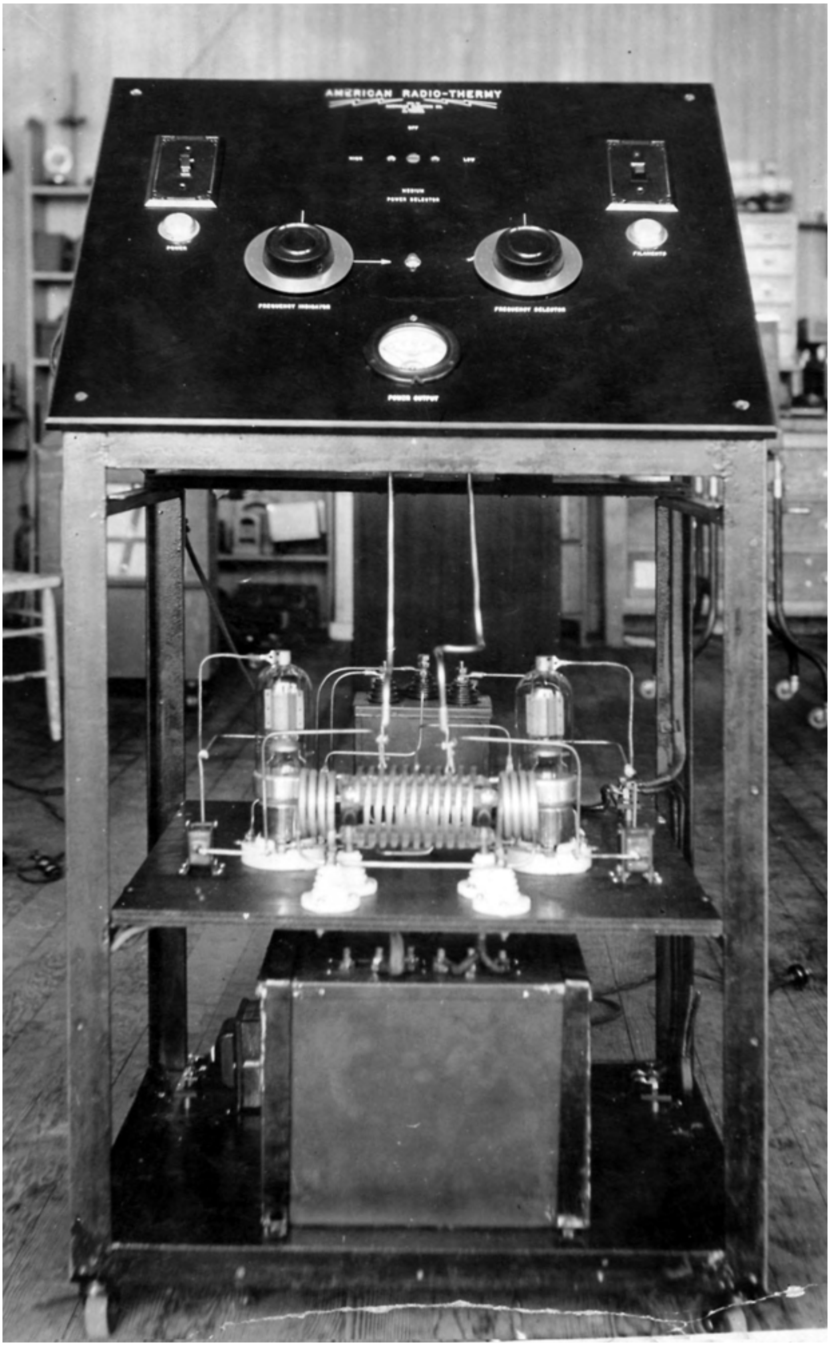


Fig. 36. The diathermy machine with the trade name "American Radio-Thermy" that Huppert made for the American Electric Company of California. (Huppert papers)

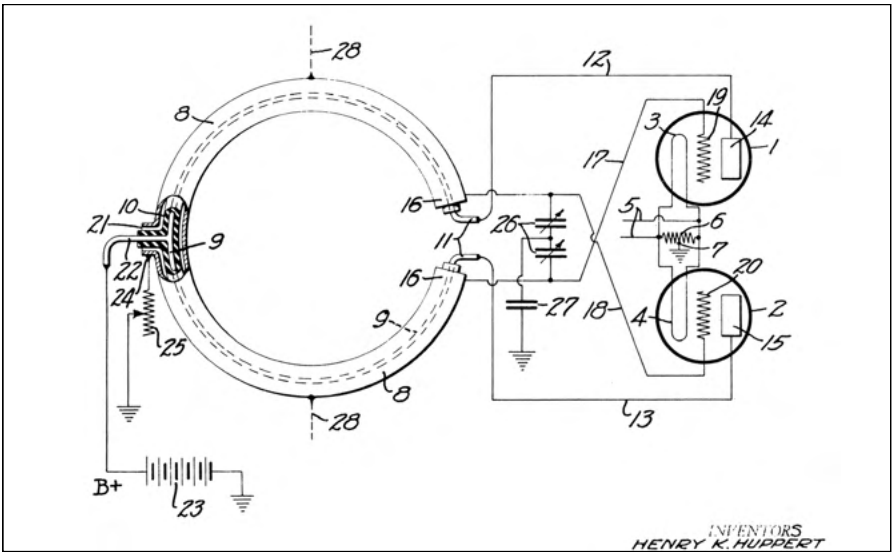


Fig. 37. The electrical oscillator circuit and its connection to the electrodes were the subject of a patent entitled "Thermionic Tube Oscillator" filed by Henry K. Huppert and Howard D. Lane on September 25, 1934, but the patent was never issued. (Huppert papers)

Fig. 38. Huppert began his private practice treating patients for a fee at a 26-story art-deco high-end medical and professional building with this entrance at 450 Sutter St. in San Francisco.

for a machine." Huppert displays his sense of humor by calling the Four Fifty Sutter Building where he began his practice "a little shack." In fact, this building was a 26-story art-deco building completed in October 1929 that was and still is a high-end medical and professional building (see Fig. 38). Huppert's private practice in the Four Fifty Sutter Building is summarized in the final section of this paper.

Lee De Forest's Diathermy Machine

Henry Huppert was not the only one who was interested in manufacturing diathermy machines in this time frame. In 1934, Lee De Forest created Lee De Forest Laboratories in Los Angles to manufacture short wave diathermy equipment. One of the first, it not the first diathermy machine De Forest sold is pictured in Fig. 39. This machine sold under the Dynatherm trade name first appeared in newspapers published circa February 10, 1937.[35] Note the similarity of De Forest's 1937 machine to that of Huppert's 1934 machine—including the slanted control panel and the two opposing circular electrodes. While not shown in this photograph, De Forest's machine also employed two high-power vacuum tubes to generate short waves.

While De Forest was developing his first diathermy machine in early 1935, Huppert was already using his machine in his practice. In February 1935, Huppert was visited by representatives of the National Recovery Administration (NRA), which was established by Roosevelt in 1933 as part of his New Deal to eliminate destructive competition, set prices, establish minimum salaries, etc., with the objective of aiding in the recovery from the depression. NRA bureaucrats forced Huppert to comply with the National Industrial Recovery Act by supplying them 65 copies of his machine specifications for distribution to his competitors in February. Apparently, a copy was sent to De Forest because Huppert immediately received a letter from Lee De Forest demanding to know why he was using oscillating vacuum tubes in his diathermy machine. In his letter, De Forest cited two patents he had filed in

Fig. 39. The first diathermy machine De Forest made circa 1937 at his new company, Lee De Forest Laboratories. (Author's collection)

1915, U.S. 1,507,016 and U.S. 1,507,017, both covering an audion acting as a generator of undamped oscillations. While his patents were on point, De Forest had transferred ownership of these patents to AT&T and Western Electric for most applications other than radio. Recognizing this fact, Huppert's attorney prepared a very clever letter for Huppert to send to De Forest under his signature (see Fig. 40). The letter states that they will respond to De Forest if he can prove he has ownership of the patents. There is no record that De Forest ever responded, and so it appears that Huppert got the best of him.

De Forest did submit another patent for a high-frequency undamped oscillator designed to generate ultra-high frequency undamped oscillations for a diathermy machine on September 20, 1935, which was issued as U.S. patent 2,126,541 on August 9, 1938. However, this patent did not affect the design for the oscillator that Huppert and Lane had submitted a patent application for the prior year on September 25, 1934.

Henry Huppert, Doctor of Physical Medicine

Huppert began his final career in January 1935 at 450 Sutter Street as an electro-therapist and X-ray technician. He enrolled at the San Francisco College of Drugless Physicians on July 26, 1937, and was granted the degree of Doctor of Physical Medicine on May 1, 1940. Physical medicine included electrotherapy, hydrotherapy, mechanical manipulation of bones and muscles and dietetics. Huppert's specialty was electrotherapy, specifically hyperpyrexia (heating) by diathermy. From 1940 until his death he was a self-employed

March 15. 1935

Dr. Lee De Forest,
5106 Wilshire Boulevard,
Los Angeles, California.

Dear Sir:

Before referring your inquiry regarding the American Radio-Thermy apparatus to our patent attorney for answer, we would like to inquire as to the extent of title held by you in U. S. Patents Nos. 1507,016 and 1507,017, as we are under the impression that the title is in other hands.

If it appears that you are entitled to such information as requested in your letter of February 27, 1935, we shall be glad to instruct our patent attorney to reply.

Yours very truly,

AMERICAN ELECTRIC COMPANY OF CALIFORNIA

per:-
H. K. Huppert.
General Manager.

H.K.H:L.G.

Fig. 40. Huppert's attorney prepared this very clever letter for Huppert to sign and send to De Forest, a letter that disposed of De Forest's request for information from Huppert to determine possible patent infringement. (Huppert papers)

Doctor of Physical Medicine as a practitioner of drugless medicine.

A photograph of Huppert with a patient in his new office at 450 Sutter St. was taken *circa* 1935 just after he moved in (see Fig. 41). It appears that he is holding a film obtained with what is believed to be an X-ray machine to the left. Note the large electrical influence machine (perhaps a Wimshurst machine) in the cabinet behind Huppert, a machine capable of generating repetitive megavolt pulses. These machines were used in this time frame for applying tingling currents to the body, but it is not known how Huppert used it in his practice.

While diathermy was Huppert's specialty, there are no pictures of the machine he used in his office during the 1930s and 1940s. Presumably, he was using the machine he developed while he was employed at the American Electric Company of California. There is an interesting record of patients treated by Huppert with his diathermy machine dated August 1934, just before he left American Electric Company to begin his private practice (see Fig. 42). This record shows the diagnosis in the left column and the results of the treatment in the right column. It also gave the patients' names and the number of treatments used, both of which have been removed from the record shown here. What is most interesting is the types of ailments treated. Most of these ailments had no better treatment options in the day. There are a number

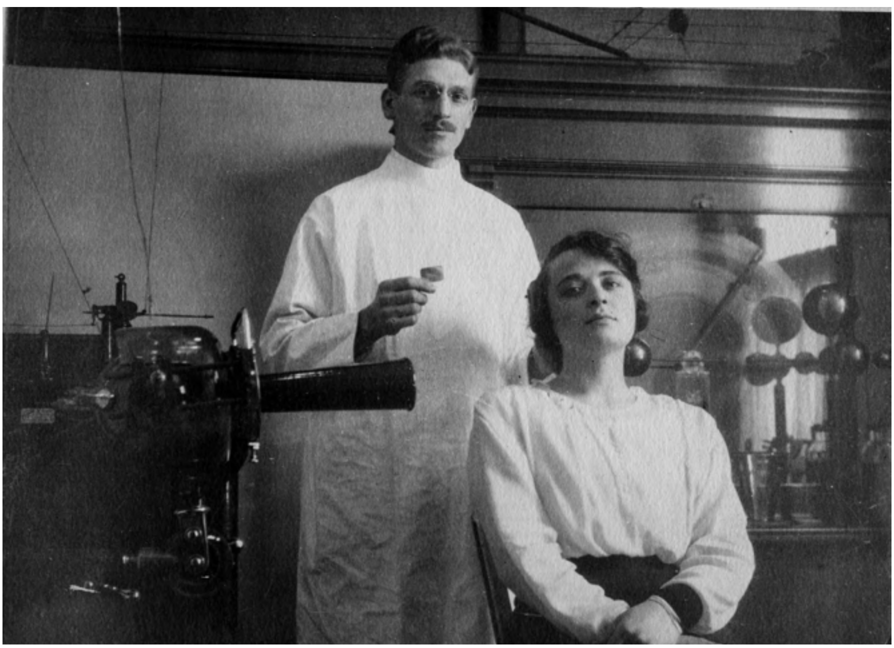


Fig. 41. A photograph of Henry Huppert with a patient in his new office at 450 Sutter St. that was taken *circa* 1935. (Huppert papers)

August 9, 1934.

American Electric Company of California

"RECORD OF PATIENTS TREATED"

Diagnosis	Results
Buracy	Cured
Chronic Arthritis	No Pain. No recurrence
Enlarged Prostate gland	No recurrence of pain
Bronchial cold	Cured
Arthritis, right shoulder	No recurrence.
Mumps	Cured.
Stiff knee, result of fibular fracture	Normal flexion.
Arthritis deformance both knees	No pain, but very little improvement in flexion.
Arthritis right hip and knee	Improved 50%
Painful arthritis Knees and spine	80% cured.
Painful arthritis both knees, 5 years standing	Patient discharged cured.
Acute Neuritis left shoulder	Cured. No recurrence
Inflammed bronchial cold	Cured.
Sciatica left side	Cured
Arthritis both knees	80% cured.
Prostatis	Improved (AND HOW!)
Spinal arthritis	90% cured.
Sacro-illiac Neuritis	Patient back at work after 8 months hospitalization.
Spinal Arthritis	Improved 60%
Sacro-illiac Neuritis	Cured.
Acute cold, lungs	Cured.
Ankelosed right wrist result of pots fracture Pain right arm	50% greater flexion No more pain
Arthritis, cervical region	Cured
Collitis	Cured
Hay Fever	Cured

Fig. 42. A record of patients treated by Huppert with his diathermy machine in 1934 that shows the type of ailments he treated and the outcomes of the treatments. (Huppert papers)

of letters in the Huppert Papers from medical doctors sending their patients to Huppert for treatments of ailments that they were unable to treat.

There is very little additional information about Huppert and his private practice between 1935 and 1947. Henry Huppert was active in the medical societies he joined, which included the State Association of California Chiropractors and the National Medical Society, which named him a Fellow. On August 5, 1946, the *San Francisco Examiner* reported, "Dr. H. K. Huppert, San Francisco chiropractor, has been elected president of the Northern California Division of the National Medical Society, it was announced yesterday. Doctor Huppert also serves as an expert witness in cases against chiropractic physicians charged with a professional code violation." Huppert wrote articles for medical magazines and in one case, a local newspaper.[36]

On July 30, 1947, Henry K. Huppert died peacefully at 54 years of age in the St. Francis Hospital in San Francisco of aplastic anemia as a result of exposure to X-rays. He was surrounded by family and friends including his wife Olga, his two sons Henry and Ralph, and one of his closest friends, Rear Admiral John "Jack" R. Redman.

Endnotes

1. Ralph M, Huppert, Sr., Kahler Genealogy: German Ancestors of Olga Marie Kahler (1897–1975). http://wc.rootsweb.ancestry.com/cgi-bin/igm.cgi?op=GET&db=rmhdbh&id=I11.
2. The requirements for joining the Naval Communication Reserves were outlined in Captain Linwood S. Howeth, USN (Retired), *History*

of Communications-Electronics in the United States Navy, (U.S. Government Printing Office, Washington D.C., 1963) p. 233: "The requirements for enrollment in [the NCR] were American citizenship, ability to send and receive at the rate of 10 words per minute, and the passing of the usual physical examination. Upon enrollment, members received an annual retainer fee of $12 until they were able to pass qualifying examinations indicating their ability to replace regular naval radio operators. Upon qualifying, they received annual retainer pay equal to 2 months pay of their corresponding grade in the regular Navy. Additionally, they were paid traveling expenses to and from the place of training and the same pay as their corresponding grades while under training. Uniforms were provided gratuitously. During peacetime, a member could be discharged at any time, upon his own request."

3. Gerald F. J. Tyne, *Saga of the Vacuum Tube*, (Howard W. Sams, Indianapolis, 1977) p. 179.
4. Lee De Forest, "Wireless Telegraph," U.S. patent 841,386 filed Aug. 27, 1906, issued Jan. 15, 1907.
5. Mignon Display Ad, *QST*, Vol. 1, No. 12, Nov. 1916, no page number.
6. Robert C. Siegel and Ralph E. Hantzsch, "Magnetically Controlled Vacuum Tube," (Thesis for Degree of Bachelor of Science in Electrical Engineering, University of Wisconsin, March 16, 1921).
7. The Shaw base was a four-pin brass base manufactured by Henry Shaw, a supplier to the Moorhead Labs prior to April 1, 1920. On that date, Shaw became president of Moorhead Labs in the course of a takeover he initiated to protect his investment in the bankrupt Moorhead Laboratories, and in the process he ousted Otis Moorhead who was then president. Moorhead was demoted from president to chief engineer at that time. Moorhead Labs was sued by AT&T on May 9, 1922, for infringing De Forest tube patents they had acquired from De Forest earlier in 1917. Immediately upon learning of the lawsuit, the directors forced Shaw out of Moorhead Labs on May 11, 1922, and tube production at Moorhead Labs ceased on May 19, 1922. Moorhead Labs and all defendants agreed to an injunction dated May 23, 1922, which precluded them from further manufacturing or selling any infringing tubes.
8. The force F on an electron of charge q with velocity v produced by a magnetic field B is given by the expression $F = qv \times B = qvB\sin\theta$ where θ is the angle between the velocity and magnetic field vectors. An electron moving perpendicular to a magnetic field will circle the magnetic field lines, while an electron moving parallel to the magnetic field ($\theta = 0$) will be unaffected by the magnetic field. For intermediate angles between 0 and 90 degrees, the electron trajectory becomes a spiral.
9. Elmer T. Cunningham reported to RCA attorney L. F. H. Betts in a letter dated April 6, 1923, that Moorhead planned to place a new tube on the market within 30 days: "Moorhead Laboratories have been carrying on development work on vacuum tubes and I have just seen a sample of a new vacuum tube produced by this Company and which they contemplate placing on the market. They are making the statement that they plan to place this tube on the market within thirty days. In view of the particular appearance of this tube, I doubt very much if their plans will materialize." Clearly, the tube Cunningham described in his letter was a prototype Solenoid tube, possibly one of the four Huppert made in 1922.
10. The AP-2 regenerative receiver made by Oard Radio Laboratories for Atlantic-Pacific Radio Supplies Company (the marketing organization for Moorhead Labs) was first advertised on the back cover of the October 1922 issue of *Radio* magazine.
11. W. F. Williamson Testimony, *Radio Case, Federal Trade Commission vs. General Electric Company, American Telephone & Telegraph Company, Western Electric Company Inc., Westinghouse Electric & Manufacturing Company, The International Radio Telegraph Company, United Fruit Company, Wireless Specialty Apparatus Company, and Radio Corporation of America*, (Sidney C. Ormaby Company, 217 Broadway, New York, 1928) p. 1560. This document is referred to hereafter as "*FTC Hearings*, 1928."
12. The narrative in the first five paragraphs was adapted from the original appearing in E. P. Wenaas, "Otis Moorhead and the Vacuum-Tube Tangle," Part III, *AWA Review*, Vol. 27, 2014, pp. 51–123.
13. "Factory Order No. 1," issued by D. C. Seagrave, President and General Manager (Huppert papers).

14. D. E. Gunn Testimony, *FTC Hearings,* 1928, pp. 1582–1589.
15. "Baker-Smith Co. National Distributors," *Hardware World*, Vol. 22, Feb. 1925, p. 119.
16. H. K. Huppert, "Tube is the Heart of the Radio Set," *Hardware World*, Vol. 22, Feb. 1925, pp. 118–119.
17. The voltage stamped on the observed high-filament-current Two-in-One tubes is "6 Volt" (without an "s"), but the A-P brochure and the instruction sheets enclosed with all the tubes specify 5 volts. Perhaps 5 volts was the nominal operating voltage, and 6 volts was the maximum rating.
18. H. K. Huppert, "A Departure in Radio Tube Design," *Radio News*, July 1926, Vol. 8, No. 1, pp. 50–51.
19. Hugo Gernsback, "The Solodyne Principle," *Radio News*, Vol. 6, No. 2, Aug. 1924, p. 153.
20. Baker-Smith Display Ad, *Radio Broadcast*, Vol. 8, No. 2, Dec. 1925, p. 236.
21. I. Langmuir, "Electrical Discharge Apparatus," U.S. patent 1,558,437, application filed Oct. 29, 1913, patent issued Oct. 20, 1925; W. Schottky, "Über hochvakuum Verstärkerröhre. III Teil. Mehrgitterröhren," Archiv für Elektrotech, Vol. 8, No. 9, Dec. 1919, pp. 299–328.
22. G. V. Dowding and K. D. Rogers, "No More H.T. Batteries, The P.W. 'Unidyne Principle,' Part I. A General Outline of the Invention," *Popular Wireless Weekly*, May 3, 1924, pp. 337–338; "More About the Unidyne Principle, Dispensing with the H.T. Battery, Part II. Final Theoretical Details," *Popular Wireless Weekly,* May 10, 1924, pp. 373–374.
23. K4 Tube, The National Valve Museum, http://www.r-type.org/exhib/aaj0001.htm.
24. Desmond Thackeray, *Radio Bygones*, April/May 1994, http://www.r-type.org/articles/art-094.htm.
25. Thorpe Display Ad, *Popular Wireless Weekly*, July 19, 1924.
26. Theodore H. Nakken, "Multiple Grid Vacuum Tubes and Their Advantages," *Radio News*, Vol. 7, No. 6, Dec. 1925, pp. 804–805, 826.
27. Nakken, p. 805.
28. Desmond Thackeray, "The Bi-grid Valve – A Needless Invention?" *Radio Bygones*, April/May 1994 (website: http://www.r-type.org/articles/art-094.htm); Ian L. Sanders, "The 'Unidyne,'" *Radio Bygones*, No. 19, Oct./Nov. 1992, pp. 21–24; Dull Emitter (Editor), "The Unidyne Popular Wireless' Damp Squid," *Bul. British Vintage Wireless Assn.*, Vol. 20, No. 2, April 1995, pp. 26–27.
29. The Formell Corporation was owned by Thomas H. Forde and Newton W. Mellars. It is not known how or why Forde founded a new company or what happened to the Formell Corporation, but the new company had ownership of all patents of the Formell Corporation.
30. A person skilled in the diagnostic or therapeutic application of Roentgen rays; a radiologist.
31. T. H. Forde, "X-Ray Tube," U.S. patent 1,949,463, filed Oct. 13, 1930; issued Mar. 6, 1934.
32. Letter from Thomas Forde Company to a potential customer dated Nov. 8, 1932 (Huppert Papers).
33. "American Electric Company of California," *Bulletin of the National Research Council*, No. 102, December 1938; *Industrial Research Laboratories of the United States*, (NRC, Washington DC, 6th Edition, 1938) p. 16.
34. Short waves were characterized by wavelengths of less than 200 meters.
35. "Radio Wizard's Newest," *The Decatur Herald*, Feb. 10, 1937, p. 14. The photograph used for this picture was taken by Wide World Photos on Feb. 4, 1937 and has the following inscription on the reverse side: "Dr. Lee De Forest, noted inventor, shown with his latest electrical invention, the 'Dynatherm.'"
36. H. K. Huppert, "High-Frequency Current Induced through Body Conquers Dread Malady," *Sunset Courier* (San Francisco), Vol. 11, No. 33, p.1; ---"Modern Electro-Therapy," *Scientific Chiropractor*, Vol. 2, No. 21, p. 30; ---"Diagnosis Contest," *J. of the California Chiropractic Assn.*, Vol. 3, No. 7, pp. 5+; ---"Electrocardiography," *J. of the California Chiropractic Assn.*, Vol. 3 No. 12, June 1947, p. 5.

Acknowledgements

I would like to thank Claudia Benish for her participation in this project, for allowing me to examine the Huppert papers in detail, and especially for preserving her grandfather's legacy. I would like to thank Joe Knight for providing several Solenoid tubes, for providing photographs of several Solenoid tubes and Two-in-One tubes, for many informative discussions throughout the project, and his detailed review of the paper. Thanks go to David Peckham for providing some interesting Solenoid tubes and for several discussions about those tubes. I am also very grateful to Ian Sanders for providing hard-to-find articles on the Dynatron principle.

About the Author

Eric P. Wenaas has had a lifelong passion for antique radios beginning with his first Radiola and crystal set given to him as a young man growing up in Chicago by family friends. He experimented with radio devices and repaired radios and televisions as a hobby while in high school, and went on to study electrical engineering at Purdue University, graduating with B.S. and M.S. degrees in Electrical Engineering. He then went to the State University of New York (SUNY) at Buffalo where he earned a Ph.D. degree in Interdisciplinary Studies in the School of Engineering. After graduating, he spent most of his career at Jaycor, a defense company in Southern California—first as an engineer and later as the President and Chief Executive Officer.

Upon his retirement in 2002, he set out to research the early days of wireless and document interesting historical vignettes based on original documents of the era. He has assembled an extensive collection of Radiolas from the 1920s and wrote an award-winning book on the subject. He has also assembled a large collection of French and American crystal sets, and he is now gathering original document collections of well-known inventors and historians that recorded the history of the wireless and early broadcast era. In recent years he has become interested in early vacuum tubes as they related to the tangled web of conflicting patent rights and litigation associated with the Fleming valve and the De Forest audion patents.

Claudia M. Benish pictured here with the author is the granddaughter of Henry K. Huppert. Ms. Benish inherited the Huppert papers from her father and kindly shared them with the author, who used them as the primary source material for this article.

Eric P. Wenaas and Claudia M. Benish

The U.S. Naval Radio School at Harvard: A New Era in Military Training

Wide-scale technical training was essential for U.S. mobilization in World War I. The country's ability to quickly recruit and to set up massive education programs allowed it to produce thousands of new soldiers and sailors for the Allied Powers. The Naval Radio School at Harvard University exemplifies these efforts. Prior to the war, the Navy did not maintain a coherent or cohesive approach to technical training for wireless telegraphy and other communications skills. In 1917, the Navy established an advanced radio school at Harvard that in only twenty-two months trained nine out of every ten naval radio operators who served in the war. This article outlines the origin, operation and role of the Naval Radio School at Harvard during World War I.

Introduction

Radio in 1917 and 1918 consisted primarily of telegraphy by Morse code. Broader concepts of regional or national network broadcasting by voice, as conceived by Charles Herrold, Reginald Fessenden, Lee DeForest, and David Sarnoff, would not become fully developed until after World War I. The *Titanic* disaster had occurred only a few years earlier in 1912, bringing worldwide attention to the importance of radio. But the technology was crude, and communication primarily relied upon man and machine sending sparks into the air to be detected as Morse code.

