HISTORY

# The Early Days of RADIO

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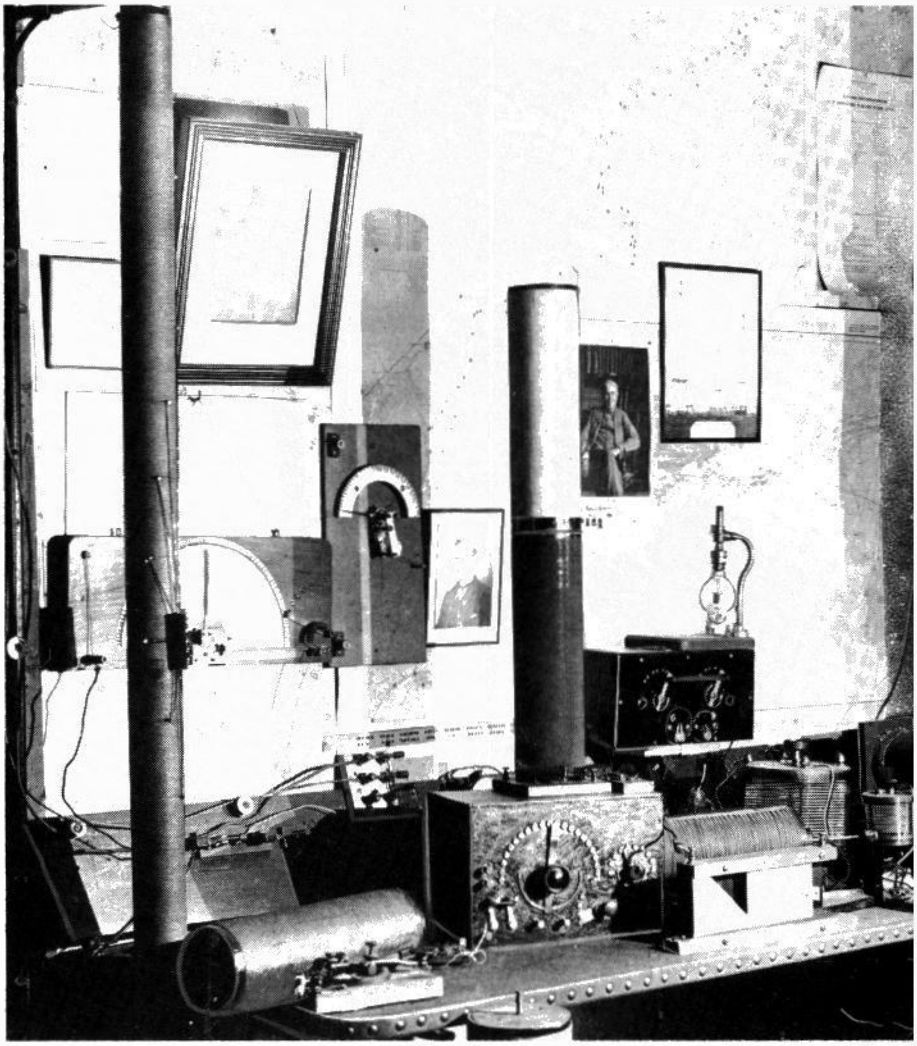
*Learn about the many discoveries and inventions that led to the development of radio.*



**Part 3** TWO GREAT TECHnological "revolutions" have changed the nature of civilization. One was the Industrial Revolution, which is commonly agreed to have begun in 1750. It was a revolution in the invention, design, and use of machinery for mass manufacturing.

Perhaps less renowned (at least in some circles), though no less important, was the "electronics revolution." It can be considered to have begun with the article "A Dynamical Theory of the Electromagnetic Field," written by James Clerk Maxwell, a Scottish physicist. That article was published in *Philosophical Transactions* in 1865.

The most significant result of the electronics revolution was radio. But, as is so often the case, radio was not the brainchild of a solitary inventor. Instead, numerous developments by independent researchers and teams led to the evolution of radio.

Remember also that many laws of radio that we take for granted now were only developed during the second half of the 19th century. For instance, by the Civil War, telegraphy was well established and telegraph wires crisscrossed the countryside. Even so, experimenters were hard at work looking for some way of communicating without wires. However, their work was severely hindered by some of the misconceptions of the time.

