EARLY RADIO AND ITS MARITIME EVOLUTION

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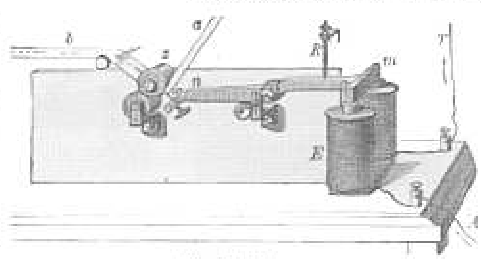
Correspondence is invited.

The tragedy of the sinking of the *SS Titanic* in 1912 stunned the world, which learned of it as a result of wireless telegraphy from the rescuing vessels. In that sad event, radio, as wireless came to be known, came of age. Maritime concerns had been its midwife as well. Radio remains a life saver on the high seas.

An early filament light bulb experiment with induction.

The opening of the San Francisco Maritime Museum's ***Radio Collections and Displays,*** set for November, 1999, by the National Park Service, provides a good opportunity to review some radio history as it relates to radio's maritime service.

Many systems of modern technology have developed first with some existing mode of accomplishing the task the system aims to do, but then call forth a new technical mode to realize the full potential of the system. In radio, Marconi adapted the experimenters' spark-generated damped electromagnetic wave to a system of communications using 19th century laboratory equipment and modeled on the land line telegraph. His system assumed the name "wireless telegraphy" and it worked. He signaled across the Atlantic Ocean in 1901, a fitting beginning to the technological wonders of the 20th century. As soon as he succeeded, many others sought to do it better. One of the most important of these men is Lee deForest, a science Ph.D. from Yale. He wanted better ways to detect the Hertzian waves that Marconi (and others, notably Nicola Tesla) sought to communicate with. He tried wire in an acid bath, and he tried a candle's flame. On that model, he thought of using a light bulb with a glowing filament. He did not work in intellectual isolation, and indeed many of his inventions were in truth adaptations (as was true with many inventors of the day, and of ours). Ambrose Flemming in England had used a filament, and a metal plate, in an evacuate bulb to gather electrons from it, as early as 1904. Edison had discovered the process some twenty years earlier. Flemming saw that his "valve" could turn an alternating current of electricity into a direct current. The Marconi company quickly put the Flemming valve to work as a detector of electromagnetic waves, turning the alternating currents they created in wire antennas into direct current in receivers, that could operate a telegraph register inker, or what we call headphones that made sounds. This "diode" valve worked better than the earlier laboratory equipment, the tube of iron and silver filings known, from its action, as the "coherer" which had been invented by Edward Branley in about 1892.

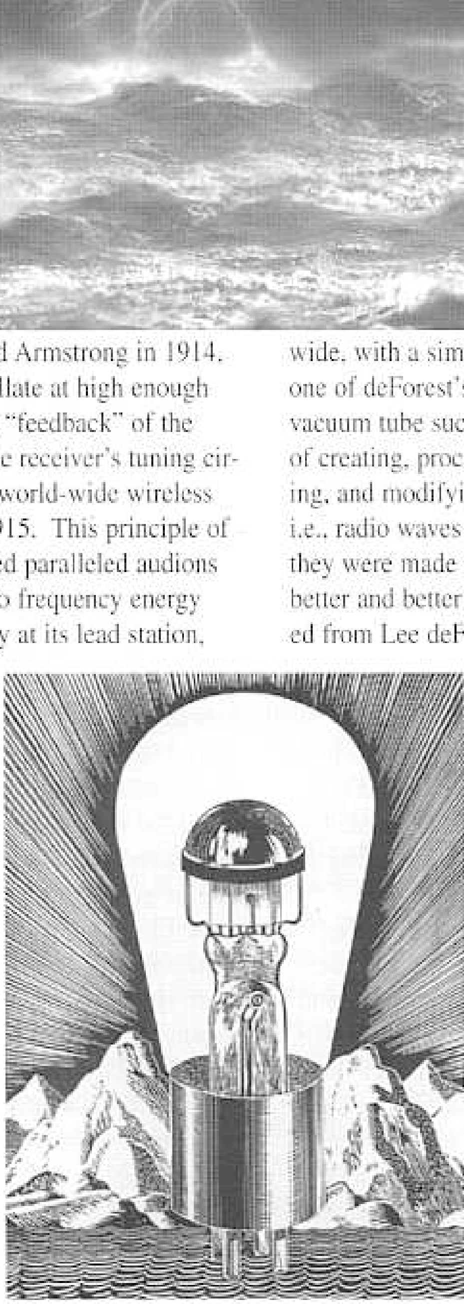


The Register.