As World War I marched through Europe from 1914 to early 1917, American plans for entry were highly disorganized and suffered from a lack of direction. The U.S. Navy needed to quickly bring together ships, materiel, officers, and enlisted men who could be trained to perform an evolving list of specialized tasks. Rear Admiral Josiah S. McKean, assistant for material in the Office of the Chief of Naval Operations,

Fig. 1. Harvard Naval Radio School banner by New England College Banner Company showing the Navy rating patch for wireless operators, 1918. (Authors' collection)

Fig. 2. Center portion of Naval Radio School at Harvard, class photo, 11th Company, 1918. (Authors' collection)

stated, "…personnel was a vital question, and the key to getting the Navy ready."[1]

The Navy responded by completely reorganizing its recruiting and training structure. A new "United States Naval Radio School" located at "Harvard University, Cambridge, Massachusetts" was hastily conceived and implemented (see Fig. 1). Although it operated for only twenty-two months from July 1917 to April 1919, it provided nine out of every ten American radio operators who served in the war (see Fig. 2).[2]

Early Navy Training Before 1917

Technological revolutions in naval architecture, design, and communications forced the U.S. Navy to undergo a major reorganization of its bureaucratic structure from 1910–1912. Responsibilities for radio operations were split across several departments, and various subspecialties were ordered to operate under the guidance of a new Naval Radio Service. Management and operations fell under the Bureau of Navigation represented by the radio officer. The Navy's shore stations fell under the Navy's fleet chain of command. Responsibility for all radio equipment, research, design, and installation fell under the Bureau of Steam Engineering represented by the head of the Radio Division. Research and training fell under the officer in charge of Naval Aeronautics, who obtained supplies from the superintendent of the Naval Radio Service in the Bureau of Steam Engineering. Visual signaling, other signal services, and training for signalmen remained under fleet operations. In addition, following the loss of the *Titanic* and the new Radio Act of 1912, the Navy assisted the Department of Commerce Bureau of Navigation by designing and administering new radio operator license testing for commercial and maritime radio operators.

In 1912, communications training and gear were scattered across the various regional naval districts. That year, the Washington Navy Yard undertook an overall review of Navy education and apparatus involving communications equipment. They obtained and demonstrated each of the basic items and began thinking about uniform training and testing requirements (see Fig. 3).[3]

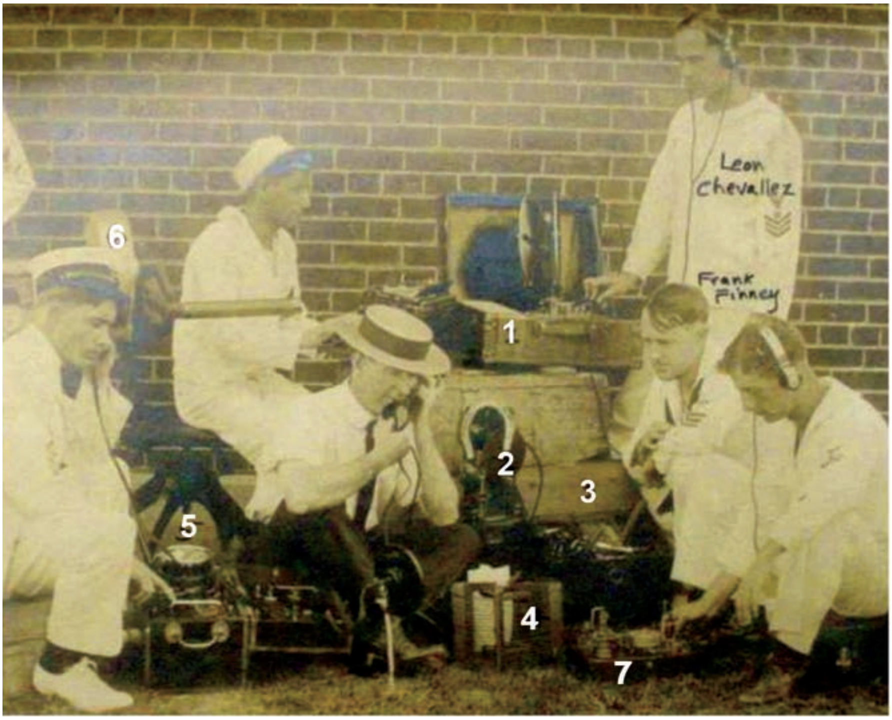


Fig. 3. Washington Navy Yard "Tools of Wireless" circa 1912: (1) Navy Portable Set (2) Poulsen Arc Set (3) Toolbox (4) Fessenden Helix (5) Wave Meter (6) Generator (7) Omnigraph Code Instruction Machine. (George Clark Radioana Collection, Museum of American History)

Although the Navy began instituting standardized provisions for radio operations, it had not reorganized its training into a standard structure that could develop and deliver uniform training and meet established minimum proficiencies in basic skills. Telegraph and wireless code-related training continued in multiple locations under different commands for the various jobs that required an understanding of code. Schools were opened, closed, or relocated by the naval districts as they tried different signaling applications.

America's entry into World War I changed everything. Suddenly, the Navy sought thousands of radio operators, and recruiting efforts dramatically expanded. For example, in 1917 artist Charles Buckles Falls issued the first U.S. Navy wireless recruiting poster seeking experienced radio operators (see Fig. 4). New recruiting booklets suddenly featured drawings, photographs and detailed descriptions of military training that was available for civilian recruits who could use the training to later establish exciting careers in electricity and radio.

In April 1917, the Bureau of Navigation established a new Training Division and facilities were regrouped

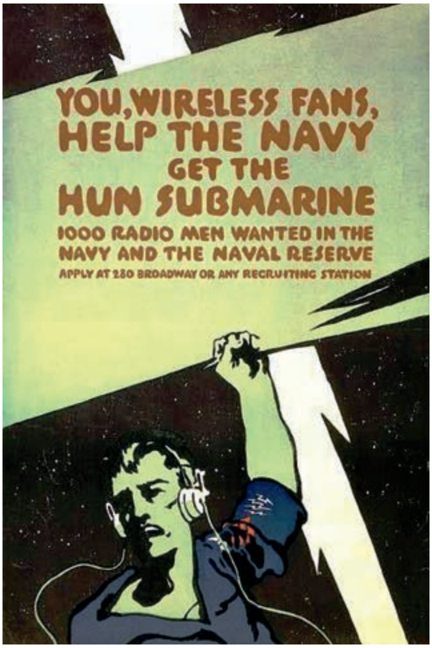


Fig. 4. The first U.S. Navy wireless recruiting poster, circa 1917–1918. (Authors' collection)

into three broad collections of training operations:[4]

(1) Training stations for regular Navy enlisted men at Newport (Rhode Island), St. Helena (Norfolk), Great Lakes (north of Chicago), and Yerba Buena (San Francisco),
(2) Training camps at many of the 18 naval districts for reservists within each district, and
(3) National specialist schools at various naval stations and Navy yards.

New "preliminary" radio schools in each naval district provided introductory training in radiotelegraphy. Advanced naval schools were established at selected universities and colleges, such as the Naval Radio School at Harvard and a similar, smaller facility that opened at the Mare Island Navy Yard in California. A Naval Aviation Ground School opened at the Massachusetts Institute of Technology (MIT). The school at Harvard was selected as the primary advanced school that would receive students from across the country. The fully combined capacity of these schools could now train 5,000 radiomen every four months.

Origins of the Naval Radio School at Harvard

Brooklyn Navy Yard

The Naval Radio School at Harvard emanated from operations at the Brooklyn Navy Yard, Building 26 (see Fig. 5).[5] The Navy Yard provided basic radio training and had a combined staff and student complement of approximately one hundred prior to the outbreak of war. The course ran twenty-four weeks, had weekly attendance of approximately eighty students, and graduated approximately seven students each week. Four chief radio electricians and one radio gunner served as instructors. Suddenly, between April 1 and June 1, 1917, the school expanded to approximately four hundred students, and basic operating classes quickly became very large and overcrowded.[6]

The sailors at Brooklyn in 1917 utilized two books for the first eight weeks of the twenty-two week course: *Naval Electricians Text Book* by Rear Admiral William G. Bullard and *Swoope's*

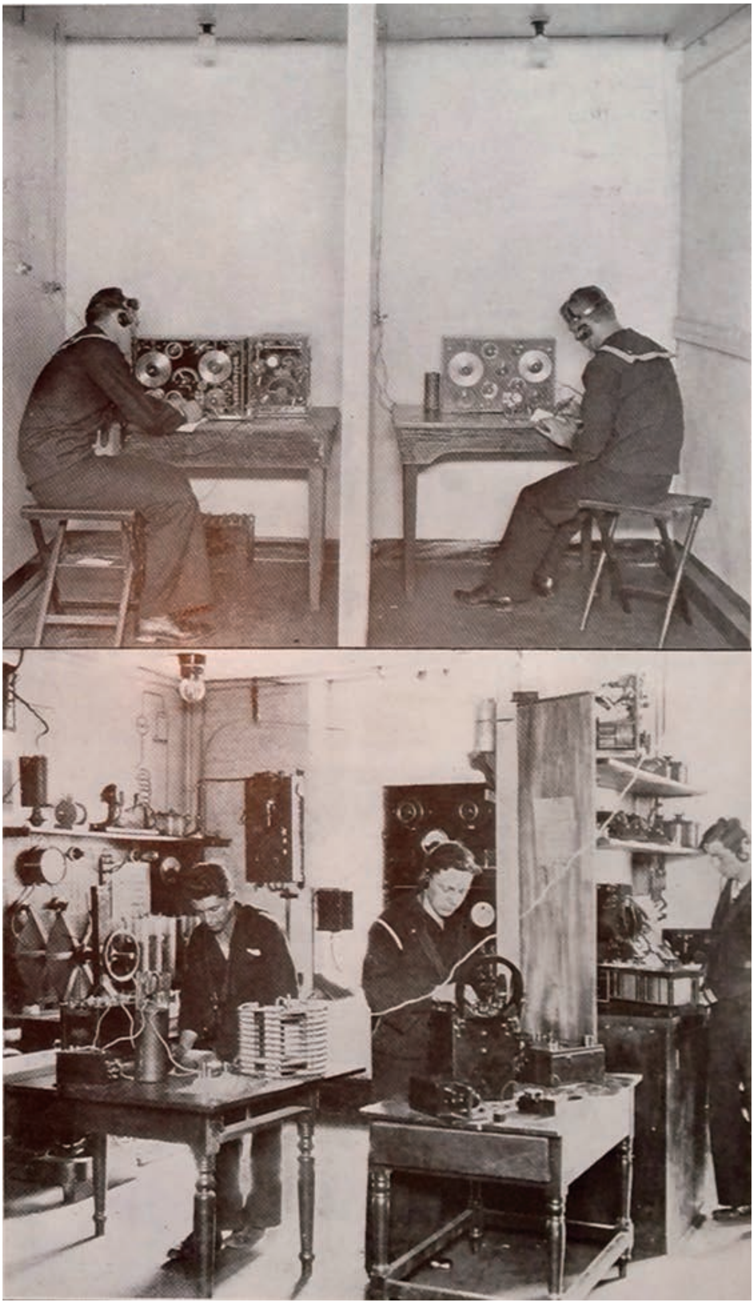


Fig. 5. Navy recruiting booklet with views of the Brooklyn Yard Naval Electrical and Radio School in 1917. Top: Copying dispatches from Washington. Bottom: Testing radio sets. (Navy Publicity Bureau, New York, 1917)

Lessons in Practical Electricity. Grades were based on daily oral recitations and weekly written exams followed by a final written examination. Both the Continental and Morse codes were taught and practiced at group operating tables, each with a capacity of twenty seated men. The tables were fitted with headphones, sounders, and transmitting keys. Chief radio electricians provided instruction. They sat at an operating desk, each with control over a certain number of tables. The average operating ability of graduating students was expected to be twenty-five words per minute, with many claimed to reach thirty words per minute.[7]

Following a study by the Navy Board, the Brooklyn Navy Yard was deemed too small to handle the expanding radio school student population. At the behest of the U.S. government, Captain William R. Rush, Commandant of the Charlestown Navy Yard, moved the school to Harvard University on July 26, 1917. At that time, the personnel consisted of forty-six staff, six chief petty officers, and one radio gunner.[8]

Harvard University

The new Naval Radio School was initially placed under the command of Lieutenant E. G. Blakeslee, Communications Superintendent of the 1st Naval District. In July 1917, Lieutenant Commander Nathaniel Farwell Ayer, U.S.N.R.F., assumed command. Ensign William E. Snyder served as executive officer and was assisted by four gunners. Captain J. P. Parker commanded the School for Ensigns, and Lieutenant E. F. Green oversaw the teaching of naval science (see Fig. 6).[9] The Navy's school for electricians, other than those assigned to radio duty, remained at the Brooklyn Navy Yard.

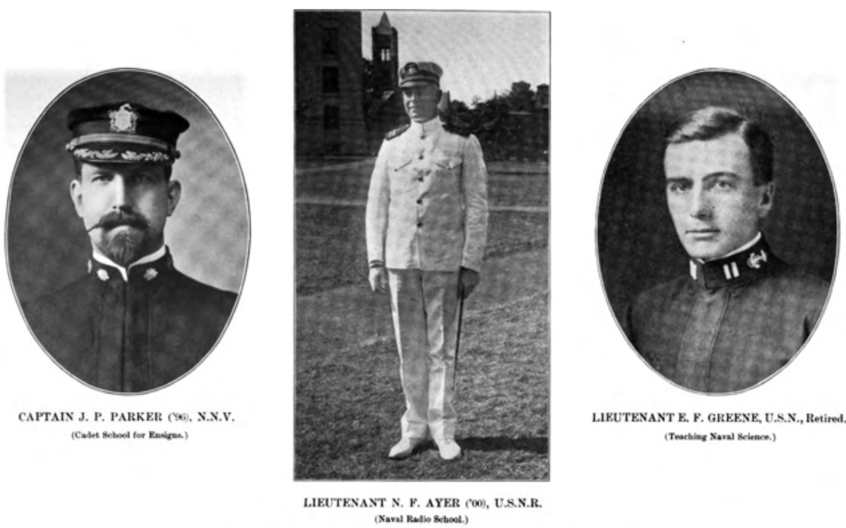


Fig. 6. Commanding officers of U.S. Naval Radio School at Harvard. (*Harvard Graduates Magazine*, Vol. 26, Dec. 1917, p. 202.)

Lt. Commander Ayer, shown here in Fig. 6, came from a prominent Boston cotton manufacturing family. Upon graduation from Harvard in 1900, he immediately entered the Boston offices of the Farwell Cotton Mills and Farwell Bleachery, where he eventually became director and treasurer. Ayer enlisted in the U.S. Naval Reserve Force in March 1917, and in April he was appointed as aide to the chief of staff of the Boston Navy Yard. On July 23, 1917, he was appointed as Lt. Commander and Commanding Officer of the U.S. Naval Radio School at Harvard University.

Almost overnight, Harvard's campus effectively became a government military school and remained so until the end of hostilities. Ayer ensured that the Radio School operated under Navy customs and discipline using Navy instructors, and classes were conducted in a military manner. The sailors were called with bugle or alarm. They filed out of classrooms and marched through the hallways, wearing uniforms at all times. Navy teaching staff instilled the Navy's own culture, spirit, discipline, and practices using Navy equipment, methods, and procedures. One course was given by university faculty for members of the Naval Reserve. A government school for ensigns, the Cadet School (later known as the Radio Material School) also operated on campus.

Cruft Laboratory and the First Students

Harvard's first radio/wireless class was instructed by a chief electrician and two other staff members, who began teaching in the new Cruft High Tension Laboratory on April 17, 1917, just eleven days after the United States declared war on Germany. The Cruft Laboratory was built only two years earlier with a $50,000 gift from the Cruft family, prominent Boston merchants (see Fig. 7).[10] It had twenty-five rooms that adhered to the latest designs in high-voltage laboratory specifications and fire safety regulations, and it had two large and distinctive antenna towers mounted on its roof. Each room had access to 500 volts direct current and 220 volts alternating current, with underground storage for the largest storage batteries in the world. These batteries were capable of storage battery

Fig. 7. Cruft High Tension Electrical Laboratory, circa 1919. (Postcard courtesy of http://ieeemilestones.ethw.org/File:Cruft_postcard.jpg)

voltage up to 80 volts. Ten rooms had access to 100,000-volt storage batteries. It was widely regarded as the best electrical laboratory in the country.

The initial arrangement with Harvard University contemplated installing and developing a radio school for 1,000 men in order to train operators, primarily for 1st District Naval patrol boats. The first students were each provided with food at a cost of $5.00 per week and dormitory accommodations at $3.25 per week, which they paid themselves from their daily Navy stipend of $1.25 per day.[11] Thirty-two recruits enrolled in the intensive, four-month program, which included lectures and practical training using the Laboratory's state-of-the-art radio and electrical equipment.[12]

After the Brooklyn Navy Yard Radio School completed its move to Harvard, the student population suddenly grew to 830 naval reserves under instruction. Harvard renovated buildings, modified electrical installations, and redesigned interiors to Navy specifications. It provided classrooms and installed dormitories. Harvard also rented nearby boarding houses and homes and constructed new buildings. Throughout, the Navy remained formally independent as it operated and drilled its recruits under strictly military guidelines and procedures.

Life At Harvard

Radio Students

Prior to the war, Harvard originally offered a Naval Course of Study given by university faculty to college students at the Astronomical Laboratory. The program included four courses for university students participating in the university's Naval Reserve program. The topics covered mathematics, navigation and nautical astronomy, marine meteorology, naval principles, seamanship ordnance, and gunnery.

Under the Navy, a complete curriculum was designed and implemented as the first Naval Radio School students arrived from across the country. They were expected to understand the fundamentals of radio and have substantial knowledge about radio construction, with some commercial experience or equivalent. They were also expected to copy in the Continental and Morse codes, including the demonstrated ability to meet sending and receiving standards.

The first 120 students included many former Harvard University students together with others from Cornell, Dartmouth, and MIT—as well as many with no college training. All were members of the U.S. Naval Reserve Force. Per Local Order No. 1 dated April 28, 1917, reveille was at 6 a.m., and the men spent their day in practical radio instruction, lectures, study of machines, paperwork, and simple infantry drills. Yet, they took their meals commingled with Harvard's general student body, initially at Foxcroft Hall and later at Memorial Hall. Formal work ended at 5 p.m., and the call to quarters occurred at 8 p.m. with taps at 10 p.m.[13]

Campus Buildings

Initially, the Navy set up the Radio School in Cruft Laboratory, but within just a few weeks, the Navy moved its administration/school services offices to the larger Pierce Hall that was adjacent to Cruft (see Fig. 8).[14] Pierce Hall became headquarters and contained the commandant's office, paymaster's office, executive offices, lecture rooms, and operating rooms where students could practice sending and receiving telegraph code. Hastings Hall served as a detention facility for newcomers who remained in detention for one month while they performed guard duty and other basic work before beginning classes.

Arriving sailor-students assembled in formations on campus for roll call and other processing. All staff and students were notified that the buildings and furnishings used by the radio school belonged to Harvard University or the Navy. The sailors were generally polite and orderly, and they were well received by civilians living in the Cambridge area. Due to housing shortages, the sailors were quickly scattered over a wide area of Cambridge. A number of sailors stayed in the nearby communities for "shore leave" or visits. Harvard's Divinity Library served as a clearinghouse for community invitations, a source for information about weekend offerings, and historic tours of Concord, Lexington, and Boston sites. The Navy and university jointly established a "friends of the family" program to host the sailors for meals

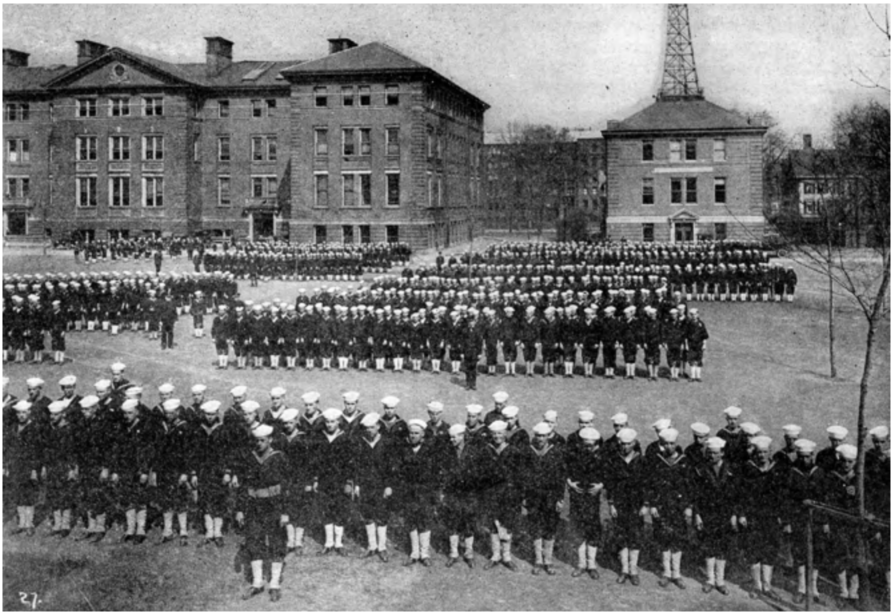


Fig. 8. Inspection and review at Harvard, with Pierce Hall (L) adjacent to Cruft Laboratory (R) in the background. (*Wireless Age*, Oct. 1918, p. 24)

and visits. In 1917, the sailors received so many invitations for Thanksgiving that more than 1,000 offers had to be refused.

Craigie Hall, Russell Hall and Perkins Hall were used as barracks/dormitories, with four sailors assigned to each room. Pierce Hall and Hemenway Gymnasium housed additional barracks. Classrooms were packed into available spaces in many locations, including Reed Chapel and Pierce Hall. Divinity Library, Parish House and the YMCA provided study facilities.

Harvard and the Navy offered opportunities for swimming, baseball, boxing, rowing, and running at campus and at other nearby facilities. The Hemingway Gymnasium offered weekly boxing activities. The YMCA built a "Y-Hut" with a large brick fireplace and heating stoves that was located next to the Ships' Store and Commissary on Holmes Field (see Fig. 9).[15] The Y-Hut, operated by the Phillip Brooks House Association as a Ladies Canteen and movie house, was staffed by the volunteer "ladies of Cambridge" from 7 a.m. to 10 p.m. daily. It had a stage at one end for entertainment as well as writing desks throughout. The Navy also built a small infirmary next to Rotch Laboratory and located twenty-eight new Navy cutters at Weld Boathouse for regular training exercises on the Charles River. Nineteen 26-foot cutters could also be rented from the Harvard Boat Club.

Accommodations were soon overcrowded. Perkins Hall operated at more than three times capacity, housing over 500 men who slept in double-deck berths (cots) packed in at two units per room. The Hemenway Gymnasium had sleeping berths in the main hall, on the running track, and in the locker rooms. Temporary barracks were constructed on the Cambridge

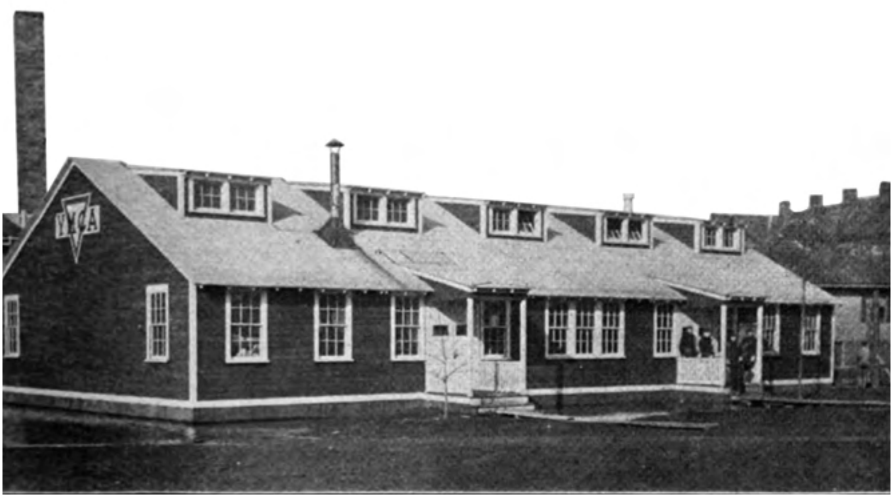


Fig. 9. The YMCA Hut built on Holmes Field in 1918. (*Harvard Alumni Bulletin*, Feb. 28, 1918, p. 405)

Commons for 1,800 men in the summer of 1918, despite the objections of Cambridge residents.

Harvard's Committee on Military Science and Tactics of the Board of Overseers noted on February 25, 1918: "The extraordinary growth of the Radio School requires that all of the available facilities needed by it be generously placed at its disposal."[16] Yet, the committee also recommended further expansion, stating that "several similar schools on the Atlantic Seaboard might well be consolidated into one school held at Harvard, thereby promoting efficiency and saving expense."[17] By the middle of 1918, almost all the university buildings north of Harvard Yard, including Memorial Hall, had become "ships" or temporary barracks.

By January 1919, approximately 2,500 sailors were under instruction in Pierce Hall and other facilities (see Fig. 10).[18] Austin Hall, formerly part of the Harvard Law School, was used to teach groups of 600 sailors at one time. The Navy instituted a "double shift" as the school ballooned to 3,200 men. The school operated in two shifts from 7:20 a.m. to 9:00 p.m., with each shift consisting of six hours of instruction in three periods. The first shift began at 7:30 a.m. and second ended at 9:30 p.m. To accommodate this schedule, the

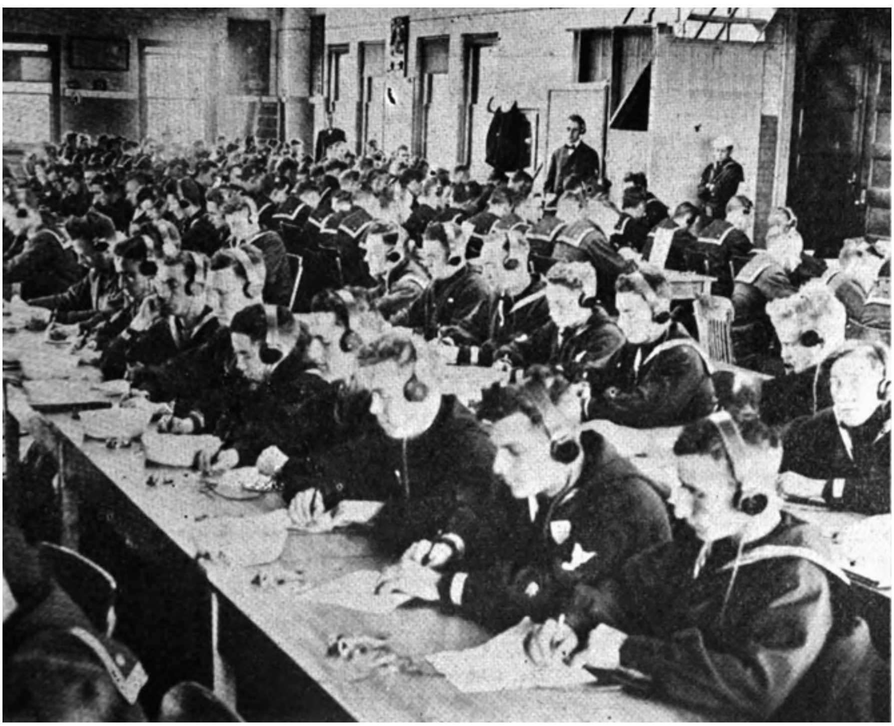


Fig. 10. Receiving class of the Naval Radio School in Pierce Hall in 1918. (*Harvard Alumni Bulletin*, Jan. 3, 1918, p. 253)

staff expanded to approximately 150. The length of the course also expanded by one week, from sixteen to seventeen weeks in duration, in order to overcome any deficiencies in total educational time. Construction of new supplemental buildings finally relieved the scheduling pressure and allowed the schedule to return to one shift; however, curriculum changes lengthened the duration of instruction by one additional week to eighteen weeks, keeping more students on campus.