For one, most people were convinced that there had to be some connecting mechanism between the transmitter and receiver. Around the middle of the 19th century, Samuel F.B. Morse, the inventor of wired telegraphy, tried a wireless system that substituted water for wire over part of a telegraph loop. The system is illustrated in Fig. 1. Note that there is no wired connection between the receiver on one bank and the key on the other. Instead, the link is provided by the water in the stream.

Morse and others also experimented with inductive schemes. In 1885, Sir William Preece, Engineer-In-Chief of the British Post Office, tried using the circuit shown in Fig. 2. He was able to establish communications over a distance of about 1000 yards, using loops of wire that each were hundreds of feet long.

### The antenna

Electricity and the possibility of wireless communications attracted enthusiasts and experimenters of all kinds. One of those was Dr. Mahlon Loomis. Dr. Loomis was a prominent Philadelphia dentist who, at the age of 28, had patented a process for making false teeth.

Dr. Loomis is also credited with making the first wireless transmission, in West Virginia in 1865. As shown in Fig. 3, the Loomis "transmitter" consisted of a telegraph key that was connected in series

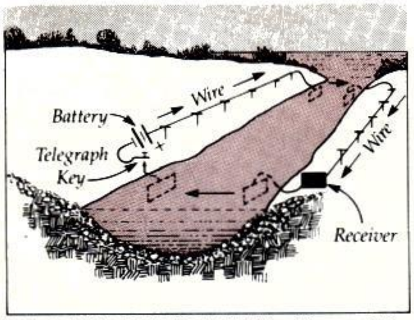



**FIG. 1—THE MORSE SYSTEM of transmitting signals through space. Water served as the link between transmitter and receiver.**

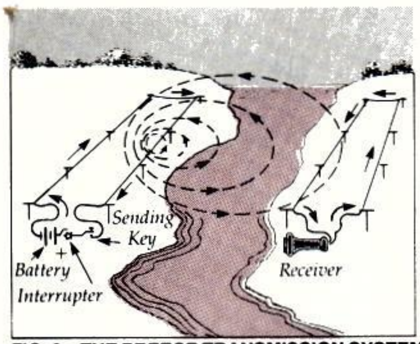



**FIG. 2—THE PREECE TRANSMISSION SYSTEM used two loops of wire, each over a hundred feet long. One loop (for transmitting) had a battery and telegraph key; the other loop, a telephone handset.**

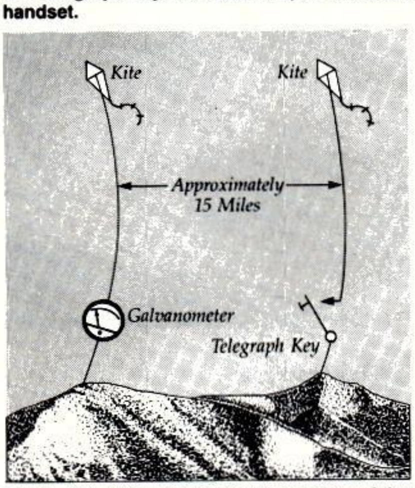



**FIG. 3—DR. LOOMIS' transmitting and receiving system. The copper wires were held aloft by kites.**

with a long length of fine copper wire. The wire was held aloft by a kite in which a small section of wire mesh was embedded. The receiver, which was located some 15 miles away was similar, except that the key was replaced by a galvanometer that was used to indicate signal reception.

Dr. Loomis was the first to use the word "aerial;" it was the term he used to describe the copper wire. He received a patent for his scheme in 1872. It was the first patent ever issued for wireless telegraphy. Dr. Loomis' wireless system was demonstrated publicly in Philadelphia in late 1879.

Despite Dr. Loomis' work, Marconi is widely recognized as the inventor of the antenna, even though Edison also held a prior patent in the field. Edison's method, shown in Fig. 4, used large metal plates at the transmitter and receiver. Those plates formed what was essentially a huge capacitor. Electrostatic charges at the transmitter plate induced a charge at the receiver plate. The system was suitable for short-distance communications only, and Edison subsequently sold the antenna patent rights to Marconi.