DeForest came to the problem of detection of radio waves with this background. Based on his work with the candle flame, in December of 1906, he put a wire between the filament and the plate. He shaped the wire in a back-and-forth manner that reminded him of a football field, so he called the wire the "grid." He connected the receiver's tuning circuit to the filament and the grid. He connected his headphones to the filament and the plate. The device "detected" radio waves, in the buzzy form from which they emanated from a spark transmitter. DeForest called his three element, triode valve the "audion." It made radio waves into audio electrical patterns that could be heard with the human ear. The developing technology of wireless telegraphy had given birth to the Vacuum Tube.

Ironically, deForest at first thought that some gas should remain in the valve. Later work, especially that of Irving Langmuir at AT&T, showed better performance with higher vacuum. DeForest first thought the audion would only be good for detection of radio waves. His own later work, at Federal Telegraph in Palo Alto in 1911, showed that the audion could also amplify signals. By 1913, still in Palo Alto, deForest made his audion oscillate, creating the same sorts of alternating electrical patterns that he had invented it to detect. Later work, especially

that of Edwin Howard Armstrong in 1914, made the audion oscillate at high enough frequencies to permit "feedback" of the original signal into the receiver's tuning circuits, which enabled world-wide wireless communication by 1915. This principle of "regeneration" enabled paralleled audions to create enough radio frequency energy that in 1915, the Navy at its lead station, NAA in Virginia, communicated by voice with Paris, and Mare Island, California, and was heard in Hawaii as well. It would only be a matter of time, and the progress of the First World War, before the vacuum tube systems replaced the earlier sparks and arcs of the first decade of wireless.



The new system of wireless communications had called forth the ideal instrument for its advancement to its full potential. The spark systems wasted enormous amounts of energy and bandwidth in damped oscillations compared to the single frequency continuous wave generated by an arc system. The vacuum tube provided a clean, single frequency at much higher efficiency than the heavy, power-hungry and electromagnetically messy arc systems. The vacuum tube permitted radio reception world-wide, and in many cases, radio transmission world-wide, with a simple tuning apparatus and one of deForest's audions (or their various vacuum tube successors). The technology of creating, processing, detecting, amplifying, and modifying electromagnetic energy, i.e., radio waves and the intelligence that they were made to carry, settled down into better and better "radio tubes" all descended from Lee deForest's audion detector valve.

Every use of wireless became more efficient in power and bandwidth. Smaller radios could cover longer distances, and be heard through challenging natural conditions, and the interference of intense use of the various radio bands. By the 1930s, receivers boasted of single-signal capabilities. Ships at sea and aircraft in flight employed small, high power vacuum tube transmitters and receivers, by the mid 1920s. The lives that wireless had saved at sea multiplied with the new powers that vacuum tubes gave to radio systems. Amateur radio operators, as well as researchers, in the early 1920s used vacuum tube equipment to explore higher and higher frequencies. They discovered the ionospheric propagation of radio waves that enabled world-wide communication reliably day and night. Commercial and maritime operations soon followed these pioneers.

By the 1930s, radio was routine in maritime service, and in international work, competing with cables. Large shore stations kept in touch with vessels and aircraft wherever they were, including the poles. The technology had stabilized into a world wide network of commercial and maritime stations, including those of the navies and governments of the world, as well as dozens of nations broadcasting to each other on the "short waves" that were the high frequencies first explored by amateurs, and many more amateurs experimenting, and communicating world-wide. Yet, one had only to listen to the short wave broadcasters to hear the distant thunder of approaching war.