Harvard University managed facilities construction and repair, and the university was reimbursed by the Navy. The Navy ensured that streets were cleaned, lawns were mowed, and fences repaired. The Navy also landscaped and placed Navy emblems in conspicuous locations. By the time the war ended, the Navy occupied fifteen school buildings, one private residence and fourteen new buildings. According to Lt. Commander Ayer, the Radio School used a total of thirty-six buildings across the campus, most of which were owned by Harvard.

Medical Operations

The Radio School operated its own Medical Department, with five assistant surgeons, a chief pharmacist, two yeoman, and fourteen hospital apprentices, and it also had a dedicated ambulance (see Fig. 11).[19] Located in Winthrop Hall, it operated under military regulations as a "sick bay" within Navy rules. A Dental Corps, also in Winthrop Hall, used twelve rooms and provided services to the Naval Aviation Detachment located at MIT. Regular sick call was made on the berth deck of Pierce Hall each day. Contagious cases were

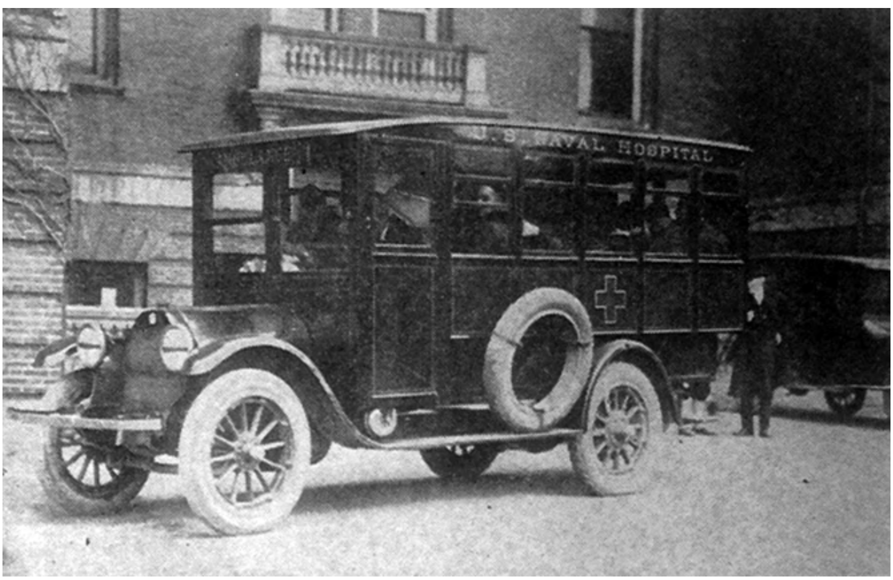


Fig. 11. U.S. Naval Radio School ambulance. (*Oscillator*, Apr. 20, 1918, p. 7)

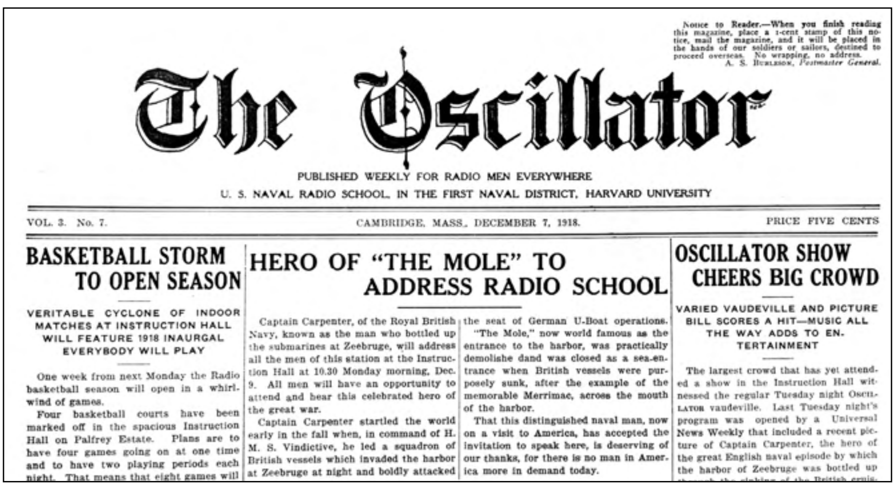
transferred to the Naval Hospital at Chelsea, Massachusetts.

In September 1918, a worldwide outbreak of Spanish Influenza occurred. Prompt action, including the isolation of sick sailors into quarantine and rapid additions to hospital staff, kept the outbreak tightly contained at the Radio School. Harvard University also quarantined 1,450 men who were part of the Student's Army Training Corps, suspended classes and used medical students to perform inspections and house visits. Dormitories, buildings, and tuberculosis hospitals operated as emergency hospitals, and tents were erected for sick patients from Cambridge and MIT. The Navy and the university successfully managed the situation, and only 258 sailors and students were impacted, a very low rate compared to the thousands of civilian cases in Cambridge and Boston, and worldwide where more than eighteen million people died.

"The Oscillator" Newspaper

The Navy published a number of "organs" at its separate stations and ships to transmit news and information to its sailors. The formats varied. *Radio Sparks*, which was published semi-monthly at the Great Lakes Radio School beginning in December 1917, was issued as an oversized illustrated magazine similar to a tabloid. The *Great Lakes Recruit* and the *Recruit* followed a similar format. At Harvard, the Navy published the *Oscillator* (see Fig. 12).

The *Oscillator,* published from October 27, 1917, to March 5, 1919, contained a masthead stating: "Published weekly for radio men everywhere," followed on the next line by, "U.S. Naval Radio School, In The First Naval District, Harvard University." The intended audience included both the general public and all military personnel. The *Oscillator* was distributed to ships and naval stations across the country. It carried a rack price of $0.05 per issue with



Notice to Reader.—When you finish reading this magazine, place a 1-cent stamp of this notice, mail the magazine, and it will be placed in the hands of our soldiers or sailors, destined to proceed overseas. No wrapping, no address.
A. S. Burleson, *Postmaster General.*

The Oscillator

PUBLISHED WEEKLY FOR RADIO MEN EVERYWHERE
U. S. NAVAL RADIO SCHOOL, IN THE FIRST NAVAL DISTRICT, HARVARD UNIVERSITY

VOL. 3. No. 7. CAMBRIDGE, MASS., DECEMBER 7, 1918. PRICE FIVE CENTS

BASKETBALL STORM TO OPEN SEASON

VERITABLE CYCLONE OF INDOOR MATCHES AT INSTRUCTION HALL WILL FEATURE 1918 INAURGAL EVERYBODY WILL PLAY

One week from next Monday the Radio basketball season will open in a whirlwind of games.

Four basketball courts have been marked off in the spacious Instruction Hall on Palfrey Estate. Plans are to have four games going on at one time and to have two playing periods each night. That means that eight games will

HERO OF "THE MOLE" TO ADDRESS RADIO SCHOOL

Captain Carpenter, of the Royal British Navy, known as the man who bottled up the submarines at Zeebruge, will address all the men of this station at the Instruction Hall at 10.30 Monday morning, Dec. 9. All men will have an opportunity to attend and hear this celebrated hero of the great war.

Captain Carpenter startled the world early in the fall when, in command of H. M. S. Vindictive, he led a squadron of British vessels which invaded the harbor at Zeebruge at night and boldly attacked the seat of German U-Boat operations.

"The Mole," now world famous as the entrance to the harbor, was practically demolishe dand was closed as a sea-entrance when British vessels were purposely sunk, after the example of the memorable Merrimac, across the mouth of the harbor.

That this distinguished naval man, now on a visit to America, has accepted the invitation to speak here, is deserving of our thanks, for there is no man in America more in demand today.

OSCILLATOR SHOW CHEERS BIG CROWD

VARIED VAUDEVILLE AND PICTURE BILL SCORES A HIT—MUSIC ALL THE WAY ADDS TO ENTERTAINMENT

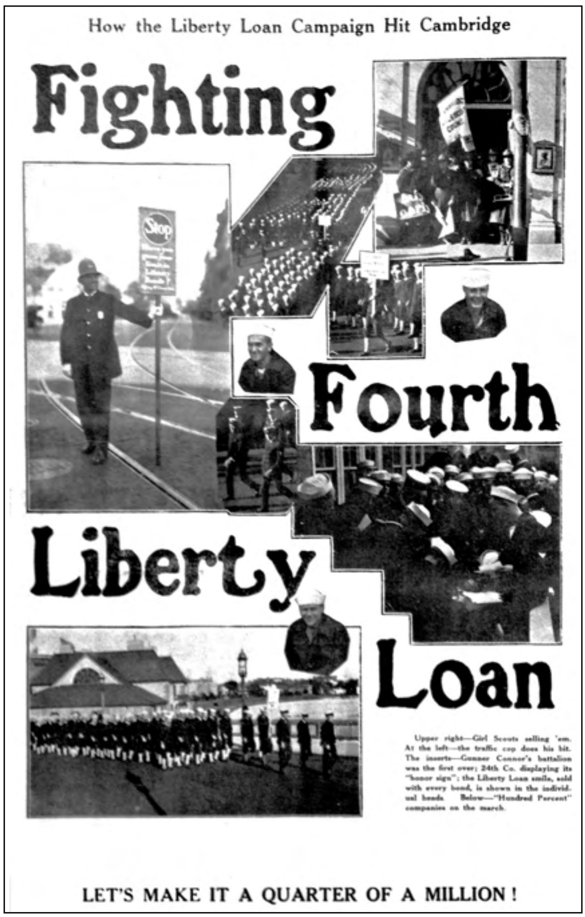
The largest crowd that has yet attended a show in the Instruction Hall witnessed the regular Tuesday night Oscillator vaudeville. Last Tuesday night's program was opened by a Universal News Weekly that included a recent picture of Captain Carpenter, the hero of the great English naval episode by which the harbor of Zeebruge was bottled up

Fig. 12. The December 7, 1918, edition of the *Oscillator* newspaper. (Authors' collection)

a subscription rate of $2.00 per year. Profits from subscriptions, advertising, and sales were donated to the Navy Relief Fund, the Navy Welfare Fund, and other charities. Beginning April 20, 1918, a "Notice to Reader" above the banner asked the reader, when finished, to place a one cent stamp on the issue so it could be mailed to overseas soldiers and sailors for general use. No address or other wrapping was required.

The *Oscillator* proudly announced that Harvard was "the concentration centre for radio instruction for the entire country."[20] A staff of 21 provided a weekly four-column newspaper in a folded broadsheet format that closely followed the larger five-column *Harvard Crimson*, the university's daily newspaper. It presented general news such as advertising, poetry, commentary and sports, as well as military notices such as casualty lists, military promotions, student contests, and honor rolls. Leading experts wrote technical articles in topical series. It also promoted wartime fundraising by announcing parades and placing advertising.

The *Oscillator* came to be recognized as the official journal of the Navy's radio service, and its circulation averaged more than 2,000 per issue. Thanks in part to advertising in the *Oscillator* (see Fig. 13), the Radio School achieved an eighty percent participation rate in the Liberty Loan Campaign, far higher than Harvard College's own participation rate. The Radio School's participation in the Fourth Liberty Loan exceeded seventy-five percent and raised more than $260,000 (approximately $4.5 million today).[21]


How the Liberty Loan Campaign Hit Cambridge

Fighting Fourth Liberty Loan

Upper right—Girl Scouts selling 'em. At the left—the traffic cop does his bit. The inserts—Gunner Connor's battalion was the first over; 24th Co. displaying its "honor sign"; the Liberty Loan smile, sold with every bond, is shown in the individual heads. Below—"Hundred Percent" companies on the march.

LET'S MAKE IT A QUARTER OF A MILLION !

Fig. 13. Advertising for the Fourth Liberty Loan. (*Oscillator*, Oct. 19, 1918, p. 4)

Supply Department

The logistics of setting up offices, handling equipment and inventory, and processing thousands of sailors in such a short period should not be underestimated. During the course of the war, the Supply Department at the Radio School managed nearly 25,000 transfer pay accounts for over 9,000 men. Distribution of clothing alone included 50,000 handkerchiefs, 18,200 pairs of drawers, 19,200 undershirts, 7,100 pairs of leggings, 2,800 flat hats, 1,800 pea jackets, and many other items. The department also wrote more than 6,000 insurance applications totaling approximately $35 million. Nearly 4,000 transportation orders were issued. The Supply Department also oversaw the "ship's store" that was operated by twenty employees who sold more than $55 million of inventory. In just 19 months, open purchases exceeded $85 million, and total shipments into the Supply Department exceeded $141 million. The department handled total equipment valued at more than $107 million. All of this was performed by hand with typewritten documentation.[22]

Student Life

The university undertook great efforts to host the Navy and the Army ROTC. President Lowell hosted gatherings for the officers and wives of the Radio School faculty to meet the Harvard faculty and their wives. The university installed new writing desks and inkwells in many locations for student use. Movies were shown and Vaudeville nights were arranged. Religious services were held with guest speakers and musical accompaniment from the twenty-six-piece Regimental Band. Harvard's Music Department provided concerts and rented pianos that were available for general use. A "Radio Library" containing about 6,000 volumes opened with writing and study rooms in the Divinity Library.[23] Harvard faculty presented academic colloquia on developments in the new technology to members of the Radio School.

Navy committees oversaw health and recreation, dances and social functions. The YMCA provided movies, lectures, dances, minstrel shows, and dance lessons. A Hostess House offered ironing and mending, magazines and newspapers, a kitchen, and other services. In addition, the *Oscillator* sponsored "Oscillator Shows," movies, and athletic events at the Radio School Drill Hall.

The school even had an official song and school mascots (see Fig. 14).[24] Staff

Fig. 14. Radio School mascots Little Salty and the Goat at the Harvard Radios football game. (*Oscillator*, Nov. 16, 1918, p. 7)

member Commander J. B. Rowden, U.S.N.R.F. composed the words and music of "In the U.S. Radio," published by the Oliver Ditson Company of Boston. The song received positive reviews and was reprinted by the *Boston Sunday Advertiser.* The mascots, Little Salty and the Goat, appeared at special events.

Parades, Musters, Field Games and Dignitaries

Daily student life was punctuated by celebrity visits, parades and marching displays, competitive company inspections and drills (see Fig. 15),[25] exercises (see Fig. 16),[26] musters, and field games. On September 19, 1917, the Navy held a "Review" to parade and inspect its 1,400 men. The school presented its colors to members of the Japanese Mission and French and British officers. Approximately 20,000 people participated in a military and naval carnival at the Harvard Stadium that included an Army-Navy football game, a two-mile relay, chariot races, and tug-of-war contests. The carnival ended with a parade of 6,500 sailors and soldiers.

Dignitaries such as Vice Admiral Montague Edward Browning (of the British navy) and Assistant Secretary of the Navy Franklin Delano Roosevelt (a 1904 Harvard College graduate) visited regularly. In April 1918, Secretary of the Navy Josephus Daniels spoke to the students, "I came to see Harvard University which has come to be a second Naval Academy."[27] Earlier that year, Roosevelt noted the rapid growth and importance of the Naval Radio School, "I think all of us were rather appalled at the growth of the Radio School, which grew from a few students to its present number of 3,300 men. It is magnificent and it is effective."[28]

The Navy instilled an esprit de corps, camaraderie, and overall pride of force by holding Great Navy Day Celebrations with parades, field demonstrations (see Fig. 17),[29] and awards (see Fig. 18).[30] Competitive sports such as baseball, basketball, football,

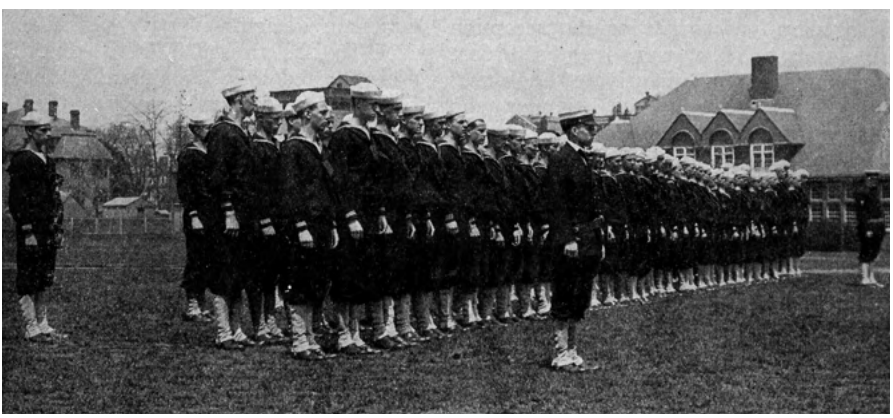


Fig. 15. Students of the Radio School lined up for inspection on Harvard Yard. (*Wireless Age*, July 1917, p. 764)

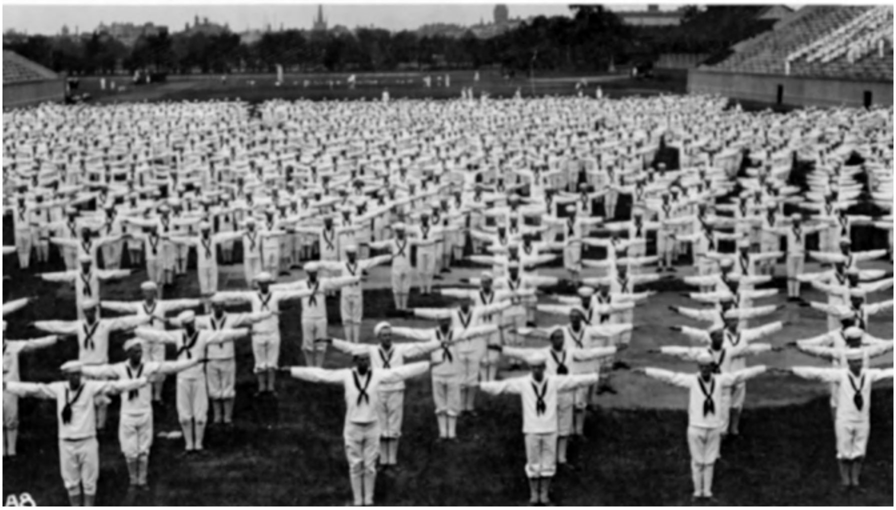


Fig. 16. Physical exercises at Harvard Stadium, Apr. 9, 1918. (Naval History and Heritage Command Photograph Collection)

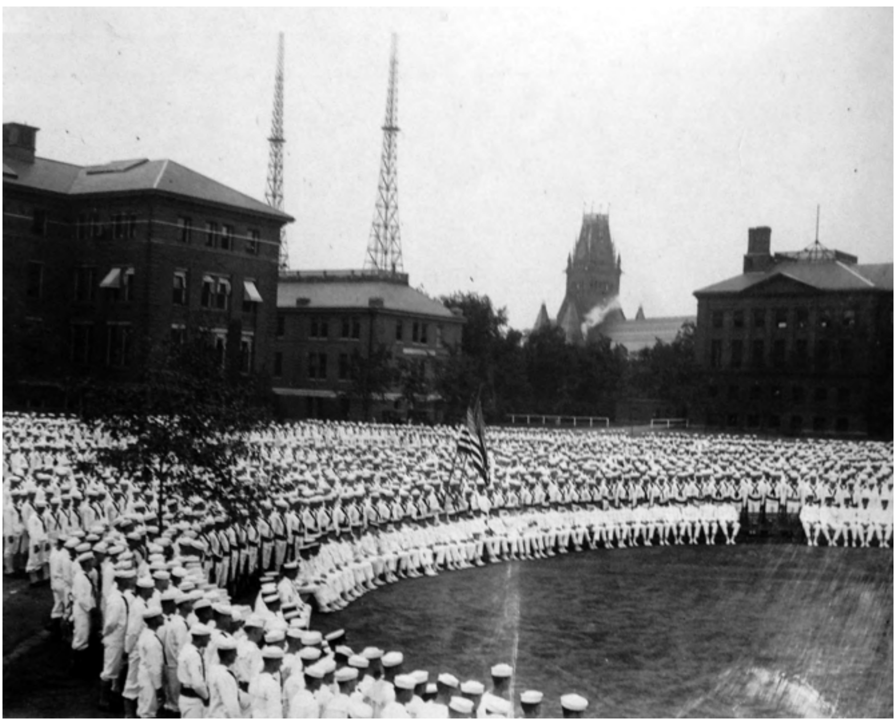


Fig. 17. The Great Navy Day Celebration, July 15, 1918. Pierce Hall (L), Cruft Hall (C), and Memorial Hall (center distance) can be seen. (Authors' collection)

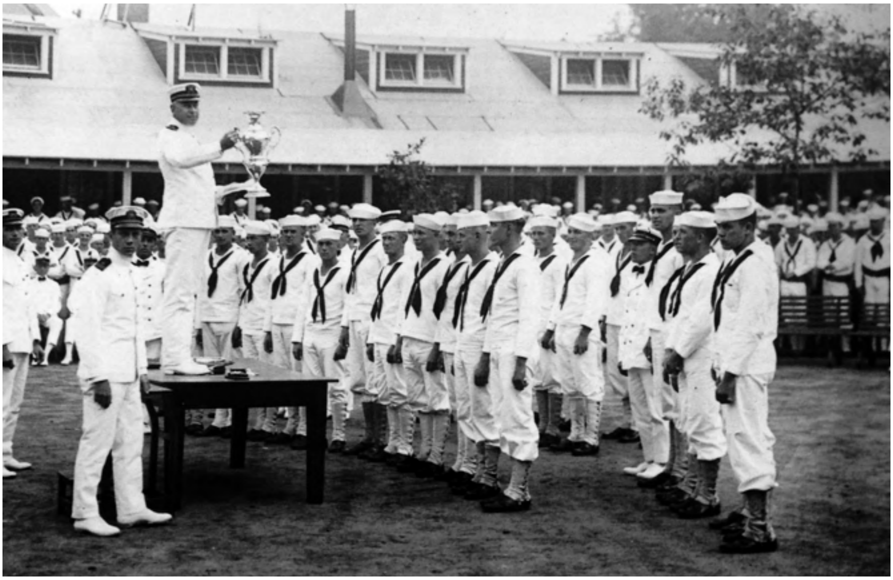


Fig. 18. Commandant Ayer presenting awards at the Great Navy Day Celebration, July 15, 1918. (Authors' collection)

Fig. 19. Championship Harvard Naval Radio School basketball team. (*Oscillator*, Mar. 23, 1918, p. 13)

swimming, racing, and boxing were encouraged, as were other student activities. The Radio School Athletic Department organized teams and won numerous trophies at local school and military sports contests, and it fielded championship teams in basketball and other sports (see Fig. 19).[31]

The Radio School's football team, "Harvard Radios," drew regular crowds in its 1918 season, and they outscored all opponents that season by a total of 193 to 71. A well-publicized poster featuring the Harvard Radios versus the Princeton Aviators remains highly collectible today (see Fig. 20).[32]

Fig. 20. Harvard Radios v. Princeton Aviators football poster *circa* Nov. 23, 1918. (Hoover Institution, Poster US 5276 XX343.29104)

Training and Staff

Navy Education and Performance Standards

The need for highly trained radiomen in the Navy was intense as the country entered the war. The Navy's fleet alone comprised 750 naval vessels and 2,500 merchant vessels, as well as shore stations. Each ship needed radio crews with between four and forty radiomen. The task was enormous as the Navy initially planned to train up to 13,000 radio operators.[33]

Navy leadership was committed to designing and implementing the most efficient and up-to-date program for training advanced radiomen. The Navy surveyed fifty experienced Navy electricians and radio operators to identify the best techniques, and it designed new approaches and built custom operating tables and practice installations for instruction (see Fig. 21).[34] It developed and used new large charts for instruction and memorization; a number of them were interactive with red, white, and green electric lights. Classrooms accommodated over 300 students each. Central control switchboards and trunk lines enabled wireless and telegraph instructors to work with separate operating tables in small groups or to connect the entire classroom together for large group practice on buzzers and keys. Students worked in pairs with one student sending and one receiving. While the schools were designed for mass teaching, the Navy dictated that each student was "treated as an

Fig. 21. Operating table telephone switchboard for instruction at Harvard Radio School. (*Oscillator*, Jan. 11, 1919, p. 15)

Fig. 22. Proficiency testing at Great Lakes for admission into Harvard Radio School. (*Great Lakes Recruit*, Jan. 1918, p. 21)

individual, with aptitude and application governing his progress."[35]

The Radio School at Harvard was manned with U.S. Navy personnel. On January 1, 1918, the school had total personnel of 3,296 with 3,000 under instruction. By 1919, the instructional staff at Harvard included fifty-four naval staff members.[36]

Admission to the Harvard Radio School from the various preliminary schools required a minimum proficiency of ten words per minute sending and receiving in Morse code (see Fig. 22).[37] Unfortunately, as the war progressed, increasing numbers of recruits arrived with no prior experience in radio because training at the various preliminary schools was not sufficient. A majority of the new arrivals had a proficiency of five words per minute, and many of the sailors were subsequently removed from the program. Harvard's Radio School remedied the situation after it provided examination and instruction materials to the various preliminary schools and sent instructors from Harvard to those schools to teach the instructors themselves, raising the overall quality of the educational program. Close and supportive cooperation between the Harvard Radio School and the primary schools continued throughout the war.

The Navy also worked with Harvard University to develop methods for stratifying the students and providing more customized support services to improve student performance. Dr. R. E. Tullos of Harvard University provided the Navy with psychiatric and mental acumen examinations to screen candidates for their abilities. This was one of the first applications of aptitude testing that had initially been developed by Harvard University for the U.S. Army, and it was a precursor to the broader use of aptitude testing in American education. The men were grouped by skill levels, and advancement was strictly based on achieving defined qualifications. This approach was consistent with a broader shift in Navy policy that had moved away from the historic seniority based system toward a meritocracy-based system of advancement. In addition to improving the training in radio theory, greater emphasis was placed on practical applications such as sending radiograms. Supplemental tutoring and training was also developed. Monthly reports were exchanged between the primary schools and the Harvard Radio School showing the qualifications of the students, and competition between schools was encouraged as another tool to stimulate and focus their efforts on education.

After becoming qualified at the primary schools, the men became eligible for the Harvard draft. The combination of screening, flexibility, applied education, and greater student support services significantly raised the incoming proficiency levels. Students who continued to have difficulty at Harvard were required to enroll in night school for additional training. The screening and use of additional support services were very successful at the primary schools. For example, by 1919, only six percent of the men sent from Great Lakes to Harvard failed in Harvard's more advanced radio course.

Morse code drilling at Harvard also became more focused as it concentrated on teaching two classes of messages: battle signals and naval dispatches. Battle signals used a system where every letter had a name. Naval dispatches came in nine different forms. Students had to learn to call ships, divisions, squadrons, or divisions minus certain ships. This focus on theory combined with application left the graduating sailors more able to adapt to the rigors of actual Navy life and radio operations in the fleet.

Academic Curriculum

The curriculum at Harvard was subject to rapid and multiple revisions. The evolving curriculum reflected the input that was sought and received from fleet commanders, who commented on their experiences with new graduates.