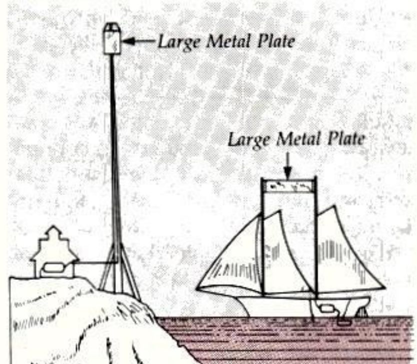



**FIG. 4—THE EDISON capacitor antenna used a large plate for transmitting and a similar large plate for receiving.**

In 1895, while experimenting with the oscillator circuit developed by Hertz, Marconi decided to ground one side of the oscillator and extend a lead at the other side of the oscillator into the air. That lead somewhat resembled the antennae of an insect, hence the word "antenna" was soon applied to that arrangement. It was quickly noted that the use of an antenna allowed communications over far greater distances.

### The detector

Wireless telegraphy introduced several problems that were of no concern to the developers of wired telegraphy. For instance, a wired system operates on DC. Signals were sent by interrupting the current flow. At the receiving end, those interruptions were made audible by an electromechanical sounder.

With a wireless system, however, some means of extracting or detecting a signal is required. That task is handled by a rectifier, which is a device that allows current to flow in only one direction. Because of the function they serve, rectifiers are also called detectors.

We discussed crystal detectors in the first installment of this occasional series. (See the July 1986 issue of **Radio-Electronics**.) However, early detectors used other schemes. One of the first detectors consisted of two metal electrodes that were immersed in an electrolytic or acid solution. Initially developed in the late 1850's, years later detectors of that type, which by then were called electrolytic interrupters, became extremely popular with amateur experimenters and wireless-telegraphy hobbyists. See Fig. 5 for an example of an electrolytic detector.

Another early detector was the coherer. The basic principal behind that device was discovered first in 1850 by Guitard. He noted that particles of dust in electrically charged air tended to adhere to each other. Later, in 1883, Sir Oliver Lodge noted that metallic dust, which is normally a poor conductor, becomes a good conductor when exposed to high frequencies.

Those discoveries led Edouard Branly to develop the Branly coherer, which was also called the Branly wave detector. See Fig. 6. The coherer consists of a small glass tube filled with metal filings. In 1894 Lodge used the coherer to detect signals from a transmitter located 150 yards away.

The coherer was not without its problems. Perhaps the most significant problem was that the filings would adhere to each other each time a signal was passed through them; that is, after each dot or

### SO THEY SAID

• While working for the Marconi Wireless Telegraph Co, Ltd. in 1916, David Sarnoff, who subsequently became President and Chairman of the Board of RCA, proposed to his superiors that the company become involved in the manufacture and sale of what Sarnoff called "music boxes." They would be used for the reception of not only music but educational programs that would be broadcast by radio.

Sarnoff was advised that there was no merit to his suggestion.

• In 1882, Professor Amos E. Dolbear applied for a patent for his invention of a wireless transmitter that used an inductive technique. The patent application was rejected by the patent office on the grounds that it was "contrary to science."

• On November 12, 1913, Dr. Lee de Forest went on trial in New York on the charge of using the mails to defraud. The indictment stated that his patents were for "a strange device, like an incandescent lamp, which he (de Forest) called an Audion, and which device had proven to be worthless."

Acording to the Federal District Attorney, "de Forest has said in many newspapers and over his signature that it would be possible to transmit the human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements, the misguided public, your honor, has been persuaded to purchase stock in his company, paying as high as $10 and $20 a share for the stock.

De Forest was aquitted by the jury, but the judge advised him to "get a common garden variety of job and stick to it."

• Charles Babbage, the designer of a calculating machine that can be regarded as the ancestor of today's computers, was asked in 1843 by British Prime Minister Robert Peel to use the machine to "calculate the time at which it will be of use." **R-E**

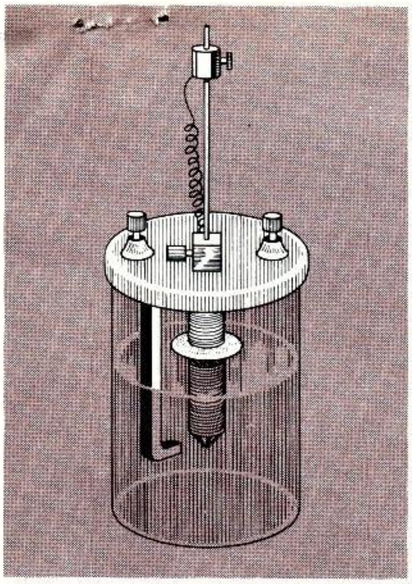


FIG. 5—THE ELECTROLYTIC DETECTOR consisted of two metal rods submerged in an electrolyte or acid solution. Such detectors eventually were very popular with hobbyists and experimenters.