The peace time maritime fleet prepared for war as early as 1939. The U.S. Government set out to build a fleet of merchantmen, first the Liberty Ships (such as the *S.S. Jeremiah O'Brien*) then the Victory Ships (such as the *S.S. Pope*). Naval construction provided battleships, submarines, and minesweepers, and everything in between. Every ship employed radio for coordination, intelligence, and safety and rescue. Usually, ships communicated using Morse Code, usually encrypted but often in plain language. As early as 1907, Lee deForest and the U.S. Navy used small arc radios to provide voice communications among ships, using amplitude modulation of the carrier signal generated by the arc. It was the vacuum tube that permitted reliable voice "radiophones," as they were called. The vast amount of traffic, however, required Morse Code by interrupted continuous wave modulation, or "CW"

Fishermen and many other maritime users preferred voice communications because they did not have to learn the code that way. In the late 1930s both fishing and pleasure craft used amplitude modulation ("AM") radios to stay in touch with shore and each other. John Steinbeck's *Voyage to the Sea of Cortez* in 1940 relates these uses for weather, fishing information, and morale. Amateur radio operators experimented with radiophone as early as 1919, when experimentation could begin again after World War One. Broadcasting, technologically and as a compelling social phenomenon, took off like a rocket in the early 1920s, using a.m. on medium waves and frequencies, and in the 1930s on short wave. However far out at sea one might be, broadcasts of voice and music could be heard, along with weather and advisories, and perhaps instructions from shore, in Morse Code. In World War Two, the merchant marine equipped each of its ships with low frequency, long wave radio sets and also high frequency, short wave sets (as well as a 1920s style crystal set receiver for emergencies). Each ship also had a short wave receiver for the crew to listen to, the "morale receiver." All equipment was highly shielded so that no stray radio waves disclosed the ship's position to a hungry wolf pack of enemy submarines. Until and into the Vietnam War era, merchant ships and for that matter Navy ships as well, continued to rely on vacuum tube radio equipment whose principles has been worked out in the early 1920s.

Performance improved the effectiveness of a standardized architecture. Modulation of traffic signals of high volume took on various modes, such as Baudot teletype and eventually digital encryption. Voice signals, initially in the Air Force, were found to carry better with the carrier str'pped away and all the power put into only one of the two intelligence-carrying sidebands of the AM transmission. This single side band "SSB" mode quickly spread to all radiophone communications except broadcasting, because of its efficiency and penetrating power. By the 1970s it was the dominant mode of military, naval, aviation and maritime communications in voice.

Three developments of the middle century changed both the principles and the architecture of their implementation. During the Second World War, the vacuum tube was pressed into the simple on-off duty of computation, initially for ballistics but soon in cryptanalysis. The computer age began, with thousands of Lee deForest's audions, standardized at high vacuum, cooking away at billions of digits. In 1947, AT&T applied the physics of quantum mechanics to the earlier work of others on crystal detectors, oscillators and amplifiers, inventing the "transistor." In time, through the work of Robert Noice and others, researchers fabricated many transistors onto single chips of semiconductors like silicon, turning sand into computer power. By 1954, the transistor was at work for the telephone company, and by 1956, it worked in radios, and by 1957, in computers. In 1957, the Russians launched the first Earth Satellite, "Sputnik" — the "fellow traveler." Its radio signals beeped down to the whole Earth. The space age had begun. Soon these three developments merged: transistorized computers on chips communicated world-wide via satellites using radio and in every other mode. Wireless evolved into the World Wide Web.