Distinct portions of the curriculum were covered in dedicated classrooms located in different buildings. Three classes were initially offered in theory (see Fig. 23).[38] Harvard's 25-kW arc transmitter was used for demonstrations. In 1918, the academic curriculum was completely revised. Five new Navy chiefs with wireless experience and aptitude for teaching theory were appointed. They were joined by fourteen new assistants, and two of the assistants were assigned to each classroom. The curriculum now encompassed magnetism, static electricity, current electricity, electromagnetism, alternating currents, generators and batteries, direct and alternating current motors, and radio power circuits. The courses incorporated demonstrations, and classrooms were fitted with examples of apparatus and equipment that the students would actually use in the fleet (see Fig. 24).[39]

The Navy expected students in the Radio School to acquire and study key textbooks in the fields of electronics and wireless, and they were used in

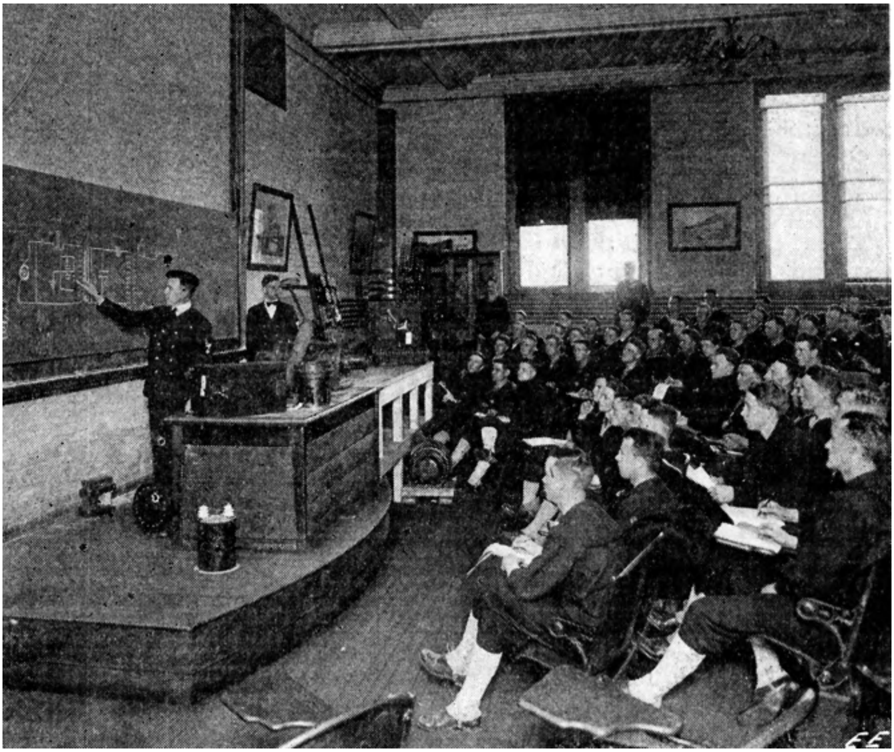


Fig. 23. Theory course at Harvard Naval Radio School. (*Electrical Experimenter*, Dec. 1918, p. 548)

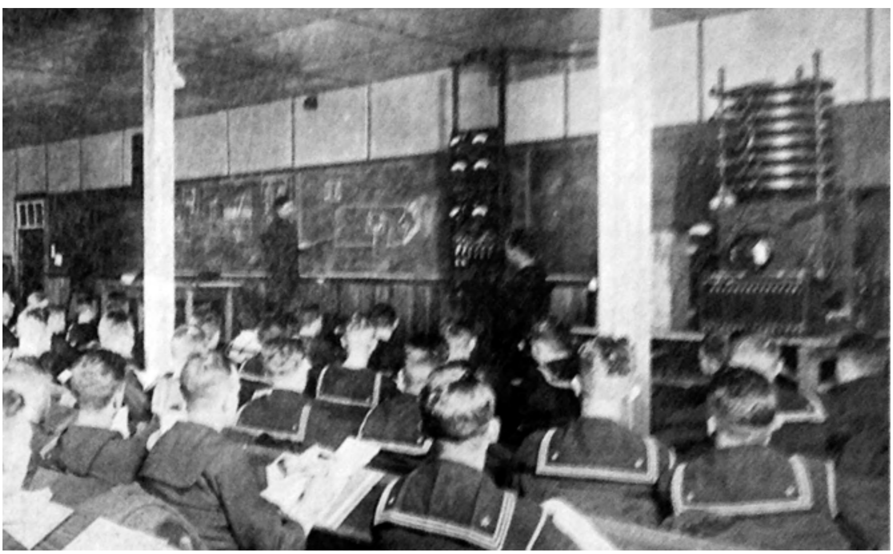


Fig. 24. Equipment lecture at the Commons. (*Oscillator*, Feb. 8, 1919, p. 9)

the classes. These books encompassed theory and application and introduced the types of equipment and apparatus installed at the various naval stations and onboard ships. The selected texts were being used at the U.S. Naval Academy and were also available to civilians. As such, they constituted some of the most important early educational treatises on wireless telegraphy and radio of the era. The *Oscillator* carried advertising from several booksellers for the sailors to purchase these books. The Radio School's library held copies of these and other required and general reference books for the students. The library also maintained a stock inventory of the books that were available for sale at cost, offering the students a significant discount from retail pricing. In many cases, these texts laid the foundation for an entire generation of radio operators. Three of the most important Navy texts included: Commander Burns T. Walling's *Electrical Installations of the United States Navy*, Rear Admiral Samuel Shelborn Robison's *Manual of Wireless Telegraphy for the Use of Naval Electricians*, and Admiral William Hannum Grubb Bullard's *Naval Electricians' Text and Handbook* (a/k/a *The Naval Electricians' Text Book*).

In October 1917, the Navy ordered the publication of a separate theory text for use at Harvard and other stations. The Navy established a drafting crew at Harvard to prepare illustrations and a printing crew to typeset and print the book. At the time of the Armistice, twenty-five men were involved in the project, and they had written the first eight chapters. Unfortunately, the Navy dropped the project when the Harvard Radio School was closed and moved to Great Lakes in 1919. Ensign Roland G. Porter's *Theory Text Book of U.S. Naval Radio School Cambridge, Massachusetts 1917-1919* contains the original text and drawings from the project. Porter was a former Marconi radio operator and served as an instructor of Radio Theory at the school during the war. He submitted the text as his *Thesis For School of Engineering Northeastern College* in 1918. Porter's text survives as the only formal record of the theory curriculum at the Harvard Naval Radio School. The materials for the course were forwarded to Great Lakes when the Radio School relocated, and it was used as the basis for its newly revised courses. After the war, Porter became a professor of electrical engineering at Northeastern University where he also used the text as the basis for his own courses in radio and wireless theory.

School sessions operated five days each week. The sailors received 3½ hours of operating instruction, 3½ hours of technical instruction, and daily lectures in two periods each. Military drills required 1¾ hours each day except Sunday, and inspections occurred on Saturdays. Classroom examinations occurred weekly on Fridays. Those passing generally rated as electricians third class, with a few high performers rated as petty officer second class, skipping over the petty officer third class rank. Exceptionally skilled sailors were retained as instructors.

Graduates were sent directly to the fleet or to armed-guard duties in the merchant marine and transports. Graduates with the rank of electricians third class (radio) were sent to larger vessels. Electricians second class were sent to destroyers and gunboats. Electricians second class who served two years at sea in radio were eligible for shore duty.

By May 1918, the structure of the instruction changed as the duration again expanded from sixteen to seventeen weeks. All sailors were required to take a common course for the first twelve weeks, thereafter splitting into specialties for the Fleet Course, Armed Guard Course, High Power Course, and the Aviation Course. After the school returned to one shift and expanded to eighteen weeks in duration in August 1919, the courses were being taught by seventy-five instructors to approximately 3,400 men.

The additional coursework and weeks of instruction yielded sailors who could meet the requirements of twenty-five words per minute code proficiency test upon graduation. Higher qualifications for incoming and outgoing students dramatically improved the overall competency, and approximately 165 sailors were graduating each week. Supplemental night courses further supported men who were failing to pass their examinations, further improving the success rates. By December 1918, the interim deficiency rates reduced from 1,500 in week one down to 200 by week ten of the program.

By April 1919, the relocation to Great Lakes and reorganization of the curriculum resulted in a thirty-two week schedule, with twenty weeks of common curriculum followed by six weeks of specialized courses in Fleet and Radio Telephone operations, four weeks of common subjects involving station operations, a week of review, and a final week of examination.

Radio Apparatus and Teaching Equipment

The Navy understood that hands-on experience was essential to demonstrating and teaching the use of equipment. Telegraph codes were taught and practiced at operating tables fitted with headphones, sounders, and transmitting keys. Supplemental classes were available from the Eastern Radio Institute and other private schools that advertised in the *Oscillator*. Sailors could purchase telegraph code practice sets, phonograph records, and other items for their own use. James W. Poole in Boston offered a Radio Buzzer Signal Set for $6.00 that a student could operate with a battery for home study (see Fig. 25).[40] Frank B. Perry and Sons of Newton, Massachusetts manufactured the set under contract for the U.S. Army Air Service. This is believed to be one of very few practice sets intended specifically for training wireless operators during World War I, and it was available in several slightly different configurations.

Although the *Oscillator* did not carry any advertising for the Omnigraph, this device was widely advertised in many magazines of the era for use in code receiving practice, and the Navy officially adopted it for military code

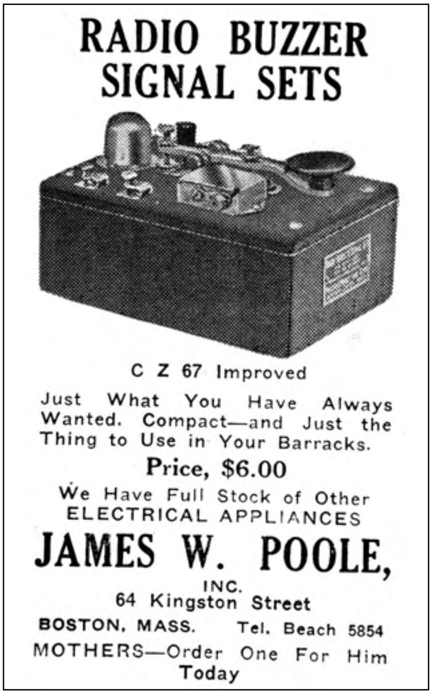


Fig. 25. The only advertisement for code practice sets appearing regularly in the *Oscillator*. (*Oscillator*, Feb. 8, 1919, p. 9)

proficiency testing (see Fig. 26).[41] Three models were available ranging from $8.00 to $20.00. The Omnigraph used metal disks with various code combinations that could be randomly ordered to permit a greater variety of listening/ receiving practice.

Radio apparatus of the period was large, heavy and cumbersome (see Fig. 27).[42] Classrooms and laboratories at the Harvard Naval Radio School were completely rewired to install a variety of actual equipment and fully operating radio stations. Custom laboratory tables were designed and built to accommodate the radio equipment for demonstration and student handling, and custom operating practice tables were built and wired to function in controlled networks for demonstration, practice and testing. Photographs of some demonstration equipment were featured in

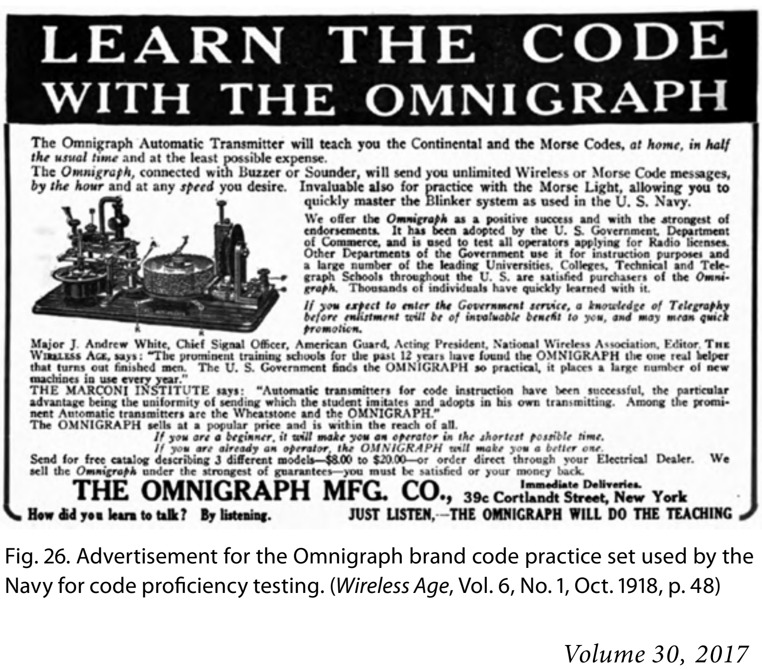


Fig. 26. Advertisement for the Omnigraph brand code practice set used by the Navy for code proficiency testing. (*Wireless Age*, Vol. 6, No. 1, Oct. 1918, p. 48)

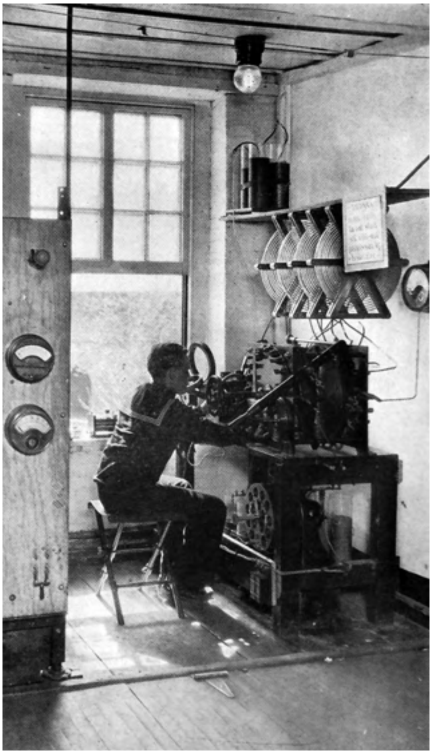


Fig. 27. Operating a 2-kW transmitter set at the Navy Electrical School, New York. Similar installations were built at Harvard. (Navy Publicity Bureau, New York, 1917)

recruiting booklets, general magazines, and popular books in order to publicize the opportunities and explain the benefits of this education to the general public as an inducement to recruits interested in receiving naval training.

Naval Radio School equipment demonstrations included portable field sets used by the U.S. Army and U.S. Marine Corps (see Fig. 28).[43] Portable sets had a range of forty to fifty miles and operated with a seventy-five foot, telescopic, collapsible aerial. Larger, fixed/mounted sets operated at 500, 1,000, and 2,000 watts and could broadcast and receive transmissions at hundreds of miles.

Instrument laboratories contained full shipboard and land based naval station sets as well as Army and Navy testing and demonstration apparatus. Switchboards and control panels, apparatus for transmitting and receiving, AC and DC voltmeters and ammeters, oscillation transformers, Leyden jars condensers, motor-generators, and other equipment were shown and demonstrated in class, and the sailors were expected to work directly with the apparatus (see Figs. 29).[44]

Courses on theory included live demonstrations as well since the radio operators were expected to be fully knowledgeable about the theory and function of the sets, and they were expected to be able to assemble, adapt, and work with the sets under any conditions (see Fig. 30).[45]

The coursework also taught the latest in radio design and instructed the sailors on compact units that were engineered for smaller spaces. American Submarine Chasers and the Mosquito Fleet used a range of equipment capable of fitting into smaller occupancy onboard ship. Destroyers offered more accommodation and could house larger units. The radioman had to be capable of adapting to his environment. Aircraft radio installations were also covered, even though this subject was also included as part of the Aviation Ground Schools and School for Radio Engineers that were operating with the U.S. Navy at MIT.

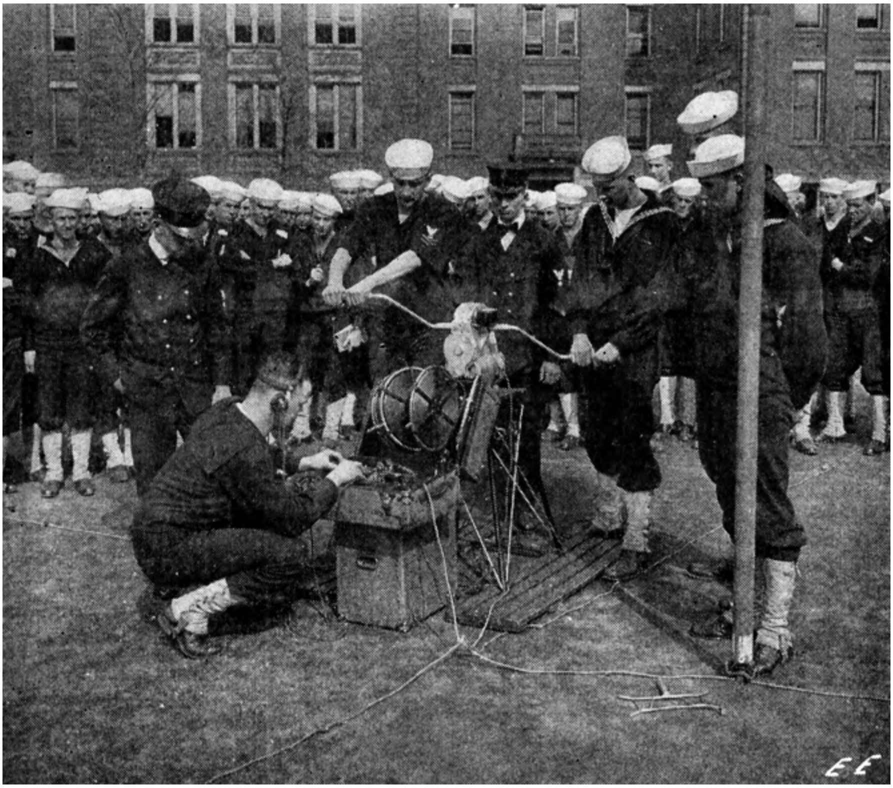


Fig. 28. Outdoor demonstration of portable radio equipment, a suitcase pack set, and a hand generator at Harvard. (*Electrical Experimenter*, Dec. 1918, p. 548)

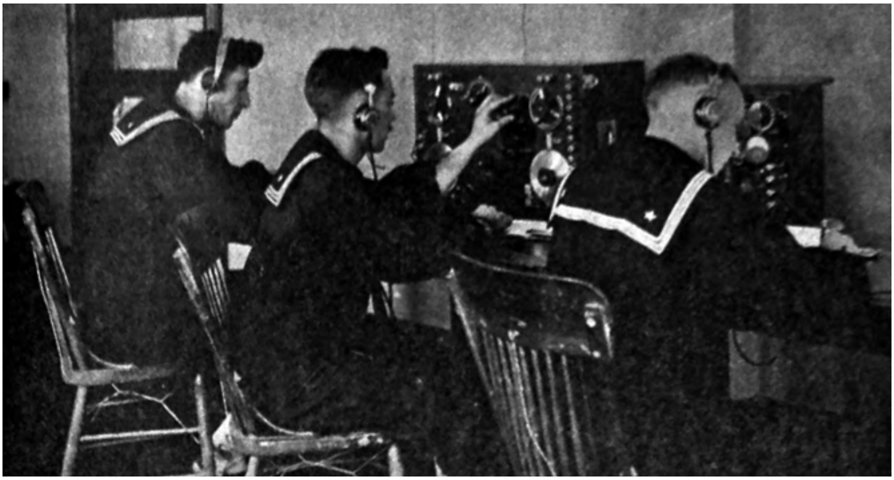


Fig. 29. Receiving practice in the "Conning Tower" at Harvard. (*Oscillator*, Dec. 28, 1918, p. 5)

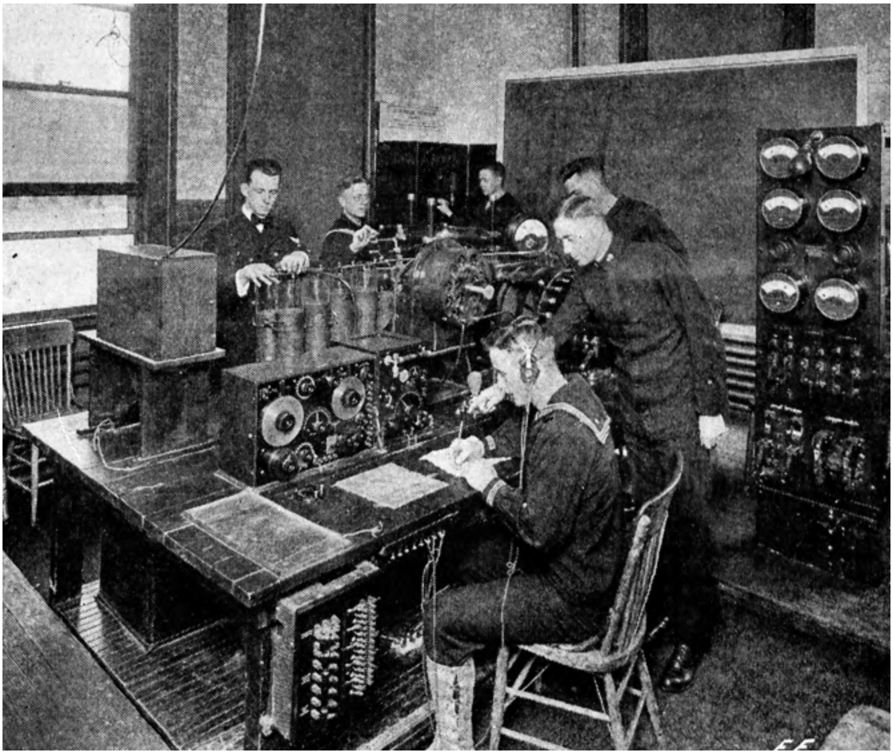


Fig. 30. A naval officer instructing an operator on receiving and transmitting apparatus in a laboratory at Harvard. (*Electrical Experimenter*, Dec. 1918, p. 548)

Demobilization

Closing The Naval Radio School

Following the Armistice on November 11, 1918, operations at Harvard were swiftly demobilized, and the buildings were returned to Harvard University. The 3,480 students under instruction were quickly reassigned. The Aircraft Radio School relocated to Pensacola, Florida. Most other operations and equipment were moved to Great Lakes by March 1919. The *Oscillator* published its last issue on March 5, 1919, and commemorative paperweights were available (see Fig. 31).[46] Temporary barracks and buildings were hastily removed,

Fig. 31. Glass paperweight memento of U.S. Navy Radio School issued by the *Oscillator circa* late 1918. (Authors' collection)

and the grounds were restored to their prewar condition. The university opted to purchase a number of buildings and land from the Navy that it had purchased during the war. On April 15, 1919, Harvard Naval Radio School personnel formally transferred to Great Lakes Naval Training Station. On May 5, only nineteen days after arriving at the new location, all classes resumed work where they left off at Harvard.

Fig. 32. Lt. Commander Nathaniel F. Ayer, commanding officer of the U.S. Naval Radio School at Harvard. (*The Recruit*, July 1919, p. 14)

Commander Ayer Retires

On March 19, 1919, Lt. Commander Ayer (see Fig. 32) was placed on the inactive list at his request following the closing of the Harvard Naval Radio School.[47] On May 3, 1919, he was recalled to active duty, commissioned commander, and again put on inactive duty. He retired with the rank of commander. His service record stated, "He developed this school from nothing to over 5,600 students, and the output which went out into the service did excellent work and stood very high… His services were invaluable and were performed to my entire satisfaction."[48] In 1942, Ayer disposed of his interest in the Farwell family businesses, but he continued to be associated with other mills and manufacturing companies and served on several boards of directors, including Boston Safe Deposit and Trust Company, National Shawmut Bank, and the New York Life Insurance Company. Commander Ayer died on a vacation in Canada on July 26, 1948.

Legacies

Impact of Harvard

Harvard University's commitment to the war effort was massive. Service records indicate that 11,319 Harvard students and alumni were in uniform during the war years, and over two hundred members of its teaching staff went into national service.[49] Major portions of the campus faced a complete shutdown. The university's decision to offer its services to the Navy was fortuitous and beneficial to both. Never before, or since, has a major American university converted itself into a significant military installation. Harvard University actively provided and participated in redeploying its educational resources and its physical assets for the benefit of a large-scale national military undertaking.

The Naval Radio School established at Harvard University was the world's first large-scale military educational center dedicated to advanced training for wireless radio operators. The Naval Radio School trained nine out of every ten naval radio operators who served during World War I. Between October 1, 1917, and April 16, 1919, the Radio School reported 16,031 men were on its rolls. The Radio School graduated approximately 8,400 men between August 1, 1917, and January 1, 1919, and another 517 were still under instruction as reserves (336) and regular (181) Navy at closing.[50] Graduates received medals for completing the course of study (see Fig. 33).

The rapid growth was stunning. The Radio School received 4,259 men from Great Lakes alone, plus students from other stations and training camps. The best graduating students were sent to New London, Connecticut, for training in wireless telephone operations. Approximately half of all graduates were initially assigned to armed guard or transport ships. These men were capable of being assigned alone to a ship where they might be expected to completely assemble, install, maintain, troubleshoot, and correctly repair a radio set, often with no support or guidance. Fortunately, most of the ships had at least two or more radio operators.

Fig. 33. U.S. Naval Radio School medal issued to Carl P. Leffler, Aug. 31, 1918. (Authors' collection)

Impact on Harvard

Harvard University benefited tremendously from the Navy's presence. The campus risked being more than fifty percent vacant during the war. The Navy brought the university to full occupancy. It installed wiring, plumbing, new walls, refinished the floors, repaired roofs, painted structures, and renovated buildings. The Navy also installed several buildings that became a permanent part of the university, and it also purchased and then resold land to the university. The university staff also learned and helped to develop new teaching techniques that it applied to the classroom after the war.

In the intervening years between the two World Wars, memories of the Harvard Naval Radio School and courses in naval and military science and tactics became an accepted part of the Harvard College lore and curriculum. Some mementos remained in the form of rings and pins sold to students and faculty (see Fig. 34), banners (see Fig. 1), class photographs (see Fig. 2), or other keepsakes. Cruft Laboratory and Pierce Hall became the centerpieces of the new Harvard Engineering School after the Navy rebuilt the laboratories for permanent peacetime use. The two buildings now contained the best facilities in the country for electrical engineering research and education. Other buildings renovated by the Navy accommodated the Sanitary Engineering Department, Mechanical Engineering Laboratory, Division of Mining and a new Aeronautical Engineering Department. Many of the lessons learned by the Navy found their way into improved teaching methods in Harvard's courses.

Fig. 34. Radio ring and sweetheart pin from U.S. Naval Radio School at Harvard *circa* 1917-1919 made by Walker Military Ring Co. and sold at the Harvard Watch and Jewelry Shop. The rings were $2.75 each, and pins ranged from $0.50 to $1.00 each. (Authors' collection)

Impact on U.S. Navy

By the end of the war, the Navy operated the largest radio communication system in the world. Its recruitment and mass training programs had been a tremendous success. Nearly eighty percent of all amateur radio operators served in the armed forces during the war, and civilians with no experience learned essential skills.

Josephus Daniels, Secretary of the Navy (1917–1921), noted, "At Harvard University we established the largest radio school that ever existed…The Navy not only transported and distributed supplies but also took over the repair and operation of the telegraph and telephone, the operation of wireless, and made possible communication by trained radio men and other naval personnel."[51] He summed up the Navy's accomplishment, noting that "half a million men and thirty thousand officers were enlisted and trained by the United States Navy in eighteen months. No navy in the world ever had as large a personnel, or ever attempted to raise and train as large a sea-force in so brief a time."[52] Sir

Eric Geddes, First Lord of the British Admiralty, said:

> *"The dauntless determination which the United States has displayed in creating a large, trained body of seamen out of landsmen is one of the most striking accomplishments of the war. Had it not been so effectively done, one would have thought it impossible and words fail me to express admiration of the feat undertaken and accomplished by your Navy Department...."*[53]

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David and Julia Bart reside in the Chicago area. Together, they have published numerous articles on telegraph, radio and broadcasting history. David has a BA and MBA from the University of Chicago. He is the Sr. Director of Litigation Consulting for the Great Lakes Region of RSM US LLP, and is the lead author of *A Practitioner's Guide to Liquidation and Litigation Trusts* and the *Standards for Distressed Business Valuation*. David is a Director and Life Member of the Antique Wireless Association, and an editor of the *AWA Review*. He is a Life Member and Director of the Radio Club of America, and serves as the Editorial Director of the *Proceedings of the Radio Club of America*. David is also Vice President of the Museum of Broadcast Communications in Chicago and Treasurer of the IEEE Historical Committee. He is a member of ARRL. David received the AWA's Dr. Max Bodmer Award, the AWA's Curator's Award, and the RCA Ralph Batcher Memorial Award for his work in publications, historical preservation and museum exhibit development. He is the former President of the Antique Radio Club of Illinois.

Julia received her BA from the University of Chicago and MA from Concordia University. She teaches elementary school in Skokie, Illinois. Julia has served as an Associate Editor of the *AWA Review* and continues to provide advisory services to the AWA Board of Directors. She has coauthored numerous peer-reviewed articles for the AWA, RCA and IEEE and works closely with David on their collecting interests. Julia was the Editor for the Antique Radio Club of Illinois' publications, and a past Treasurer and advisor to the ARCI Board of Directors.

David and Julia's work on the IEEE Edison Medal and the IEEE Medal of Honor is included on the Engineering and Technology History Website (f/k/a IEEE Global History Network).

David and Julia Bart

The Cradle of College Radio: WJD and the Prescient Professors

Before broadcast radio there was college radio. It began with a series of science experiments as university professors, and then their students moved from the construction of equipment for sending coded wireless messages to entertaining friends and fellow students using the new wireless telephone. This is primarily the untold story of Richard Howe and his early 1922 Denison University station, the short-lived WJD. And while he was early to college broadcasting, he was not the first. The Howe work supports the idea that radio broadcasting did not begin with the idea of entertainment for a mass audience; typically, it was born in a quiet lab, the wireless curiosity of professors and their students. In this paper, Richard Howe's story is presented within the greater context of the evolution of university-based radio broadcasting.

PART I. COLLEGE BROADCASTING

Introduction To College Broadcasting

This is the larger story of radio broadcasting as part of the higher educational experience. Historically, the beginning of the radio broadcast era is often marked by the well-known broadcast of the presidential election returns by KDKA on November 2, 1920. However, radio broadcasting actually began years before in various colleges and universities in the United States. In this context, radio broadcasting is defined as entertainment or informational content transmitted by radio to a known audience, on a regular basis, and pre-announced in the press. This is a definition attributed to RCA historian George Clark, well known for the Clark Radioana Collection at the Smithsonian.

The college radio broadcasters addressed here are distinct from the first wireless telephone experimenters, who may have resembled broadcasters, but had goals far more practical. They intended to develop and prosper from inventions that allowed the telephone to operate without wires, just like the earlier successes of those who experimented with wireless telegraphy. The two inventors best known for the early transmission of voice and music were Reginald Fessenden and Lee de Forest.

While de Forest could, under the Clark definition, be defined as an early broadcaster (his October 26, 1916 programs of phonograph music over 2XG were announced ahead of time in a music trade publication and elsewhere), he was clearly interested in selling hardware for point-to-point communication—not for broadcasting. For example, the ads he placed in mid-1916 specifically listed only point-to-point applications, never mentioning broadcasting (see Fig. 1). Even in the catalog he published in 1920, large radiotelephony and radiotelegraphy installations were directed at point-to-point communication, as evidenced by the set pictured at the front of the catalog in which a large receiver and transmitter are installed in an office setting (see Fig. 2). And while de Forest and Fessenden did not begin their radiotelephone experiments in a teaching-learning environment, both inventors were surely role models for the university experimenters that followed.

University-based broadcasting developed along four different lines. The first model was curriculum-based and used radio as an applied resource for classroom instruction in radio announcing, radio news, and sports play-by-play—all of it supplemented by lectures, textbooks, and pen and paper tests. The second model sent the

Fig. 1. Ads for radiotelephones placed by the De Forest Company in the last half of 1916 listed only point-to-point applications, never mentioning broadcasting as a possible application. (*Electrical Experimenter*, Dec. 1916, p. 548)

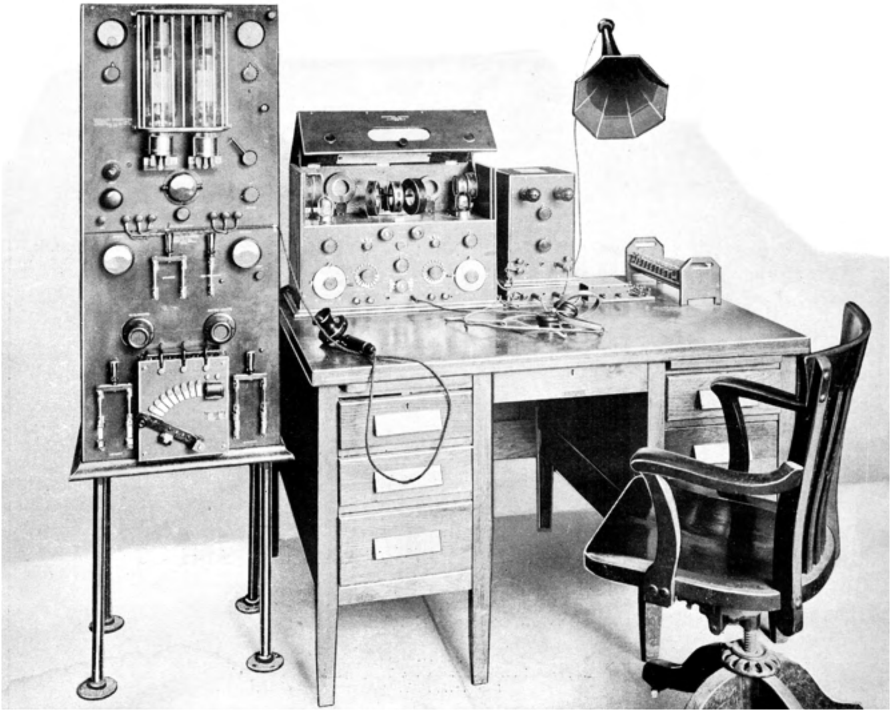


Fig. 2. The De Forest catalog published in 1920 pictured a large radiotelephony and radiotelegraphy installation directed at point-to-point communication rather than broadcasting, as evidenced by a large radiotelephone receiver and transmitter installed in an office setting. (*De Forest Oscillion Radio Equipment* catalog, 1920, p. 2)

content of the college classroom into homes as for-credit classes. A third model used professional broadcasters to play classical music and offered other programming such as national news and talk while keeping the students out of the university station altogether. The fourth model turned programming over to the students, making it more of a student activity than part of a program of study. Many stations used some combination of these four basic models. All of these genres, which are often referred to as "college radio," still exist today.

College Broadcasters Emerge From the Laboratory

The evidence suggests that the so-called "college" radio stations happened accidentally, but that in no way reduces their significance. Four pioneering stations that could be defined as early "college broadcasters" are listed in Table 1. The first three of the pioneers listed in the table are well known and their exploits have been chronicled previously, while the story of pioneer Richard Howe at Denison University, the main subject of this paper, is relatively unknown.[1] The dates first issued and

Table 1. Stations call signals licensed to four early college broadcasters and the dates bracketing their periods of operation.

Licensee	Call Sign	License Type[1]	Date First Issued	Deletion[2] or Transfer Date	Radio Service Bull.	
					Issued	Deleted
Chas. Herrold Herrold Col.	6XF	Special	Nov. 1915	May 1926	No. 12, p.2	No. 111, p.9
	6XE	Special	Sept. 1920	May 1926	No. 42, p.5	No. 111, p.9
	KQW	B'cast	Dec. 1921	July 1925[3]	No. 57, p.2	No. 100, p.6
U. Wisconsin	9XM	Special	June 1915	Dec. 1926	No. 7, p.3	No. 117, p.8
	WHA	B'cast	Jan. 1922	Still operating	No. 58, p.2	N/A
Ohio State U.	8XI	Special	May 1920	Oct. 1921	No. 36, p.5	No. 55, p.7
	8XJ	Special	Mar. 1922	See text	No. 60, p.6	See text
	WEAO	B'cast	Jun. 1922	Name change	No. 62, p.24	c. Sept. 1933
	WOSU	B'cast	Sept. 1933	Still operating	No.: ?	N/A
R. H. Howe	8ABR	Amateur	Feb. 12, 1916[4]	Unknown	N/A	N/A
R. H. Howe or Denison U.	8YM	Special	Mar. 1921	Nov. 1924[4]	No. 48, p.4	Not found
	8XW	Special	Apr. 13, 1925[4]	Sept. 1925	Not found	No. 102
	WJD	B'cast	Mar. 1922	Dec. 1925	No. 60, p.26	No. 105, p.6

[1]Special land station types were identified by the first letter after the initial number in the call signal: X for Experimental, Y for Technical and Training School, and Z for Special Amateur.
[2]Excludes license suspensions/cancellations during WW I when reissued after the war.
[3]License transferred to the First Baptist Church in San Jose in 1925 after sale.
[4]Date of issue and expiration appear on licenses

last deleted or changed serve to bracket the time period the station was in operation with the call letters indicated. Unless otherwise noted, the months listed are determined from entries in the Radio Service Bulletins, which are identified by issue number and page number in the last two columns.[2] These dates are consistent with other documents deemed to be reliable.

The stories of the first three pioneers are briefly summarized in the remainder of Part I as a prelude for the more detailed story of Richard Howe and his stations that follows in Part II. The story of Richard Howe is of particular interest because his activities have been so well documented in the archives at the Denison University Library, although little of it has been previously chronicled. This author discovered the Howe Papers at Denison University in the process of identifying Columbus Ohio radio stations for a new book *Columbus Radio*, part of the "Images of America" series from Arcadia Press, published December 2016.[3] The Howe Papers at Denison University consist of photos, correspondence with the Department of Commerce and its regional office in Detroit, licenses, personal papers and remembrances, and listener verification postcards.

The four institutions listed in Table 1 have something in common. All introduced radiotelegraphy into their curricular or extracurricular activities before 1912, the year that licenses were first required and call signals were first assigned.[4] Call signals, if they were used at all before 1912, were self-generated. For example, the Herrold College selected the letters FN and SJN to identify its early broadcasts. All these colleges applied for one or more Special land station licenses after 1912, and all received one or more call signals from the Department of Commerce. Finally, all applied for broadcast licenses in late 1921 or early 1922, shortly after that category of license was first issued by the Department of Commerce.

The institutions appearing in Table 1 are only representative examples of how science and engineering programs in schools and colleges led to college broadcasting. While most of these stations began as a series of technical trials, the outcome of these radio experiments would have lasting importance. Charles Herrold's station was the first to be curriculum-based, as he used it to educate students in radio practice. University of Wisconsin's WHA and Ohio State's WEAO (later re-named WOSU) became important stations for over-the-air education. Other college-affiliated broadcasters followed a classical music and lecture programming model to reflect their university's mission. How do these early stations compare? How did they end up? These are their stories, small histories that set the stage for Richard Howe's modest WJD at Denison University in Granville Ohio.

Three Examples of Early College Broadcasters

The Herrold College of Wireless and Engineering (KQW)

College broadcasting began in San Jose at the Herrold College of Wireless and Engineering. Charles Herrold's students were the first college broadcasters. His radiotelephone invention was undeniably the first college radio station. The written evidence suggests that they actually may have known what they were doing as early as 1909. Herrold's broadcasting model was curriculum-based, as his wireless students learned the technical side of radio station construction. But it was also extra-curricular, as Herrold allowed and encouraged his students to use the station as an after-class activity, to send music and talk to their small audience of mostly fellow wireless hobbyists.

His first station was the pre-vacuum tube, DC arc-powered transmitter that was on the air in 1909. Located in downtown San Jose, the Herrold College was a for-profit trade school primarily set up to meet the urgent need for trained wireless operators for ship and shore stations. Stanford engineering drop-out Charles Herrold was its founder, and while his mission was to teach students code and wireless practice, he was an inventor who used his school laboratories to develop a radiotelephone, this at a time when voice transmission was rare. In 1909 Herrold only had three choices: the spark of Marconi, an alternator as used earlier by Fessenden, or the Poulsen arc as used in 1907 by de Forest. Herrold settled on arc technology and improved it continuously until after WWI when he used the vacuum tube oscillator-based radiotelephone. He did obtain a number of patents for his system. Much is known of the Herrold story.[5]

The famous scene showing Charles Herrold in his makeshift "broadcast studio," posed in 1912 with his so-called "arc fone" transmitter, is shown in Fig. 3. With a close look, a water-cooled carbon telephone acting as a microphone can be seen right next to a small horn on the phonograph. The phonograph was used for broadcasting musical programs. Herrold is standing in the doorway, pretentiously holding a slide rule while two of his students operate the station. On the right is a Herrold technician, an early version of the broadcast engineer, apparently maintaining the equipment. This famous photo was used as the basis for a museum exhibit at the former Foothill Electronics Museum. The exhibit, built by museum craftsmen in the early 1970s, contains very little actual Herrold technology. The only real equipment that remains of the 1912 Herrold station is in the exhibit: a water-cooled microphone, a telegraph

Fig. 3. This famous scene of Charles Herrold in his makeshift "broadcast studio" was posed in 1912 with his so-called "arc fone" transmitter. A water-cooled carbon telephone used as a microphone can be seen right next to a small horn on the phonograph. (Author's collection)

key, and several meters. No Herrold arcs are known to exist. The exhibit is now in storage at History San Jose.

While Herrold continued to tinker and invent, his students seemed to enjoy their version of college radio. A local newspaper reporter visited the Herrold College and wrote this story of students on the air, a story that could be written today: "Herrold and his operator successfully demonstrated that wireless telephony was a reality and a fact. For two hours they conducted a concert . . . which was heard for many miles around. The music was played on a phonograph. Immediately after the first record was played numerous amateurs notified the station that they had heard the music distinctly. The operator told the listeners what records he had on hand, and one asked for "My Old Kentucky Home," which was furnished."[6] The written record demonstrates the activities of broadcasting, including listener requests made as early as 1909 in San Jose. Herrold used the call letters FN and SJN, which he himself selected to identify his early broadcasts before the government issued licenses were required beginning in 1912.

Herrold's early radio station was an accident. There were no models to emulate, just two-way communication of messages, mostly code, with a few using voice. This was the cradle of college radio. His students continued to send out scheduled programs of music and talk. The broadcasts continued from the Herrold College on the Special land license 6XF issued in November 1915,[7] which was revoked along with most other experimental stations when the country entered World War I in Europe on April 6, 1917. After stations were allowed to operate again, beginning in June 1919, Herrold applied for an experimental license or licenses. He received a license with the call letters 6XE for a mobile station in September 1920,[8] and he then received a second license with his prewar letters 6XF in March 1921,[9] but he could no longer use his arc radiotelephone transmitter. He had to learn to construct vacuum tube technology, and because the war had taken all his students, his college closed. He struggled to get on the air with station KQW, which was licensed in December 1921.[10] He was a college broadcaster without a college. His important contributions were all in the past. He sold his KQW station and transferred his interest in the station to the local Baptist church in July 1925.[11] Both his 6XF and 6XE stations expired in June 1926.[12]

University of Wisconsin Madison (WHA)

The second example of an early college broadcaster is station WHA, licensed to the University of Wisconsin at Madison, which is considered to be one of the very early university-birthed stations. Professor Earle Terry began radiotelephone broadcasts in 1917 over station 9XM,[13] which was first licensed in June 1915 and later became WHA in January 1922.[14] Station WHA on the Madison campus of the University of Wisconsin can claim to be one of the first serious educational broadcasters. It began with the early 20th century "Wisconsin Idea" with a goal of using the influence of the university to serve the people of the state.[15] In 1903, University President Charles Van Hise stated: "I shall never be content until the beneficent influence of the University reaches every home in the state."[16] Although Van Hise could not have realized it in 1903, his philosophies for education of all the people of his state could and would be realized using radio.

It is generally believed that Professor Earle Terry, the person responsible for bringing the talking wireless to the University of Wisconsin, began construction of its experimental station in 1910 using a small group of graduate students in the sciences. Early radio would be born from chemistry, physics, and electricity. And while the 1910 experiments were almost entirely code transmissions, it was in early 1917 that the Wisconsin scientist began using the radiotelephone: "In Terry's science hall lab, graduate student Malcolm Hanson had rigged a telephone mouthpiece to capture the sound from the horn of a photograph."[17] The results must have been startling. As former director of Wisconsin Public Radio, Jack Mitchell writes in his 2016 book, *Wisconsin on the Air*, "On a wintery evening in 1917, university professor Earle Terry listened with guests as the popular music of the day filtered from a physics laboratory in Science Hall into a receiving set in his living room. Little did they know that one hundred years of public service broadcasting had just begun."[18]

A famous wall mural still preserved near the site of what would become 9XM/WHA at the University of Wisconsin, Madison, marks this occasion (see Fig. 4). WHA founder Earle Terry is believed to be the bearded fellow standing at the microphone in what is portrayed as his broadcast room. With the exception of the piano trio on the right, it depicts scientists rather than radio-content broadcasters.

The significance of this 1917 experiment was not immediately grasped: "Not a single guest [in Terry's living room] realized that one hundred years of broadcasting from the University of Wisconsin had just begun."[19] It was also said that along with the underwhelmed early audience in Terry's

Fig. 4. WHA founder Earle Terry and fellow academics in the radio room. The author took this photograph of the famous wall mural still preserved near the site of what would become 9XM/WHA at the University of Wisconsin, Madison. (Author's collection)

residence, other physics faculty members were not impressed, as they apparently believed that the study of theory was more important than its practical application in the manifestation of the radio. Terry's work toward the eventual assignment of WHA in 1922 evolved out of an experimental license, 9XM, issued to the physics department in 1914. It was believed that "when telephonic transmission became a possibility, Professor Terry grasped the significance of radio broadcasting for the extension work of the University."[20] This fit into the Wisconsin Idea of extending the boundaries of the institution to the entire state.

Here is an example of the "perfect storm" of station and institution. The construction of the equipment, including blowing glass for transmitting tubes, was of great educational value to faculty and students in the sciences. The university president's original master plan could be realized using radio broadcasting. But it would not be until a new, more supportive president took office in 1925 that the station appeared to be accepted as a permanent part of the university. By the end of the 1920s, and with both administrative and curricular support, other ideas for educational programming were developed: "Terry envisioned radio's power to do good, to educate, to inform, and to inspire large numbers of people simultaneously."[21]

Terry, as the first station manager, began to interest other professors at the university to participate in WHA. Programs were created for a large audience of farmers, weather forecasts were aired, and programs that taught literacy skills to citizens of Wisconsin met the objectives of the Wisconsin Idea. There were lectures on all subjects, and the classical music and sports of the school were also aired. Here was early radio broadcasting with an educational purpose. When in a letter to the station a listener asked for fiddle tunes and music with a beat, Terry responded: "The air is overcrowded every night with jazz and other worthless material, and it would be quite beneath the dignity of the university to add to it."[22]

Ohio State University (WEAO)

The Engineering Department at Ohio State had an early station in 1910 that received strong support from its administration. This backing often meant the difference between having a radio station that was used to promote university values and a student-operated music station that could be sold or converted to news and classical music. Ohio State would never operate a student-programmed station; instead, the broadcasts were always handled by a paid professional staff under the direction of radio faculty and the office of the president. In its early days, the Ohio State station was performing community service in the form of agriculture news and the teaching of classes by radio. But the station actually can trace its beginnings to 1910 and a laboratory under the direction of Electrical Engineering Professor W. L. Upton. A press release in the OSU archives states that the OSU Electrical Engineering Department "began to experiment in wireless telegraphy around the turn of the century. By 1913 the university had a good station which, during the flood of that year, was one of the few ways Columbus had of keeping in touch with the outside world."[23] This 1913 station was wireless telegraph—code, not voice. The station received an experimental license in March 1920 with the experimental call signal 8XI.[24] This was several months ahead of the licensing of KDKA, which also began earlier with an experimental call signal 8XK.

Wireless experiments led to radiotelephone. Engineering Professors R. A. Brown and C. A. Wright continued to use the experimental license 8XI, but in June of 1922 the limited broadcast license WEAO, a random letter assignment, was issued to OSU by the Department of Commerce. Professor Brown was involved with early Columbus radio; his university-licensed WEAO was the first radio broadcasting station licensed in Columbus. Brown was also one of the originators of the "Columbus Agreement," a document that recognized that the existing regulation and channel assignments by the government were not good enough to protect stations from interference (see Fig. 5). The agreement divided on-air times between hams, the new broadcasters, and commercial wireless operators. This "agreement" allowed each faction to meet as a group and work out their rights amicably. This was all brand new in 1922, and the pre-war radio holdovers, the hams and two-way commercial operators, would now have to make room for the broadcasters.

The president of the university, William Oxley Thompson, dedicated station WEAO live, on the air, in 1922 (see Fig. 6). He told the tiny radio audience that they were listening to Columbus's first radio program, first in 1920 as 8XI and later with the call letters WEAO. He announced: "We are starting tonight the first of a series of programs of entertainment and instruction for the citizens of Central Ohio. These programs will be of the highest type, including music, science, and other subjects of popular interest."[25] In conclusion Dr. Thompson said this: "I congratulate you on the prospects before you as the result of this marvelous development."[26] Right from the beginning there was acceptance at the top. This presidential "blessing" would ensure that the station would remain viable, less of an engineering classroom experiment and more of a useful voice for the university.

OSU also had Special land station license 8XJ, which was first issued in March of 1922.[27] This station was later categorized as a "relay broadcast station" in conjunction with station WEAO, beginning in September 1927. According to a newspaper article appearing on October 23, 1927, "Thirty-six broadcasting stations were known to be offering programs on the short waves or higher frequencies….These are listed as experimental stations used chiefly for rebroadcasting on channels [wavelengths] between 26.3 and 109 meters…"[28] According to the new listing in the RSB under "Relay broadcast stations," 8XJ was operating at 54.02 meters.[29]

The Columbus Agreement

An Agreement Reached Between the Columbus Radio Club and Representatives of the Principal Broadcasting Stations of Columbus.

We, the undersigned, do hereby agree to observe and obey the following rules and regulations:

I. (a) All spark continuous wave and amateur radiophone sets (regular and special licensed amateur included) which are located in the city of Columbus, Ohio, or whose owners are members of the Columbus Radio Club, shall not transmit between the hours of seven (7) and ten (10) p. m. nightly except Saturday.

(b) These hours shall be known as "Quiet Hours."

(c) There shall be no Quiet Hours on Saturday nights.

II. All broadcasting stations located in the city of Columbus, Ohio, or whose owners are members of the Columbus Radio Club, may transmit any night during the Quiet Hours, except as follows:
There shall be no local broadcasting between the hours of nine (9) and ten (10) p. m. nightly during the Quiet Hours.

III. All testing of the transmitting sets of all local amateurs and broadcasting stations shall be done between the hours of six (6) a. m. and five (5) p. m.

IV. The time used shall be Columbus City Time.

V. These rules cannot be changed without the consent of all participants of this agreement.

Signed this 27th day of October, 1922, in the belief that this will give the general public a period in which they may operate their receiving sets without local interference, and will eliminate friction between the various branches of local radio enthusiasts.

AMATEURS — (Signed) **FRED W. REDDING, President,**
The Columbus Radio Club.

WBAV (Signed) **R. C. BOHANNAN,**
The Erner & Hopkins Co.

WCAH (Signed) **C. A. ENTREKIN,**
Entrekin Electric Co.

WEAO X (Signed) **PROF. R. A. BROWN,**
Ohio State University.

WPAL (Signed) **R. C. GARFINKEL,**
Superior Radio & Telephone Equipment Co.

Fig. 5. To avoid interference between and among stations in Columbus, Ohio, in 1922, the Columbus Agreement divided on-air times between hams, the new broadcasters, and commercial wireless operators. (OSU Archives)

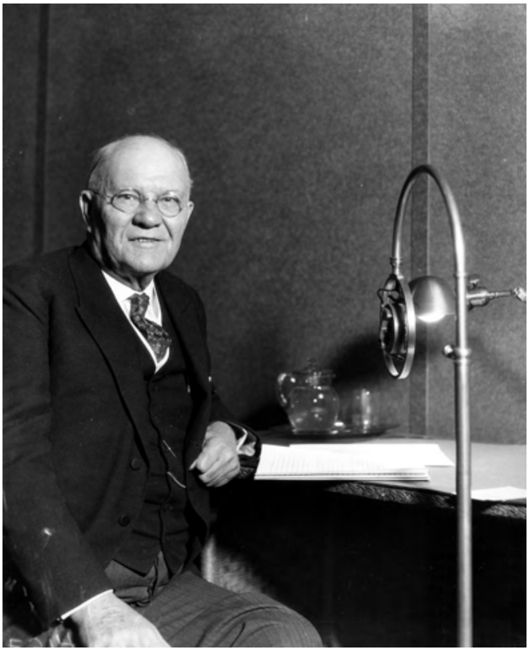


Fig. 6. The president of the university, William Oxley Thompson, dedicated station WEAO live, on the air, in 1922. He announced: "We are starting tonight the first of a series of programs of entertainment and instruction for the citizens of Central Ohio." (OSU Archives)

The university explained their new radio station in a 1925 story on WEAO in the journal, *University Studies*, as follows: "Radio broadcasting is a laboratory product that is being put to extensive use in the education and entertainment of our country."[30] On the occasion of the station's 25th anniversary it was still an educational station: "Through this medium of radio, Ohio State has thousands of students who have never seen its campus. In their own homes they study French and Spanish and Russian; they hear lectures and discussions on economics, history, and social problems; they develop a knowledge of and appreciation for music and art. Thus, the services and the influence of members of our faculty today are extended far beyond the walls of their classrooms."[31] By 1930 the call letters had been changed to WOSU to better reflect the brand. WOSU would go on to be nationally known as one of several stations conducting education by radio. University faculty member I. Keith Tyler created the Institute for Education by Radio, and for many years a national conference sponsored by WOSU was held in Columbus. Today WOSU operates two influential FM stations, one for public radio news and discussion, the other for all-classical music. The original AM channel was recently sold to a religious broadcaster.

The broadcasting nature of WEAO in 1922 is memorialized by its studio and control room as it existed in 1922. The WEAO studio had drapes on the walls for sound deadening, a grand piano, a microphone on a stand, and not much more (see Fig. 7). Every studio would have these three features at a minimum. The WEAO control room shown in Fig. 8 features a control board made with a combination of telephone and electrical parts. There is a monitor speaker mounted on the right wall next to the double-paned glass window separating the control room from the studio.