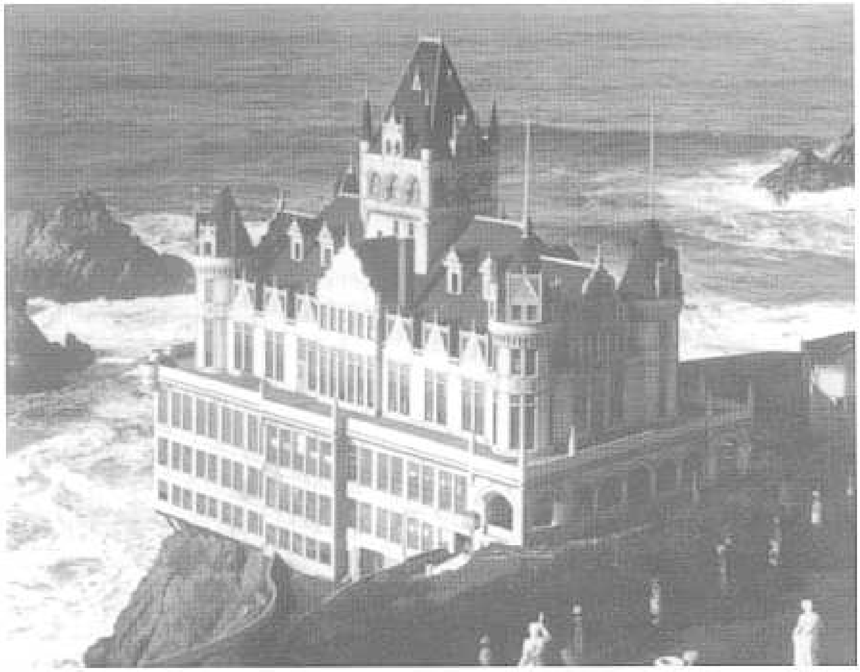
Today's mariner can talk anywhere in the world via satellite, or maritime high frequency SSB radio. He can use a satellite telephone to link to the world's telephone networks. He can enjoy digital e-mail traffic messaging anywhere in the world by satellite or by high frequency digital radio. He can determine his position within yards by satellite Global Positioning System transmissions supplemented by long wave radio beacons supplying digitize local data. He can steer his ship by a star or by a man made GPSS satellite's data. If in distress, he can launch a Emergency Radio Beacon (the EPIRB system) so help can find him. All of these systems use chips and digital technology, yet all of them are the children and grandchildren of Marconi, Tesla, deForest, and a host of others dedicated to improving the radio art.

SCIENTIFIC AMERICAN

January 1897

An invention which promises to be of the greatest practical value in the world of telegraphy has received its first public announcement at the hands of Mr. William H. Preece, the telegraphic expert of the London post office. During a lecture on 'Telegraphy Without Wires' recently delivered in London, Mr. Preece introduced a young Italian, a Mr. Marconi, who, he said, had recently come to him with such a system. Telegraphing without wires was, of course, no new idea. In 1893 telegrams were transmitted a distance of three miles across the Bristol Channel by induction. But young Marconi solved the problem on entirely different principles, and the post office officials had made a successful test on Salisbury Plain at a distance of three-quarters of a mile.

AMERICA'S FIRST RADIO STATIONS, RIGHT HERE IN SAN FRANCISCO



The two accompanying photographs depict two of the world's first radio stations. The San Francisco Call building, still standing (although modernized) at Third and Market Streets, housed on its very top floor the first 1899 Rhumkorff Coil spark transmitter used for the feasibility experiments of April, 1899 between the building and Telegraph Hill. These worked well enough to test out to Ocean Beach, about seven miles. With that distance working, the men using wireless for the *Call* were confident that they could transmit a signal from the *Lightship San Francisco* nine miles to the Cliff House. They did so on August 23, 1899, getting the journalistic scoop. This was the first working use of wireless, of radio, in America; Marconi reported yacht races in New York in October, 1899. The Cliff house, as it looked in 1899, is the second photo. A 1982 CHRS article by **Kathryn and Roy Tucker**, details this San Francisco wireless feat as one of the main radio adventures of 1899.(it is used by their permission) Another paper of theirs, about the Coherer, the detector of radio waves used at the time, also appears nearby.