Fig. 7. The broadcasting nature of WEAO in 1922 is memorialized by its studio and control room as it existed in 1922. (OSU Archives)

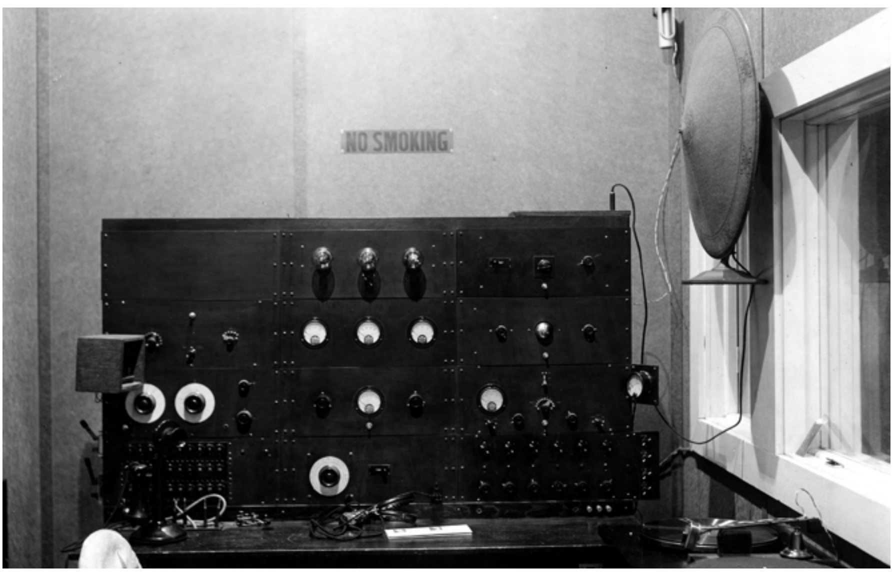


Fig. 8. The WEAO control room featured a control board made with a combination of telephone and electrical parts. There was a monitor speaker mounted on the right wall next to the double-paned glass window separating the control room from the studio. (OSU Archives)

PART II. COLLEGE BROADCASTER RICHARD HOWE AND WJD

The Richard Howe story is a small one, largely unfamiliar and mostly unreported by broadcast historians. The story is accurately understood because Howe kept good records in the form of correspondence with the Department of Commerce—early broadcast and experimental licenses, many listener verification cards, and photos of equipment. This demonstrates the difference between the many told and untold stories of radio's history, much of which has been based only on anecdotal evidence.

The Denison University Library has catalogued Howe's papers, and the later papers are housed at the local historical society. After retirement from Denison, Howe became the curator of the Granville Historical Society; so it is known that he cared about historic preservation. His work survived because he worked all his life in the same small town, at the same small college in Ohio. Howe never left home—nor did his papers.

Status of Early Radio Broadcasting In Central Ohio

To provide the necessary context for the creation of WJD at Denison, it is necessary to understand the new radio broadcasting game in Richard Howe's Central Ohio immediately following the KDKA broadcast at the end of 1921. There was no consensus on programming, no concept of audience, no radio networks, no agreement on how broadcasting was to be monetized, and no idea what positions were needed to run a radiotelephone operation. There were ideas: Some believed that if a church had a radio transmitter, it could greatly increase the size of its congregation and thus gain more influence, leading to higher income with which to fund the Lord's work. One local model was station WMAN, the ten-watt, flea-powered station of the Columbus Baptist Church that was on the air for an hour a week on Sunday morning. Others in traditional commerce envisioned radio programs broadcast from their stores that were designed to bring in new customers. Perhaps there was an uncle or other family member who was gregarious enough to serve as a pitchman. In Central Ohio, Howe was almost certainly familiar with the model of station WCAH that was assigned to the Entreken Electric Company appliance store of Columbus. The company had received a broadcast license to operate at 360 meters in May of 1922.[32] Using a small transmitter, the owner's wife played the piano between announcements to advertise products available at the store.[33]

Based on these models, radio in 1922 was a mashup of student-professor-amateur-hardware-focused wireless types, would-be entrepreneurs, high-minded artists, and entry-level vaudevillians competing in an exciting post-war American milieu in an atmosphere of lax regulation and technical confusion. Would the new device be used to educate with readings of great literature and classical music to be paid for by the sale of radios, or would government own it (the Navy actively campaigned to control it), or would universities use the device for lectures by faculty, or would capitalism win the day? As it turned out, the most practical way to get a radio audience is the same way that the concert venue sells seats, singers sell phonograph records, newspapers sell copies, or movie stars attract box office: focus on quality. The amateur talent that gave broadcasting its early impetus was rapidly replaced by a new cohort of professional singers, announcers, managers, programmers, and yes, time salesmen—all leading to the professionalism and thus the success of an important 20th century media format.

Recall that there was no generally agreed upon definition of radio broadcasting before the early 1920s. It had to be invented, or more accurately it evolved out of what existed, both technically and creatively. The radio was how soldiers in WW I communicated. It was the wireless that saved ships at sea in the first two decades of the new century. It was the neighbor kid with his pile of parts and his copy of *Electrician and Mechanic.*

Early History of Radio At Denison

The Seeds of a Radio Station at Denison University

Denison University is located in tiny Granville, Ohio, east of Columbus in the center of the state. It small size notwithstanding, the university was early in the teaching of wireless. In June 1899, an article by physics faculty member Alfred Cole appeared in the *Granville Times*. Entitled "Wireless Telegraphy at Denison," it documented the use of wireless telegraphy in the physical laboratory of Denison during the preceding four years. Cole wrote:

> "The writer's experiments with electrical oscillations began in 1894 in Germany. The following year was entirely devoted to the subject, and the leisure summers occupied in the continuation of the study. For the past four years Denison's physical laboratory has been familiar with electrical oscillations and incidentally many a signal has been flashed across the wireless space. A considerable amount and variety of apparatus for this kind of study has been gradually accumulated here.
>
> "On account of the sudden development of popular interest in the subject due to Marconi's telegraphing across the English Channel, it is proposed to give the friends of Denison an opportunity during the coming commencement period to see the apparatus in use.
>
> "Incidentally, demonstrations of the methods actually employed in the new system of wireless telegraphy will be given and messages sent across the campus.
>
> "The sending apparatus consists of an induction coil capable of giving a spark four to twelve inches long, two metal balls placed one over the other

about one inch apart and a vertical long wire from 15 to 150 feet long according to the distances which it is desired to send."[34]

Thus, the students at Denison repeated the Hertz experiments using spark transmitters and coherer receivers. This early article, albeit in a non-academic publication, revealed the work of its writer, professor Alfred Dodge Cole, who joined the Denison faculty in 1885. While he was not involved in broadcasting, his early wireless work set the stage for Richard Howe and other faculty and students at Denison that would lead to station WJD. In fact, Cole's early wireless work at Denison was so impressive that he was invited to join the physics department at Ohio State in 1901. And as in hundreds of other university physics departments, knowledge was transmitted from teacher to student. This is the purpose of the university. This is the genesis of Howe's work leading to licensed radio broadcasting at his school.

Richard Howe Comes to Denison University

Richard Howe was born in 1899 in Newark, Ohio, at a location a few blocks from where this author would be born many years later. His family moved west seven miles to Granville where Howe apparently spent most of the remainder of his life. He never left rural Licking County where he was born. In 1912, Howe enrolled in Granville High, where he distinguished himself with his wireless work, building the "first wireless station for sending and receiving signals around Granville with a 1-inch spark coil."[35] This may be a bit of hyperbole because, as documented in the previous section, Professor Cole had set up a demonstration wireless station at Denison more than a decade earlier.

Four years later, at age 17, Howe was about to exit high school for college (see Fig. 9). Like other students, he would take his equipment to school. Howe received his original amateur license, 8ABR, on Feb. 12, 1916, under the rules of the Radio Act of 1912 when he was 17—about the time he graduated high

Fig. 9. An undated photograph of a young Richard Howe taken about the time he graduated from high school. (Howe Papers, Dension U.)

school (see Fig. 10). Note that on this license he was restricted to two wavelengths, 200 meters and 175 meters, and the license was valid for one year. Also note that amateur licenses of this era specified power limitation as the power at the "transformer input," in this case 30 watts. A picture of his station 8ABR in his bedroom is reproduced in Fig. 11. Notice his license pennant next to the Granville pennant, and also notice the letters "AWA" on the 8ABR pennant. There was an organization called the American Wireless Association

2

SCHEDULE OF STATION AND APPARATUS

Name of owner, Richard H. Howe *; Age,* 17

Location: State, Ohio *; County,* Licking

City or town, Granville *; Street,* Pearl *; No.* - -

Official call, " 8 A B R "

Name of naval or military station, if within 5 nautical miles,

Power: Transformer input, 30 *, W.**

Antenna: Type (T, ˥, fan, umbrella, etc.), Inverted L.

Height, 45 ft. (Above ground) *; Horizontal length,* 65 ft.

Wires: Number in vertical part, 4 *; In horizontal part,* 4

The normal sending and receiving wave length shall be 200 (Not exceeding 200) *meters and the station is authorized to use the following additional wave lengths, not exceeding 200 meters:* 175 *meters,* - - - *meters.*

--- ~~*Satisfactory proof has been furnished that the station was actually operating August 13, 1912.*~~ ---

This License expires on Feb. 11, *191*7.

EDWIN F. SWEET,
Assistant Secretary of Commerce.

E. T. CHAMBERLAIN,
Commissioner of Navigation.

Delivered by [signature] (Radio inspector)

Place, Cleveland, Ohio. *, Date,* Feb. 12, *191*6.

mjs. * Not to exceed 1,000; or if the station be within 5 nautical miles of a naval or military station, not to exceed 500. 11—

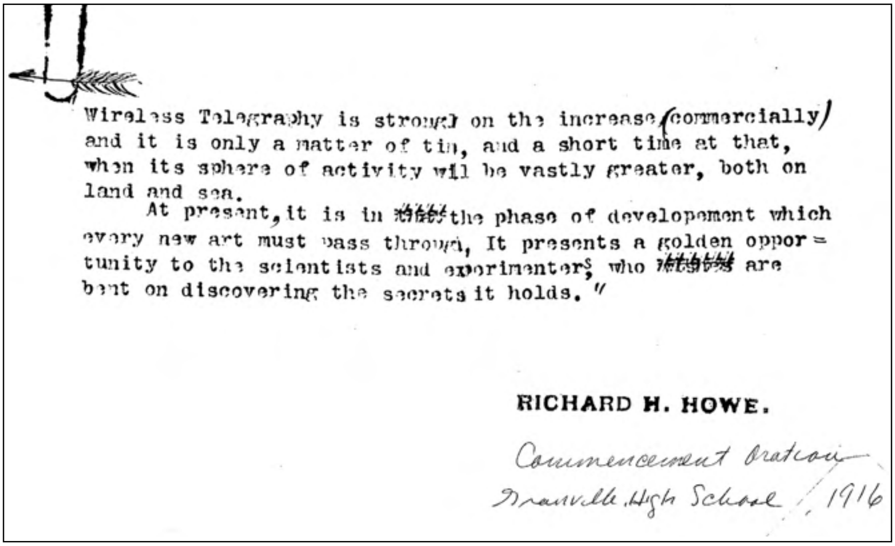
Fig. 10. The second page of Richard Howe's original amateur license, 8ABR, contained the following interesting information: Issued on February 12, 1916, expiring on February 11, 1917, transmitting wavelengths limited to 200 and 175 meters, and the maximum power at the "transformer input" limited to 30 watts. (Howe Papers, Denison U.)

Fig. 11. Howe's amateur radio station as it appeared in his bedroom with two pennants on the wall—one with the license call signal 8ABR and the other with the location of the station as it is listed on the license, namely Granville, Ohio. (Howe Papers, Denison U.)

to which many hams apparently belonged.[36]

Richard Howe was surely among the smartest in his high school class, for he was tasked with giving the commencement address upon graduation in 1916. In his speech entitled "The Evolution of Wireless Telegraphy," he begins by stating "The last decade has brought a most remarkable change in the history of science."[37] He cleverly starts with the role of electricity in civilization, then tells his fellow high school graduates, "There is one form of electricity, however, which has proved itself invaluable to the people of all nations. That is wireless telegraphy."[38] His speech really traces the history of communications from its inception—smoke signals, signal flags—and describes why wireless is better. It is a long speech, and it seems very technical for a general high school audience. The conclusion to his speech is memorialized on the last page of his address shown in Fig. 12. He concludes with: "At present, it [wireless] is in the phase of development which every new art must pass through. It presents a golden opportunity to the scientists and experimenters who are bent on discovering the secrets it holds."[39]

He understood well the concept of STEM one hundred years earlier. (STEM is an acronym for Science, Technology, Engineering, Math, which is a common shorthand for the modern college technical curriculum.) It is not


Wireless Telegraphy is strongly on the increase (commercially) and it is only a matter of time, and a short time at that, when its sphere of activity will be vastly greater, both on land and sea.

At present, it is in the phase of development which every new art must pass through. It presents a golden opportunity to the scientists and experimenters who are bent on discovering the secrets it holds."

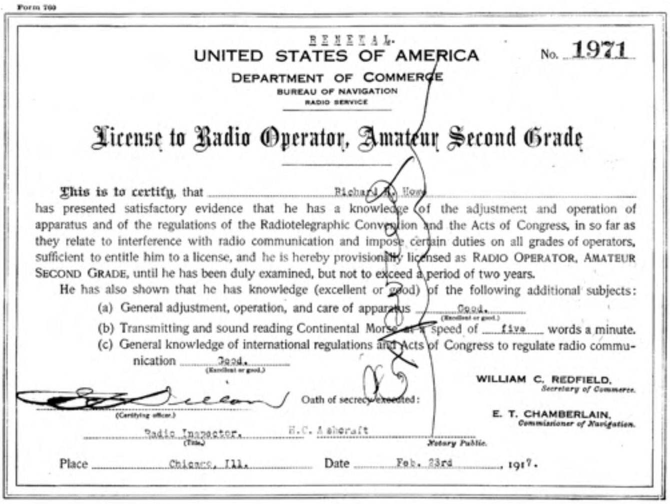
RICHARD H. HOWE.

Commencement Oration
Granville High School, 1916

Fig. 12. According to last page of the school commencement address that Howe gave in 1916, he closed with the statement, "At present, it [wireless] is in the phase of development which every new art must pass through. It presents a golden opportunity to the scientists and experimenters who are bent on discovering the secrets it holds." (Howe Papers, Denison U.)

known if his address influenced any of his fellow grads to seek a future in science and electricity. In rural Granville, the percentage of students attending college would be in the single digits. Most would work on the family farm, with the exceptions being those children of Denison faculty, who would either enter their local college or travel the 35 miles to Ohio State.

In the fall of 1916, following high school graduation, Howe enrolled in Denison as a freshman. He would take his station 8ABR to college and set it up in the science lab of the Physics Department so fellow students could have access to it. On February 23, 1917, he received a routine renewal of this amateur license (see Fig. 13). Less than two months later, on April 6, 1917, the United States entered World War I. The next day Howe received a letter from his regional Radio Inspector that was sent to all licensed operators (see Fig. 14): "Dear Sir, In accordance with the order of the President of the United States, promulgated in a letter of instructions from the Commandant of the Great Lakes District, you will immediately dismantle all aerial wires and radio apparatus, both sending and receiving, and place the same out of commission until further notice."[40] It was feared that sympathizers to the German cause could send surreptitious messages to submarines operating off the shore of the United States informing them of shipping schedules, or that amateurs could send messages to aid the English and French in violation of



Form 760

RENEWAL.

UNITED STATES OF AMERICA

No. 1971

DEPARTMENT OF COMMERCE

BUREAU OF NAVIGATION

RADIO SERVICE

License to Radio Operator, Amateur Second Grade

This is to certify, that Richard H. Howe has presented satisfactory evidence that he has a knowledge of the adjustment and operation of apparatus and of the regulations of the Radiotelegraphic Convention and the Acts of Congress, in so far as they relate to interference with radio communication and impose certain duties on all grades of operators, sufficient to entitle him to a license, and he is hereby provisionally licensed as RADIO OPERATOR, AMATEUR SECOND GRADE, until he has been duly examined, but not to exceed a period of two years.

He has also shown that he has knowledge (excellent or good) of the following additional subjects:

(a) General adjustment, operation, and care of apparatus Good. (Excellent or good.)

(b) Transmitting and sound reading Continental Morse at a speed of five words a minute.

(c) General knowledge of international regulations and Acts of Congress to regulate radio communication Good. (Excellent or good.)

(Certifying officer.)

Radio Inspector. (Title.)

Oath of secrecy executed:

H.C. Ashcraft

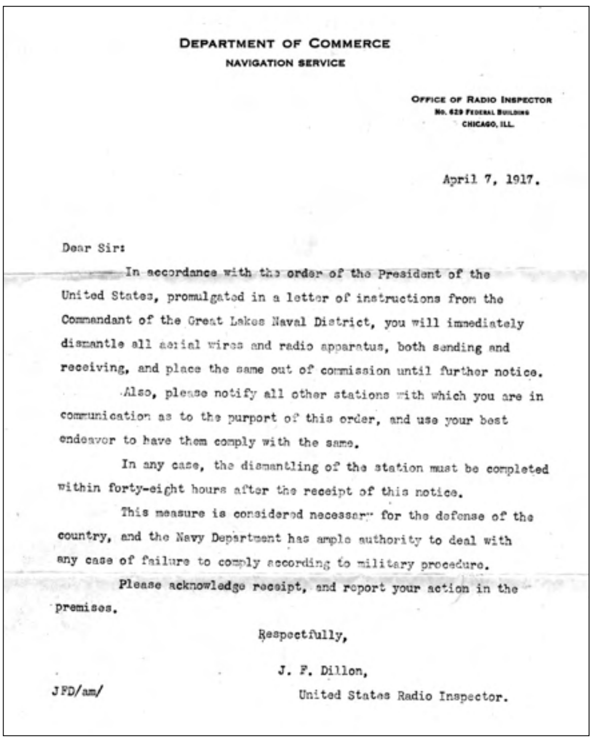
Notary Public.

WILLIAM C. REDFIELD, Secretary of Commerce.

E. T. CHAMBERLAIN, Commissioner of Navigation.

Place Chicago, Ill. Date Feb. 23rd, 1917.

Fig. 13. The February 1917 renewal of Howe's amateur license 8ABR appeared to be routine. (Howe Papers, Denison U.)



DEPARTMENT OF COMMERCE

NAVIGATION SERVICE

OFFICE OF RADIO INSPECTOR
No. 629 FEDERAL BUILDING
CHICAGO, ILL.

April 7, 1917.

Dear Sir:

In accordance with the order of the President of the United States, promulgated in a letter of instructions from the Commandant of the Great Lakes Naval District, you will immediately dismantle all aerial wires and radio apparatus, both sending and receiving, and place the same out of commission until further notice.

Also, please notify all other stations with which you are in communication as to the purport of this order, and use your best endeavor to have them comply with the same.

In any case, the dismantling of the station must be completed within forty-eight hours after the receipt of this notice.

This measure is considered necessary for the defense of the country, and the Navy Department has ample authority to deal with any case of failure to comply according to military procedure.

Please acknowledge receipt, and report your action in the premises.

Respectfully,

J. F. Dillon,

United States Radio Inspector.

JFD/am/

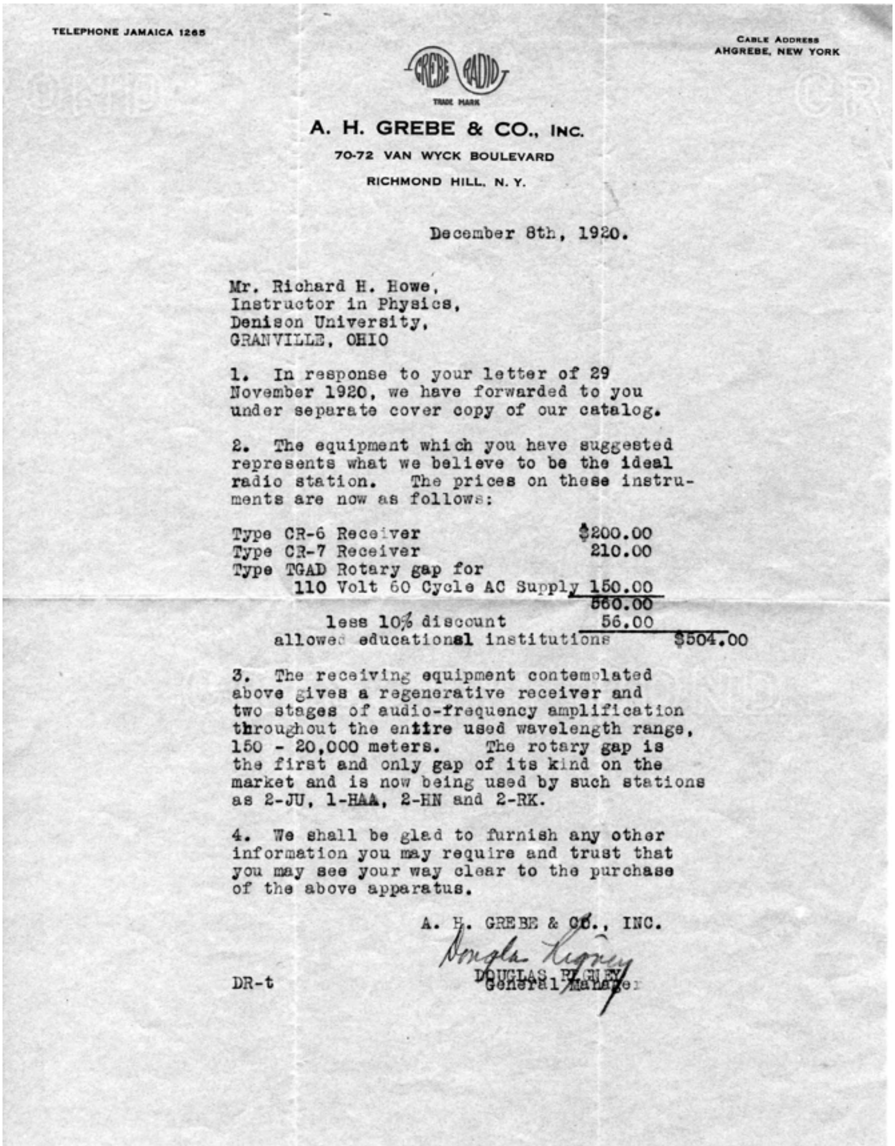
Fig. 14. This "cease and desist" letter from the Department of Commerce dated April 7, 1917, was sent to all licensed radio operators asking them to stop all radio activity. (Howe Papers, Denison U.)

neutrality regulations, or that they might interfere with military communications.

This letter effectively put the Howe amateur radio station, now at Denison, out of commission until well after the armistice. He was completing his sophomore year at that time, and for the next two years he became heavily involved in the activities of the student physics club. If he couldn't be on the air, at least he would learn well the theoretical foundations of wireless. He also spent several months in uniform as a member of the Student Army Training Corps (see Fig. 15), although he never left the college campus in uniform. He and others like him could have been called, but the American involvement in the war was of short duration so he never saw action. By November 11, 1918, the Great War had ended and Howe had fulfilled his service obligation. Soon he could go back on the air.

Fig. 15. Richard Howe appears in an Army uniform worn by the Student Army Training Corps on the campus of Denison University during WWI. (Howe Papers, Denison U.)

Richard Howe received his B.S. degree in Physics in 1920 and was honored as a Phi Beta Kappa. He obviously impressed his professors, as upon graduation they made him a faculty member, a non-tenure-track instructor of physics. His areas of specialization were physics, electricity, and wireless, and as part of his extra-curricular duty he was advisor to the student physics club. That group was most interested in Howe's wireless work. Equipment for two-way communication was purchased and several early amateur licenses were obtained. And because the Howe station was hundreds of miles from a radio parts store, Howe often ordered his equipment from New York by mail order, which is verified by a December 1920 letter from the A. H. Grebe & Company. Howe is quoted an "educational discount," but the cost was still over five hundred dollars for two receivers and a transmitter (see Fig. 16). The receivers, valued by collectors today as highly desirable, were the Grebe CR-6 and CR-7.



TELEPHONE JAMAICA 1265

CABLE ADDRESS
AHGREBE, NEW YORK

A. H. GREBE & CO., INC.
70-72 VAN WYCK BOULEVARD
RICHMOND HILL, N. Y.

December 8th, 1920.

Mr. Richard H. Howe,
Instructor in Physics,
Denison University,
GRANVILLE, OHIO

1. In response to your letter of 29 November 1920, we have forwarded to you under separate cover copy of our catalog.

2. The equipment which you have suggested represents what we believe to be the ideal radio station. The prices on these instruments are now as follows:

Type CR-6 Receiver	$200.00	
Type CR-7 Receiver	210.00	
Type TGAD Rotary gap for 110 Volt 60 Cycle AC Supply	150.00	
	560.00	
less 10% discount allowed educational institutions	56.00	$504.00

3. The receiving equipment contemplated above gives a regenerative receiver and two stages of audio-frequency amplification throughout the entire used wavelength range, 150 - 20,000 meters. The rotary gap is the first and only gap of its kind on the market and is now being used by such stations as 2-JU, 1-HAA, 2-HN and 2-RK.

4. We shall be glad to furnish any other information you may require and trust that you may see your way clear to the purchase of the above apparatus.

A. H. GREBE & CO., INC.
DOUGLAS RIGNEY
General Manager

DR-t

Fig. 16. This 1920 letter is an equipment price quote from the A. H. Grebe & Company in New York. Howe would have to beg the tiny physics department at Denison for money to purchase equipment for his experiments. (Howe Papers, Denison U.)

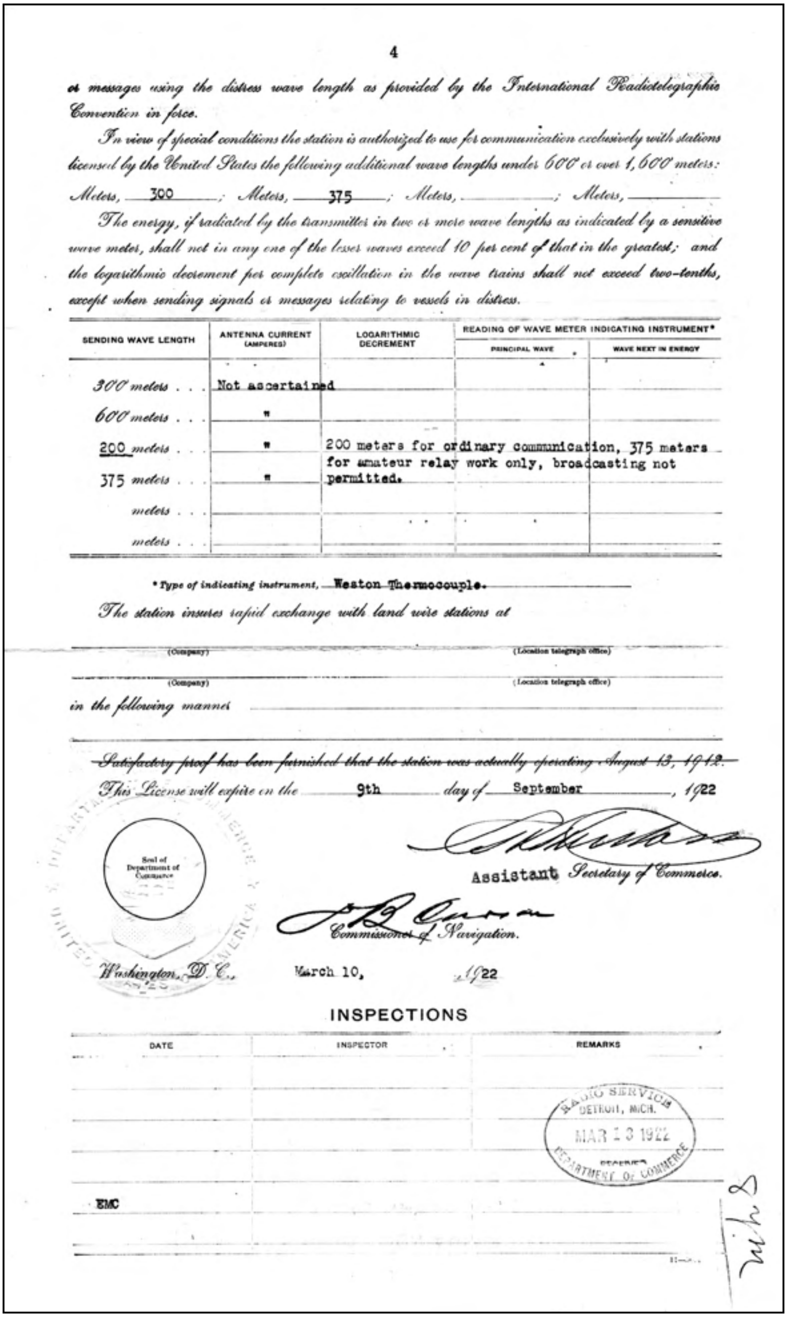
Licensed Radio Stations Begin Operating at Denison

There were a number of classifications of radio licenses throughout the 1920s. Between Richard Howe and Denison University, there were at least four: Amateur (8ABR), Experimental (8XW), Technical and Training (8YM), and Limited Commercial (WJD). It has already been mentioned that Howe moved his station to Denison and operated there under his amateur license 8ABR. One of the primary stations used by students for amateur-like contacts was 8YM, which started operating in March 1921. According to page three of its license, this station was licensed as "Class 4, Technical and Training," a special classification for schools. The following statement appeared: "licensed for the specific purposes shown, no broadcasting of any description permitted." This was further clarified on page four of the license (see Fig. 17): "200 meters for ordinary communication, 375 meters for amateur relay work only, broadcasting not permitted."[41] This station was obviously very popular because one page of the 8YM message logbook dated November 1921 has entries for multiple contacts in Ohio, West Virginia, Pennsylvania, Kansas, Indiana, New Jersey and New York (see Fig. 18).

There is evidence in the form of letters from "listeners" that Howe and his students may have been operating outside of the stipulations of their amateur and technical-training license classes. A listener confirmation letter (QSL card) from a ham, 8BHY, said, "Your radiophone music very QSA (strong) on the night of May 18, 1921."[42] While the regulation of radio transmission was in transition, it was clear that music was forbidden content with an experimental, amateur, or technical-training license. And while the licensed purpose of Howe's technical-training-licensed station at Denison was code and two-way radiotelephone communication, music was commonly heard over the air. The fact that a specific broadcasting prohibition was included twice in the technical training license may have indicated that the Federal Radio Inspectors of the Commerce Department had experienced illegal broadcasting by other scofflaw schools.

Other listener verification postcards began to arrive about 1921–22, and many of them seemed to congratulate Howe on having a high-quality broadcast of music, content not allowed under his license. There was no question that the radio inspector had his ear on the tiny Denison operation because a warning letter came from the Commerce Department on April 7, 1922 (see Fig. 19): "It has come to the attention of this office that the station under your control, call signal 8YM, is causing serious interference with the reception of radio broadcasting conducted on the wavelength of 360 meters."[43]

It is possible that Howe, like others of the era, did not fully understand or even believe the new and ongoing attempts at government regulation, even though his 8YM license clearly prohibited broadcasting. He was also in the backwater of radio, Granville, Ohio,



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or messages using the distress wave length as provided by the International Radiotelegraphic Convention in force.

In view of special conditions the station is authorized to use for communication exclusively with stations licensed by the United States the following additional wave lengths under 600 or over 1,600 meters:

Meters, 300; Meters, 375; Meters, ____; Meters, ____

The energy, if radiated by the transmitter in two or more wave lengths as indicated by a sensitive wave meter, shall not in any one of the lesser waves exceed 10 per cent of that in the greatest; and the logarithmic decrement per complete oscillation in the wave trains shall not exceed two-tenths, except when sending signals or messages relating to vessels in distress.

SENDING WAVE LENGTH	ANTENNA CURRENT (AMPERES)	LOGARITHMIC DECREMENT	READING OF WAVE METER INDICATING INSTRUMENT*	
			PRINCIPAL WAVE	WAVE NEXT IN ENERGY
300 meters . . .	Not ascertained			
600 meters . . .	"			
200 meters . . .	"	200 meters for ordinary communication, 375 meters for amateur relay work only, broadcasting not permitted.		
375 meters . . .	"			
meters . . .				
meters . . .				

* Type of indicating instrument, Weston Thermocouple.

The station insures rapid exchange with land wire stations at

(Company) (Location telegraph office)

(Company) (Location telegraph office)

in the following manner

~~Satisfactory proof has been furnished that the station was actually operating August 13, 1912.~~

This License will expire on the 9th day of September, 1922

Seal of Department of Commerce

Assistant Secretary of Commerce.

Commissioner of Navigation.

Washington, D. C., March 10, 1922

INSPECTIONS

DATE	INSPECTOR	REMARKS
		Radio Service Detroit, Mich. MAR 13 1922 Received Department of Commerce
EMC		

Fig. 17. Typed on page four of Howe's 8YM license was the instruction, "200 meters for ordinary communication, 375 meters for amateur relay work only, broadcasting not permitted." (Howe Papers, Denison U.)

Form No. 2

8 YM - RADIO STATION - 8 YM

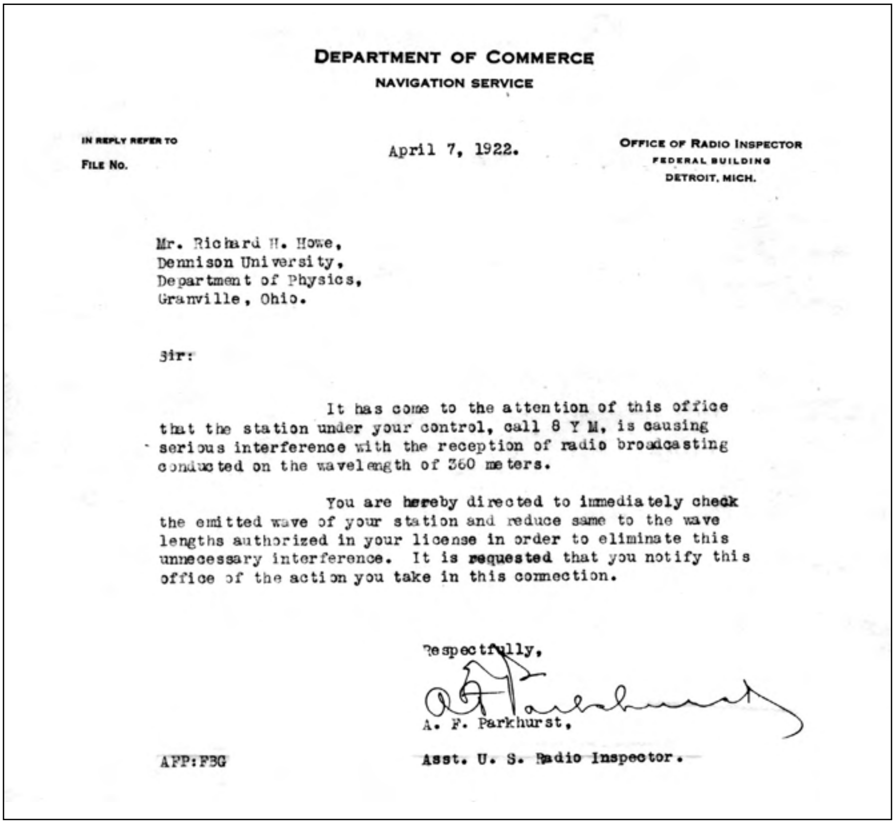
DENISON UNIVERSITY GRANVILLE, OHIO

MESSAGE LOG SHEET

MSG. NR.	DATE RECEIVED	STATION RECEIVED FROM	DESTINATION OF MESSAGE	REMARKS	STATION SENT TO	DATE SENT
1	Nov. 1921	8afd	Cin. Ohio	from Toronto Canada	8app	Nov. 1921
2	Nov. 1921	8afd	Mt. Vernon O.	" Clarksburg W.Va	8bky	Nov. 1921
3	Nov. 1921	8afd	Conneaut O.	a good station "8oi"	8oi	Nov. 1921
4	Nov. 1921	8BBZ	Canton	trouble getting thru	8bky	Nov. 1921
5	Nov. 1921	8app	New Concord O	Cambridge 2nd sta	8bky	Nov 1921
6	Nov 1921	8akp	E Cleve Ohio	sent to 8oi steady	8oi	Nov 1921
7	Nov 1921	Personal [illegible]	Col. Ohio	Personal msg	8app	Nov. 1921
8	Nov 1921	8aje	Cambridge O.	to 8bkn	8bky	Nov 19 1921
9	Nov 1921	8bkc	Lancaster O	fm. Horton	8AQZ	Nov 1921
10	Nov 1921	8XE	Lawrence Kas	State Col. Pa 8XE	8app	Nov. 1921
11	Nov 12, 1921	8XE	Lawrence Ka	" "	8app	Nov 13 1921
12	Nov 12, 21	[illegible]	Clarksburg W.Va	good connection	8afd	Nov 12, 1921
13	Nov 12 1921	✓	Anderson Ind	via tel. from [illegible]	9agr	Nov 12 1921
14	Nov 1921	8bbu	Buffalo N.Y.	2pk	8oi	Nov 12 1921
15	Nov 1921	8akp	Fir Hill N.J.	Cev 8akp	8EW	Nov-1921
16	Nov 1921	8akp	Evening Mail N.Y.	8EW. QRK'd mail	8EW	Nov-1921
17	Nov-1921	8akp	E. Cleve. O.		8oi	Nov 1921
18	Nov-1921	9awz	akron	rec'd fm 8bbu	?	Nov-1921
19	Nov-1921	8AKP	New Castle Pa		8JQ	Nov 19, 1921
20	Nov-1921	8AKP	Norwalk, Conn	no record kept	8RQ	Nov 19 1921
21	Nov-1921	8akp	1bbu	fm Chicago	8ew	Nov. 1921
22	Nov-1921	8akp	2 bds	—	8ew	Nov 1921
23	Nov-1921	8akp	Staunton Va	Hutchinson Ka	8ew	Nov 1921
24	Nov-1921	8ZY	Granville O.	fm Defiance O.	—	Nov-1921
25	Nov 12-21	8bky	Delaware	— he QRK'd mail	8aje	Dec. 8 '21
26	Nov 12-21	8bky	Delaware	duplicate (same as 25)	8aje	Dec 8, 21

TIMES PRINT, GRANVILLE, OHIO

Fig. 18. One page of Howe's 8YM message logbook dated November 1921 has entries for multiple contacts in Ohio, West Virginia, Pennsylvania, Kansas, Indiana, New Jersey and New York. (Howe Papers, Denison U.)



DEPARTMENT OF COMMERCE
NAVIGATION SERVICE

IN REPLY REFER TO
FILE NO.

April 7, 1922.

OFFICE OF RADIO INSPECTOR
FEDERAL BUILDING
DETROIT, MICH.

Mr. Richard H. Howe,
Dennison University,
Department of Physics,
Granville, Ohio.

Sir:

It has come to the attention of this office that the station under your control, call 8 Y M, is causing serious interference with the reception of radio broadcasting conducted on the wavelength of 360 meters.

You are hereby directed to immediately check the emitted wave of your station and reduce same to the wave lengths authorized in your license in order to eliminate this unnecessary interference. It is requested that you notify this office of the action you take in this connection.

Respectfully,

A. F. Parkhurst,

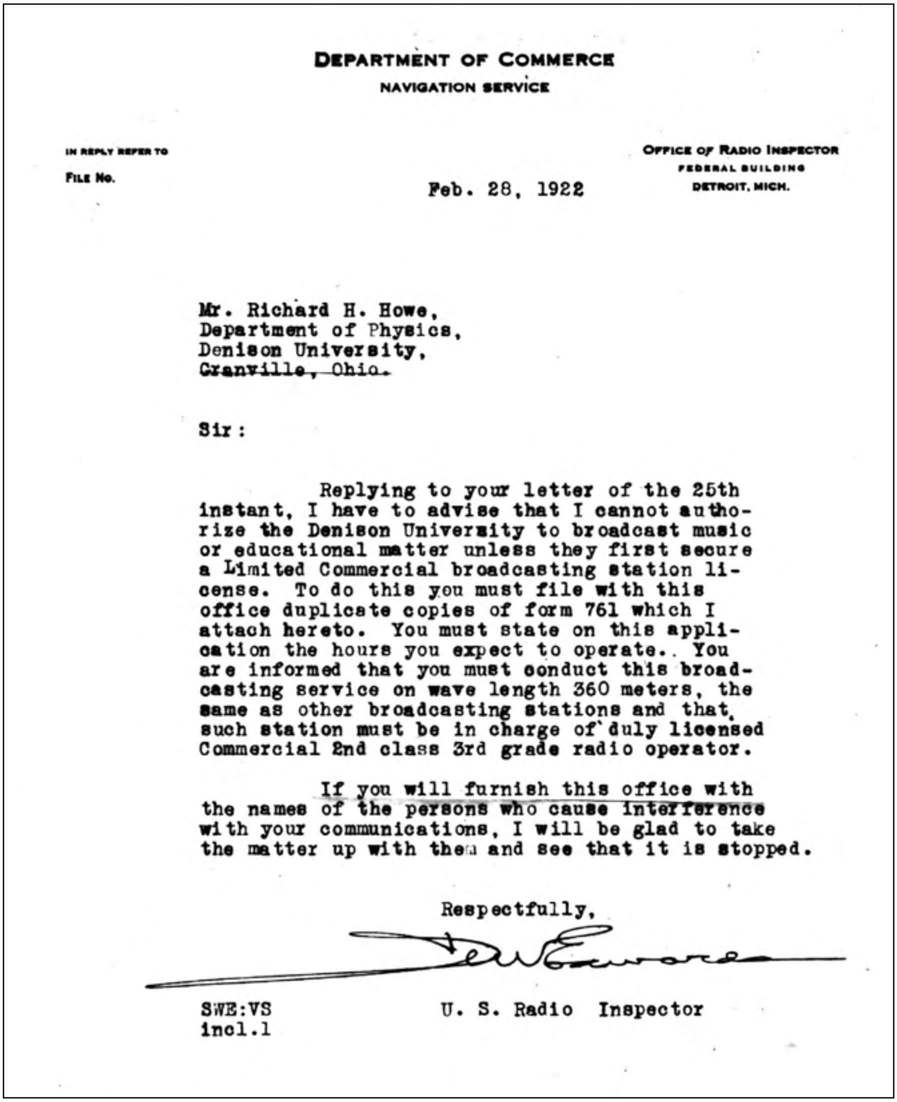
Asst. U. S. Radio Inspector.

AFP:FBG

Fig. 19. A letter from the Commerce Department dated April 7, 1922, alleged that Howe's station 8YM station was causing serious interference with the reception of radio broadcasting conducted on the wavelength of 360 meters. (Howe Papers, Denison U.)

in rural Licking County, so perhaps he thought his broadcasting would not be noticed. He may have believed that the inspectors themselves were confused. Clearly, there was a lack of communication between Howe and two of the inspectors operating out of the Detroit Navigation Service of the Commerce Department.

While the April 1922 letter from Inspector A. F. Parkhurst referred to interference to licensed broadcasters by Howe over 8YM, it was preceded two months earlier by a letter dated February 28, 1922, from the same office, but signed by a different inspector (see Fig. 20). The following sentence taken from this letter implied that Howe had requested permission to broadcast on this license: "I have to advise you [Howe] that I cannot authorize the Denison University to broadcast music or educational matter unless they first secure a Limited Commercial broadcasting station license."[44] The letter goes on to explain



DEPARTMENT OF COMMERCE
NAVIGATION SERVICE

IN REPLY REFER TO
FILE No.

OFFICE OF RADIO INSPECTOR
FEDERAL BUILDING
DETROIT, MICH.

Feb. 28, 1922

Mr. Richard H. Howe,
Department of Physics,
Denison University,
Granville, Ohio.

Sir:

Replying to your letter of the 25th instant, I have to advise that I cannot authorize the Denison University to broadcast music or educational matter unless they first secure a Limited Commercial broadcasting station license. To do this you must file with this office duplicate copies of form 761 which I attach hereto. You must state on this application the hours you expect to operate.. You are informed that you must conduct this broadcasting service on wave length 360 meters, the same as other broadcasting stations and that, such station must be in charge of duly licensed Commercial 2nd class 3rd grade radio operator.

If you will furnish this office with the names of the persons who cause interference with your communications, I will be glad to take the matter up with them and see that it is stopped.

Respectfully,

U. S. Radio Inspector

SWE:VS
incl.1

Fig. 20. This February 28, 1922 letter from the Commerce Department suggests that Howe had requested permission to broadcast on his 8YM license. (Howe Papers, Denison U.)

the process Howe should follow to obtain a commercial station license. So, by the arrival of the April interference letter, Howe had already asked permission to play music using his 8YM technical-training call signal. Although not stated, it is possible that the "interference" referred to was music and other prohibited transmissions. In any event, the station 8YM license expired on November 21, 1924, and was not renewed.

The Story of WJD

Broadcasting on Station WJD Begins

The letter dated February 28, 1922, from the Detroit regional office explained that Denison University had to secure a limited commercial broadcasting station license in order to play music: "You must file with this office form 761 which I attach hereto." It was that simple: Submit a form and WJD was born. The first WJD license was issued in April 1922 for a wavelength of 360 meters.[45] While there was no indication of the station power in this issue of the *RSB*, the next issue, No. 61, stated that the range was limited to 25 miles, which indicated that the Commerce Department had limited the WJD station to 10 watts.[46]

The year 1923 was a critical time for radio broadcast stations. The *RSB* for April 2, 1923 (p. 9–13) states that recommendations by the radio conference represented a step in ideal development of measures for the prevention of interference in public broadcasting. The report recommended making available all wavelengths from 222 to 545 meters for public broadcasting, the various bands to be assigned to different stations so as not only to reduce direct interference but also to build up zonal regions of distribution. Consequently, WJD was assigned a wavelength of 229 meters in May 1923.[47] At the same time, the power limitation of the station was raised to 50 watts, although in 1925 the power limitation was reduced back to 10 watts. Thus, WJD operated on the original assignment of 360 meters for only a year of its three-year life, but it operated at 50 watts for more than a year.

The "Class A Limited Commercial" license issued for WJD specified that this station was allowed to broadcast "entertainment and like matter on the exact wavelength specified."[48] Years later Howe recalled the days when WJD was on the air, namely between April 1922 and December 1925: "The station was built by members (students) of the physics department and the parts for the studio and transmitter were purchased from the meager departmental budget."[49] Quoting from the same paper, Howe recalled that "the station output was listed as 10 watts on the original license; however the transmitter was usually operated at double this power." His listeners were said to write letters confirming reception from up to 70 miles away. "Students in the physics department obtained their practical experience from designing and operating the station. There was no attempt to train studio announcers."

This was typical in early college/educational broadcasting. The technical academic majors built the equipment, and eventually members of the drama, speech, and music departments contributed arts programming. And to connect WJD to one of the four models of college broadcasting, as Howe was the advisor to the physics club and the university catalogue listed WJD as a student activity in the physics department, his station would best fit the fourth model, radio as an extra-curricular activity. Physics students constructed the equipment, not

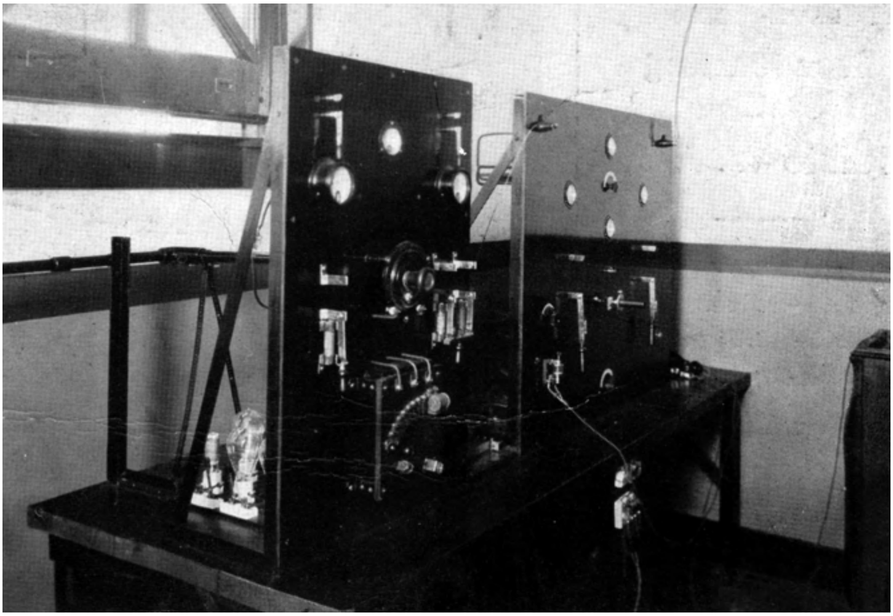


Fig. 21. The WJD Transmitter, an early vacuum tube device, likely made by Howe and his students in the Physics Department laboratories, 50 watts only. (Howe Papers, Denison U.)

as part of the curriculum but as club members (see Fig. 21). Music students performed on the air, but informally, not for credit. In the earlier story of Earle Terry and WHA, it was said that the professors of the sciences did not care to teach radio station operation, thought theory only was the proper way to teach, and believed the radio broadcasting of entertainment to be lowbrow.[50]

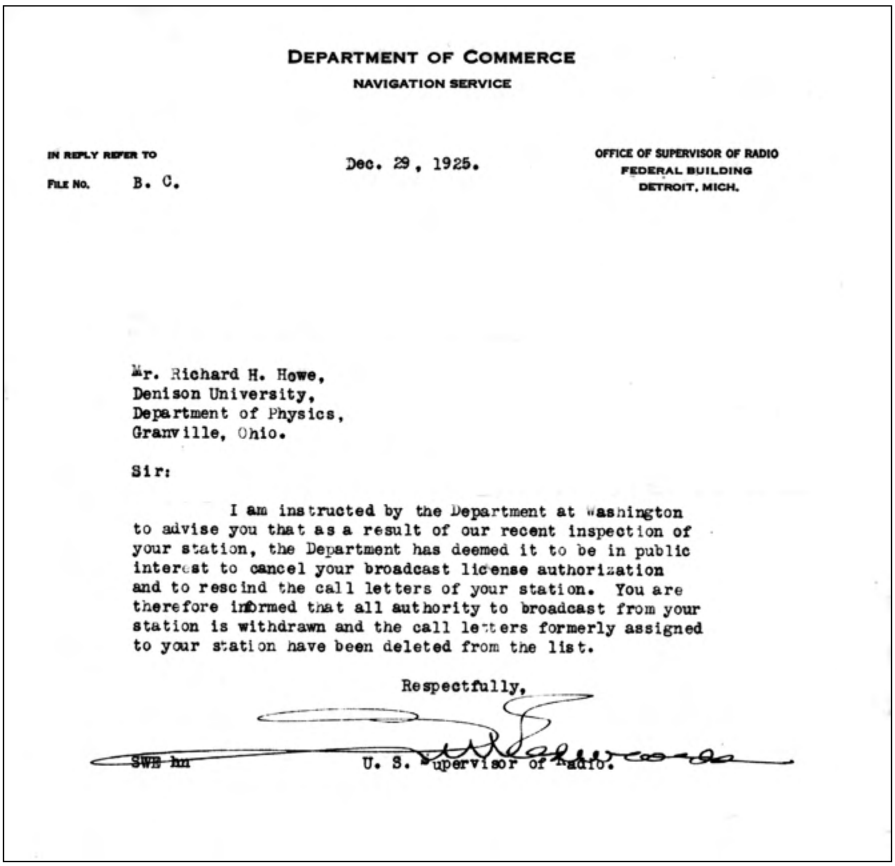
Broadcasting at Station WJD Comes to an End

Alas, station WJD would broadcast for only slightly more than three-and-a-half years, from April 1922 to December 1925. The demise of WJD was a combination of a lack of operating monies and lack of support and interest from the greater university. It was likely that the station also failed a technical inspection.

Howe recalled: "About 1925 government restrictions on the design of equipment for maintaining stability of frequency and for increased power became much more strict, and Denison was going to have to invest about $10,000 [~$140,000 today] to improve its station if it wanted to stay in the broadcasting business. The college authorities could not see spending this amount at that time."[51] The official letter from the Detroit office dated December 29, 1925, informed Richard Howe that the license for WJD had already been cancelled and deleted from the list (Fig. 22). Indeed, the deletion was recorded on page six of *RSB* No. 105 dated December 31, 1925, very likely a few days before Howe even received the letter.

The December 29, 1925, letter addressed to Howe was unequivocal: "I am instructed by the Department at Washington to advise you that as a result of our recent inspection of your station, the Department has deemed it to be in the public interest to cancel your broadcast license authorization and to rescind the call letters of your station. You are therefore informed that all authority to broadcast from your station is withdrawn and the call letters formerly assigned to your station have been deleted from the list."[52] It is very clear that the Detroit regional office blamed it on Washington. One can imagine the sound of the stamp hitting the paper—"Deleted."

Technically, the license for WJD was not cancelled—it was just not renewed. For some reason, the licenses for WJD during 1925 were issued for



DEPARTMENT OF COMMERCE
NAVIGATION SERVICE

IN REPLY REFER TO
FILE NO. B. C.

Dec. 29, 1925.

OFFICE OF SUPERVISOR OF RADIO
FEDERAL BUILDING
DETROIT, MICH.

Mr. Richard H. Howe,
Denison University,
Department of Physics,
Granville, Ohio.

Sir:

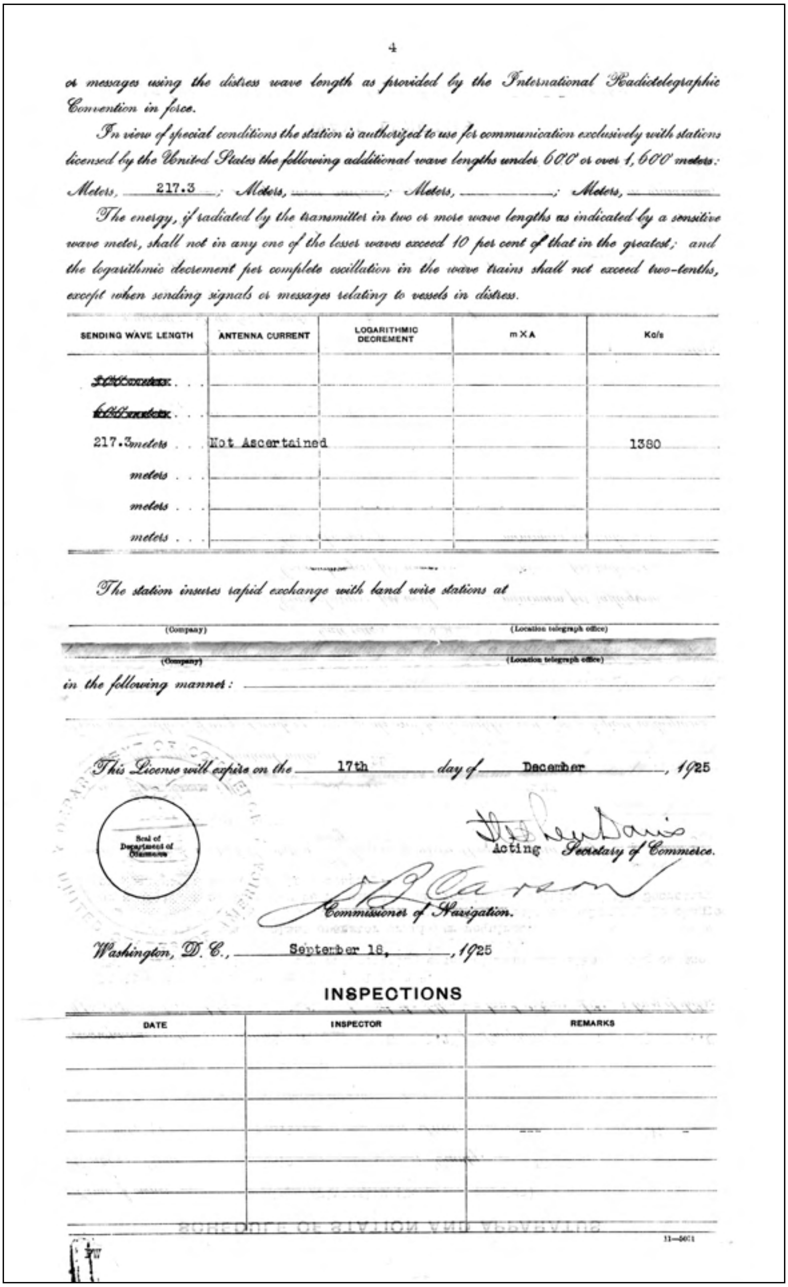
I am instructed by the Department at Washington to advise you that as a result of our recent inspection of your station, the Department has deemed it to be in public interest to cancel your broadcast license authorization and to rescind the call letters of your station. You are therefore informed that all authority to broadcast from your station is withdrawn and the call letters formerly assigned to your station have been deleted from the list.