The cover of this journal shows the *Lightship San Francisco,* number 70, transmitting America's first wireless telegraph message: SHERMAN IS SIGHTED, on August 23,1899 at 5 PM from the bar nine miles off the Golden Gate (after a newspaper-published etching circa 1899). A long wire antenna came up to a "capacity hat" from a large Ruhmkorff coil, powered by the ship's dynamo, the primary of which was keyed with the message, as soon as the troopship *Sherman* loomed in the fog, returning the regiment of the First California Volunteers to San Francisco from the Spanish American War.
Drawing by Kent Leech, CHRS

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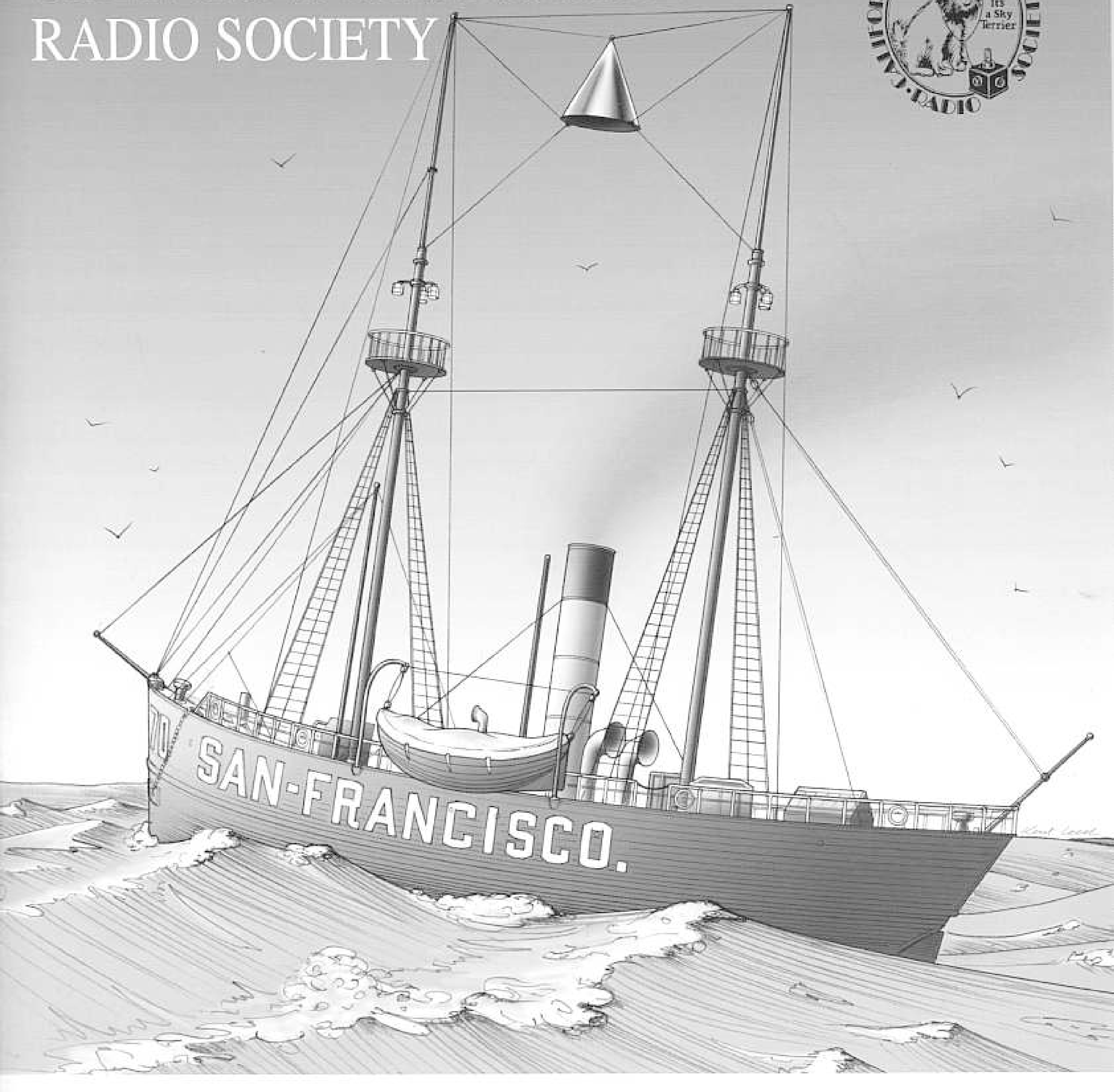

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