Respectfully,

SWB hm

U. S. Supervisor of Radio.

Fig. 22. This letter from the Detroit office of the Department of Commerce dated December 29, 1925, canceled the WJD license, which at this time was held under the name of Denison University rather than Richard Howe. (Howe Papers, Denison U.)



4

or messages using the distress wave length as provided by the International Radiotelegraphic Convention in force.

In view of special conditions the station is authorized to use for communication exclusively with stations licensed by the United States the following additional wave lengths under 600 or over 1,600 meters:

Meters, 217.3 ; Meters, ______; Meters, ______; Meters, ______

The energy, if radiated by the transmitter in two or more wave lengths as indicated by a sensitive wave meter, shall not in any one of the lesser waves exceed 10 per cent of that in the greatest; and the logarithmic decrement per complete oscillation in the wave trains shall not exceed two-tenths, except when sending signals or messages relating to vessels in distress.

SENDING WAVE LENGTH	ANTENNA CURRENT	LOGARITHMIC DECREMENT	m X A	Kc/s
~~___ meters~~ . . .				
~~___ meters~~ . . .				
217.3 meters . . .	Not Ascertained			1380
meters . . .				
meters . . .				
meters . . .				

The station insures rapid exchange with land wire stations at

(Company) (Location telegraph office)

(Company) (Location telegraph office)

in the following manner:

This License will expire on the 17th day of December, 1925

Seal of Department of Commerce

Acting Secretary of Commerce.

Commissioner of Navigation.

Washington, D. C., September 18, 1925

INSPECTIONS

DATE	INSPECTOR	REMARKS

11—5601

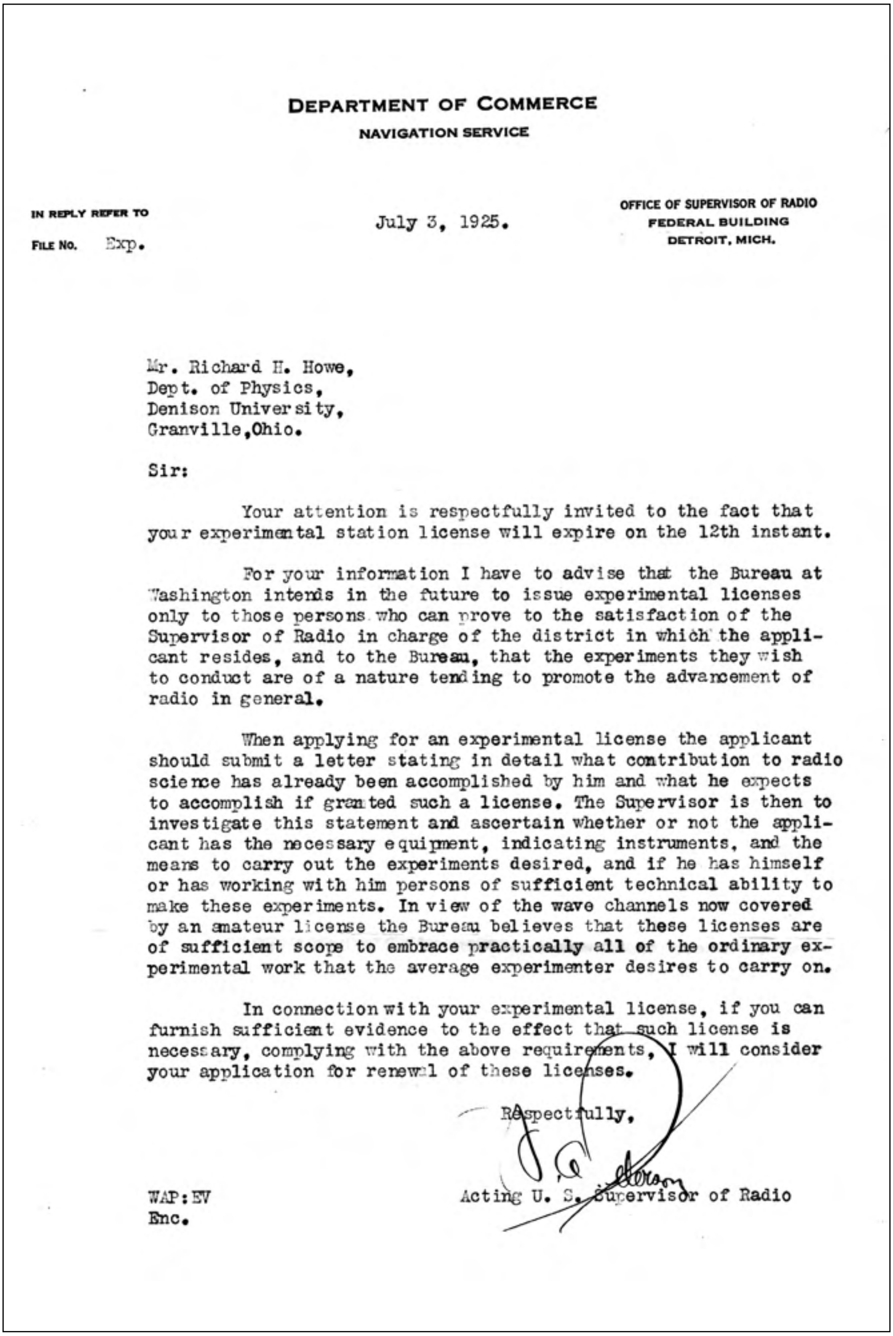
Fig. 23. Page four of the last WJD license (class A – Limited Commercial) issued on September 18, 1925, states that it was scheduled to expire on December 17, 1925. It also indicated that the operating wavelength had been reduced to 217.3 meters from the previous wavelength assignment of 229 meters made in May 1923. (Howe Papers, Denison U.)

three-month periods, and they had to be renewed at the end of each period. It is possible that three-month renewals were a common normal procedure for all limited broadcast licenses at that time because of the rapid changes in requirements for broadcast stations. In any event, according to page three of the WJD license issued on September 16, 1925, it was scheduled to expire on December 17, 1925, twelve days before the date of the letter informing Howe that his authorization was withdrawn (see Fig. 23). It should also be noted that the operating wavelength during 1925 had been changed from the previous wavelength assignment of 229 meters made in May 1923 to 217.3 meters.

Experimental Station 8XW

At this point, it should be noted that Howe received another category of license in early 1925—"Class 3, Experimental"—and according to the license application: "This station is licensed for the specific purpose of conducting experiments for the development of radio communication or the apparatus pertaining thereto." The equipment described in this license is "Composite V.T. Telephone." Composite is another word for "home brew." According to the 8XW license, it was issued to Richard Harris Howe on April 13, 1925. In the beginning years of broadcasting, as detailed earlier in this paper, there are other examples of an experimental license leading to a commercial license, but there is no indication that station 8XW was used for broadcasting purposes. It may never have been used for anything!

Three months after that license was granted, a letter dated July 3, 1925, was addressed to Howe from the Radio Inspector in Detroit questioning the viability of Howe's experimental license, 8XW (see Fig. 24): "For your information I have to advise that the Bureau at Washington intends in the future to issue experimental licenses only to those persons who can prove to the satisfaction of the Supervisor of Radio in charge of the district in which the applicant resides, and to the Bureau, that the experiments they wish to conduct are of a nature tending to promote the advancement of radio in general."[53] The station call signal to which the inspector refers is not mentioned in this letter but it must have been 8XW because it is referred to as "experimental," and the entry after "File No." printed on the form letter at the top left is "Exp." Station 8XW was the only experimental station at Denison in 1925, and the date of expiration cited in the letter (July 12, 1925) matches the scheduled expiration date appearing on the 8XW license. Apparently Howe did not follow up with a proper justification because the license was deleted from *RSB* No. 102, page 6, dated October 1, 1925. Howe apparently thought maintaining all of these license categories was too much work, so the Denison physics department continued to operate using just a standard ham license, W8SG. Amateur communication was their real interest, not radio broadcasting.



DEPARTMENT OF COMMERCE
NAVIGATION SERVICE

IN REPLY REFER TO
FILE NO. Exp.

July 3, 1925.

OFFICE OF SUPERVISOR OF RADIO
FEDERAL BUILDING
DETROIT, MICH.

Mr. Richard H. Howe,
Dept. of Physics,
Denison University,
Granville, Ohio.

Sir:

Your attention is respectfully invited to the fact that your experimental station license will expire on the 12th instant.

For your information I have to advise that the Bureau at Washington intends in the future to issue experimental licenses only to those persons who can prove to the satisfaction of the Supervisor of Radio in charge of the district in which the applicant resides, and to the Bureau, that the experiments they wish to conduct are of a nature tending to promote the advancement of radio in general.

When applying for an experimental license the applicant should submit a letter stating in detail what contribution to radio science has already been accomplished by him and what he expects to accomplish if granted such a license. The Supervisor is then to investigate this statement and ascertain whether or not the applicant has the necessary equipment, indicating instruments, and the means to carry out the experiments desired, and if he has himself or has working with him persons of sufficient technical ability to make these experiments. In view of the wave channels now covered by an amateur license the Bureau believes that these licenses are of sufficient scope to embrace practically all of the ordinary experimental work that the average experimenter desires to carry on.

In connection with your experimental license, if you can furnish sufficient evidence to the effect that such license is necessary, complying with the above requirements, I will consider your application for renewal of these licenses.

Respectfully,

Acting U. S. Supervisor of Radio

WAP:EV
Enc.

Fig. 24. This letter from the Commerce Department dated July 3, 1925, questioned the viability of Howe's experimental license 8XW and asked him to justify it. (Howe Papers, Denison U.)

Howe Reflects on His Life as a Broadcaster

In 1963 Howe reflected on his experience as a broadcaster.[54] "A spring wound victrola cranked out the latest Victor records. The microphone was simply placed in front of the victrola horn to pick up the music. Paul Whiteman was famous at that time. The records were furnished gratis by the Wyeth Victrola Store at Newark in payment for an occasional plug for the store over the air."[55] This is exactly the way that de Forest described music pickup in 1907, as did Herrold in 1909. The microphones were undoubtedly carbon telephone microphones. Howe further described his programming as music from a player piano, a device that could be played manually when "talent from the Denison Conservatory was available." The talent was usually individual soloists because of the difficulty encountered in trying to pick up several instruments at one time with the inferior carbon microphones of the day."[56]

In the 1922 Denison catalogue, WJD was promoted in the section under the Physics Department: "A telephone transmitting station, licensed under the call WJD, is used for the broadcasting of musical and educational matters."[57] Other programming included basketball and football games "broadcast play-by-play from the field using a remote microphone connected over the college telephone system."[58] This system of using the telephone circuits and wiring for sports broadcasting was continued with few technical improvements right up to the use of the higher-bandwidth Internet for remote game broadcasts. While Howe did not comment on the studio that was used for broadcasting, the photograph of Fig. 25 from the Denison papers document the studio that shows the pianos and the curtains and fabrics on the walls for sound deadening. On the table (or is it a console phonograph?) to the left of the piano appear either boxed cylinders of recorded music or player piano rolls.

Summary

This is the story of four early college broadcasters and their foresighted professors—with an emphasis on Richard Howe at Denison University, whose story has not been chronicled in any detail before. All four had similar stories about the early days of broadcasting. They all began to broadcast without licenses, albeit in a rather ad hoc fashion, until government licenses were required in December 1912. Radio Service Bulletins show that they all received their first Limited Broadcast licenses during the period December 1921 to June 1922. There the similarity ends. Two of these stations are broadcasting even to this day, and the other two stopped broadcasting during the second half of 1925. What was the difference?

The two stations still broadcasting today—WOSU at Ohio State and WHA at the University of Wisconsin—were operated by large universities whose broadcasting goal was bringing the educational riches of the university to all the residents of the state. They intended

Fig. 25. The WJD Studio features pianos, curtains, and other fabrics on the walls for sound deadening. On the table (or is it a console phonograph?) to the left of the piano appear either boxed cylinders of recorded music or player piano rolls. (Howe Papers, Denison U.)

to benefit farmers and homemakers, to bring world-class educators into isolated rural schoolrooms, and to teach people all over the state everything educational. These stations had the backing of their respective university regents, who staffed the radio station with professionals rather than students. The other two early broadcasters (Howe at Denison University and Herrold at the Herrold School of Wireless and Engineering) ended their broadcasting experience during the second half of 1925. These two were associated with small educational institutions, and broadcasting was incidental to the education of students at the respective universities. Broadcasting evolved as part the teaching experience rather than as part of an outreach program to the state's population.

The detailed files at Denison University show that Howe faced severe financial problems that were caused by, or at the very least greatly exacerbated by the increased government regulations on broadcast stations that forced Howe to modify the transmitter at an ever-increasing cost. While the story of radio at Denison begins well before 1912, the story of Howe's contribution to radio at Denison begins in earnest when Howe received an amateur license to operate a station with call letters 8ABR. According to the amateur license found in the Denison archives February 12, 1916, he began operating his amateur radio on wavelengths of 200 and 175 meters with a power limited to 30 watts "at the transformer input." This constitutes the baseline characteristics for his transmitter just before the U.S. participation in World War I caused all amateur activity to cease circa April 1917.

Howe began transmitting again after the war upon receipt of a Special land license with call letters 8YM issued on March 9, 1921. It is likely that he was operating once again on 200 meters because his renewal license issued a year later specified that wavelength. Howe must have encountered his first economic problem when new regulations went into effect on December 13, 1921 that created a Limited Commercial class of license. As a result, broadcasting activities were restricted to wavelengths of 360 and 485 meters. Howe quickly found that he could no longer broadcast music and talk on his Special land license specifying 200 meters; instead he had to obtain a Limited Commercial license and change the frequency of operation of his existing transmitter to 360 meters. He applied for and received a broadcasting license dated March 22, 1922, with call letters WJD. The license restricted his broadcast transmission to 25 miles (~10 watts).

Howe's problems were just beginning. In May 1923, the dual broadcasting wavelength system (360 and 485 meters) was abandoned and replaced by a number of allowed wavelengths between 222 and 545 meters for broadcasting to the public. At the same time, his station was assigned a wavelength of 229 meters and the maximum power was raised to 50 watts. The bandwidth requirements were tightened to prevent interference on adjacent channels, which incurred even more expense. Then in 1925, the wavelength specified on the WJD license was changed again, this time to 217.3 meters. The fractional wavelength specification indicates that the bandwidth requirements were even more restrictive. Worse yet, the power limitation of Denison's station was reduced back to just 10 watts, severely limiting audience coverage.

This was the last straw. Rather than attempt to meet ever-changing government requirements, Denison let its license expire in December 1925. Howe explained this decision as follows, "About 1925 government restrictions on the design of equipment for maintaining stability of frequency and for increased power became more strict and Denison was going to have to invest about $10,000 [~$140,000 today] to improve its station if it wanted to stay in the broadcasting business. The college authorities could not 'see' spending this amount at that time, so after September 21, 1925, the license was not renewed." Thus ended the radio broadcast experience at Denison.

The economic problems, and indeed the entire broadcasting experience that Howe experienced at Denison University, must have been similar to the experience and the problems faced by other small university broadcasters of the day, not to mention small commercial stations. A number of these stations that disappeared between early 1922 and the end of 1925 were likely put out of business by these new regulations.

In many ways, this paper can be regarded as a case study in this class of early broadcasters because it includes more than just economic issues caused by increased regulations intended to reduce interference on the ever-crowed broadcast band. It also includes information and photographs that characterize the entire experience—the broadcasting studio, the correspondence between Howe and government regulators, the station logs that record contacts with listeners, radio equipment, and the like.

Endnotes

1. "1922—year radio's population soared," *Broadcasting*, May 14, 1962, pp. 82–122. This article is one of a series of articles included in a section entitled "Special Feature: Radio at 40" that chronicled radio in the wonderful year, 1922, which marked radio's emergence as a truly national medium. It should be noted that college stations KQW, WHA and WEAO were included in this article, but WJD, a relatively unknown college station, was not.
2. Most Radio Services Bulletins, referenced hereafter RSB, are dated on the first of the month, in which case the data within apply to the previous month; in these cases, the month entered in this table is one month preceding the month of the publication date.
3. Mike Adams, *Columbus Radio*, (Arcadia Press, Images of America, Charleston, SC, 2016).
4. *Radio Service Bulletins* from inception through the 1920s used the term "call signals" for the letters and numbers appearing the licenses issued by the Department of Commerce. Correspondence from the Department of Commerce to license holders at Denison University found in the Archives of the university by the author referred to the station's call signals as "call letters." According to Google Ngrams, the term "call sign" did not gain popularity until after 1940, and so that term is not used here. —Editor.
5. The earlier research and discoveries were made by the late Gordon Greb of San Jose State University, who later collaborated with this author for the book, *Charles Herrold, Inventor of Radio Broadcasting*, McFarland Press, 2003).
6. *San Jose Herald*, July 22, 1912.
7. *RSB*, No.12, Dec. 1915, p. 2.
8. *RSB*, No, 42, Oct. 1, 1920, p. 5.
9. *RSB*, No. 48, April 1, 1921, p. 4.
10. *RSB*, No. 57, Jan 2, 1922, p. 2.
11. *RSB*, No. No. 100, Aug. 1, 1925, p. 6.
12. *RSB*, No. 111, June 30, 1926, p. 9.
13. *RSB*, No. 7, July 1915, p. 3.
14. *RSB*, No. 58, Feb. 1, 1922, p. 2.
15. Randall Davidson, *9XM Talking: WHA Radio and the Wisconsin Idea*, (University of Wisconsin Press, 2007). This book describes how, with homemade equipment and ideas developed from scratch, 9XM endured many struggles and became a tangible example of "the Wisconsin Idea," bringing the educational riches of the university to all the state's residents.
16. Jack Mitchell, *Wisconsin on the Air*, Wisconsin Historical Society, 2016, p. 4.
17. Ibid., p. 11.
18. Ibid., inside cover.
19. Ibid., p. 11.
20. Ibid., p. 12.
21. Ibid., p. 14.
22. Ibid., p. 16.
23. Press Release, March 18, 1945, OSU Archives.
24. *RSB*, No. 36, April 1, 1920, p. 5.
25. OSU Archives.
26. Ibid.
27. *RSB* No. 126, Sept. 30, 1927, p. 12.
28. "Many Stations on Low Waves, *Democrat and Chronicle* (Rochester, N.Y.), Oct. 23, 1927, p. 60.
29. *SB*, No. 126, Sept. 30, 1927, p.12.
30. *University Studies*, 1925, OSU Archives. This document is a journal.
31. 25th anniversary, OSU Archives. Press Release.
32. *RSB*, June 1, 1922, p. 22.
33. Robert Dildine's unpublished history of WBNS, Columbus, a history mostly of WBNS but also details of other early Columbus stations. Dildine was a transmitter engineer who passed around this mimeographed historical document. The author received his copy from the Columbus Area Society of Broadcast Engineers, SBE, Chapter 52.
34. Granville Times, June 2, 1899, Howe Papers, Denison Library.
35. Introduction to Howe speech, 1916, from

the Howe Papers at the Denison University Library.
36. For example: "Local Youths Are Interested in Wireless Telegraphy Study," *The Daily Republican* (Monongahela, PA), May 2, 1912, p. 1; "Obituaries, Geo. David Tepper, Jr.," *The News Journal* (Wilmington, De), Sept. 4, 2015, p. 27.
37. Granville High School address, 1916, Howe Papers, Denison Library.
38. Ibid.
39. Ibid.
40. Howe Papers, Denison.
41. Ibid., pg 4.
42. QSL card collection, Howe Papers, Denison.
43. Commerce letter, April 1922, Howe Papers, Denison.
44. Ibid.
45. *RSB*, No. 60, April 1, 1922, p. 26.
46. *RSB*, No. 61, May 1, 1922, p. 3.
47. *RSB*, No. 74, June 1, 1923, p. 11.
48. (WJD License, Howe Papers, Denison)
49. Richard Howe, "Broadcasting at Denison, April 6, 1922 – September 21, 1925," Howe Papers, Denison.
50. Jack Mitchell, *Wisconsin on the Air*, Wisconsin Historical Society, 2016
51. Richard Howe, "Broadcasting at Denison."
52. Commerce letter, December 1925, Howe Papers, Denison
53. Commerce Department letter, Detroit district, Howe Papers, Denison.
54. "Broadcasting at Denison, April 6, 1922 – September 21, 1925" by Howe, March 12, 1963, Howe Papers, Denison.
55. Ibid.
56. Ibid.
57. Denison University 1922 catalogue, Denison Library.
58. Ibid.

Special Acknowledgement

I want to thank the editor of the *AWA Review*, Eric Wenaas, for his help with this project. He is knowledgeable and dedicated, and I could not have completely told the Howe story without his interest, perspective, and significant additional research.

About the Author

Mike Adams is professor emeritus of radio, television, and film at San Jose State University, where he has been a department chair and the Associate Dean of the College of Humanities and the Arts. As a researcher and writer of broadcast and early technology history, he created two award-winning documentaries for PBS, the Emmy-nominated "Radio Collector," and "Broadcasting's Forgotten Father." Mike is the Board Chair of the California Historical Radio Society, CHRS. For his service to historical radio research and publication he received the AWA Houck Award, the SCARS President's Award, the TCA Stokes Award, the RCA Ralph Batcher Award, and he was named a CHRS History Fellow. He has published numerous articles and six books, including *Lee de Forest, King of Radio, Television and Film*, 2012, Springer Science, *The Radio Boys and Girls: Radio, Telegraph, Telephone and Wireless Adventures for Juvenile Readers*, 1890–1945, McFarland Press, 2015, and *Columbus Radio*, Arcadia Publishing, 2016.

Mike Adams

Letters to the Editor

Re: WHA Madison—Is it Really the Nation's Oldest Station?
by Dan Clark, Vol. 28, 2015

In a chance meeting with Dan Clark at the WHA transmitter site in Madison, Wisconsin, I learned that he had written an article in Volume 28 of the *AWA Review* on the station. He loaned me a copy of his article and I read it with enthusiasm. I'd like to offer a couple follow-up points to Dan's article excellent article.

In 1972, the present transmitter site was built not far from the earlier site pictured in Dan's article. Located in a marsh, this highly-effective, centrally-located transmitting site has served WHA very well. In 2008, I replaced the quarter-wave, series-fed tower and ground system (no change in design). This project slightly improved the station's coverage—but the main goal was not to mess up the already great signal!

Dan's impression that WHA became a minor part of the larger organization is not entirely correct. While Wisconsin Public Radio has grown to be one of the largest public radio groups at 34 FM and 2 AM stations, WHA has remained the flagship station, and the ratings show it serves about 30,000 individual listeners each week.

WHA is also not a daytime-only station as described in Dan's article. For several decades now, WHA has operated 24-hours, seven days a week. Power is reduced at night but covers the city and surrounding suburbs quite well (thanks to the good transmitter location). In hindsight, it was probably a mistake to allow WHA to remain a daytimer for so long, but my research shows this to be an understandable situation. For most of its early history, WHA was truly an educational station that focused on broadcasting lectures and cultural programming. School was over by evening in those days, so it would have seemed natural to close down and go home. I also understand that, over many decades, there was pressure from commercial broadcasters jealous of the competition from a state-owned station. Each time the station sought to expand and improve, they lobbied against the proposed project. After enough of this opposition, I suspect past management was willing to leave it be and concentrate on other ways to improve the system. In more recent decades this back-door opposition faded away and allowed the station to gain night-time authorization—albeit at a more limited power level thanks to the many stations that came on the air in other cities that need to be protected from interference—and to make other improvements such as adding HD digital (2006) and program-associated text data for radio displays (2011).

As to the question of being the oldest station in the nation, I think this is a matter of definition. Before World War One, WHA had been scheduling Morse code transmissions meant for reception by the general public. These broadcasts involved news of the day, farm market reports, weather forecasts, and the like. Primitive voice transmissions were added shortly thereafter. This is long before any of the usual dates for "first station" claims. By my definition, regularly scheduled transmissions for the general public constitutes "broadcasting." Thus, in my view, WHA must be considered one of the very earliest broadcast stations. Other contenders may rely on other definitions of broadcasting for their claims, which is fine because there is room in the history of early broadcasting for all the participants. Radio became the craze in those days because so many were willing to get going early with gusto! And as a medium, radio continues to thrive and grow today.

—**Steve Johnston**, Director of Engineering and Operations, Sept. 6, 2016

Ed. Note: In the last paragraph of this letter, Steve Johnson is responding to Dan Clark's conclusion that WHA in Madison, WI, was not the oldest broadcast station still in operation. Steve Johnson writes "I think this is a matter of definition. . . . By my definition, regularly scheduled transmissions for the general public constitutes 'broadcasting.'" He then says, "Before World War One, WHA [actually 9XK, forerunner station to WHA] *had been scheduling Morse code transmissions meant for reception by the general public. . . . This is long before any of the usual dates for 'first station' claims."*

Steve's definition of broadcasting, which includes code broadcasts, is at odds with the definition accepted by most "oldest station contest" arbitrators and candidates (and Dan Clark). Apparently the University of Wisconsin also excludes code from the definition of broadcasting because a plaque there entitled 9XM~WHA/ "The Oldest Station in the Nation" states, "On this campus pioneer research and experimentation in 'wireless' led to successful transmissions of voice and music in 1917, and the beginning of broadcasting on a scheduled basis in 1919."

Re: Amory H. "Bud" Waite, Polar Explorer by John Dilks, Vol. 29, 2016

I enjoyed John Dilks's excellent article about Amory H. Waite, W2ZK. Please permit me one minor correction. The Lowell Institute School from which Waite graduated in 1926 is not "now known as the Massachusetts Institute of Technology." The Lowell Institute was located on the MIT campus until 1996, at which time it was transferred to Northeastern University, about a mile distant from the MIT campus.

—**Ray Soifer**, W2RS, August 12, 2016