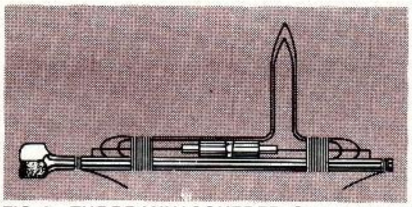


FIG. 6—THE BRANLY COHERER. One drawback was that the metal filings in the glass tube tended to stick to each other.

dash. To separate the filings some type of automatic tapping device was required to mechanically tap or shake the tube after each signal passed.

Marconi used an improved version of the Branly coherer in some of his work. Marconi's coherer used filings made from a nickel-silver alloy. Although a tapping device was still required, the coherer was able to detect signals from a transmitter located two miles away.

Marconi, with the assistance of Lodge and Dr. John Ambrose Fleming, also developed the electromagnetic detector shown in Fig. 7. That detector consisted of a moving band of iron wire (A) mounted on a pair of wheels (E). The band passed through a coil (B) that was connected to the antenna. As a section of the band passed through a pair of permanent magnets (D), it was magnetized. When that section later passed through coil B, a magnetic field that varied with the signal applied to the coil via the antenna was created. That field was electromagnetically coupled to coil C, which was connected to a telephone receiver. In many ways, Marconi's detector resembled the wire recorder, which would not be developed until over four decades later.

## Edison and radio

Edison's work in developing the electric light also played an important part in the development of radio. That's because it led to the invention of the vacuum-tube diode, and later to the triode.

Edison was not the first person to turn his attention to developing an electric light, however his work was the most successful. One problem with earlier efforts, like that of W. Edward Staite, was that the filament was exposed to the atmosphere, allowing rapid oxydation. Once Edison hit upon the idea of placing the filament in an evacuated globe, he was on the way to success. But there were still obstacles to overcome.

Edison's difficulties with his electric light are well documented. One of the most significant was that one side of the

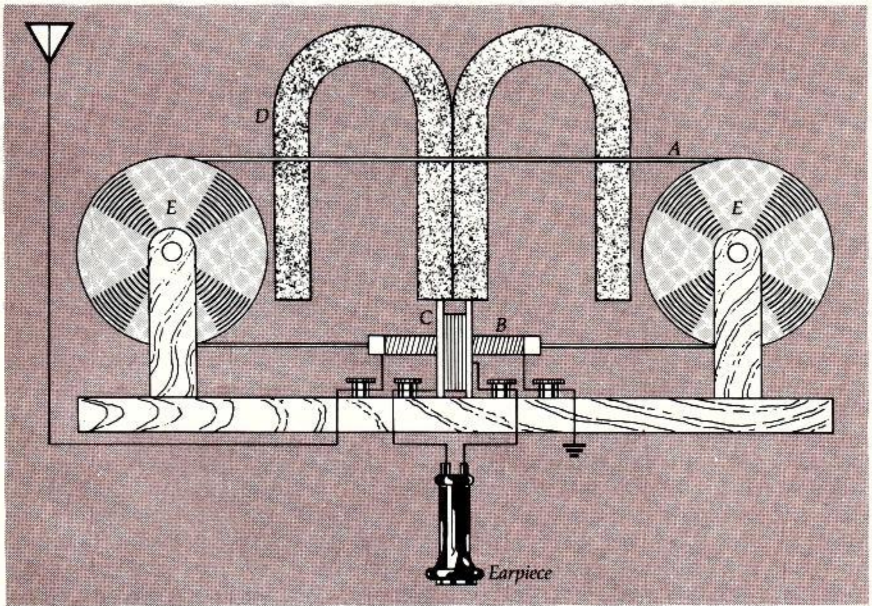



FIG. 7—MARCONI'S MAGNETIC DETECTOR used electromagnetic induction to produce an audible signal in the earpiece.

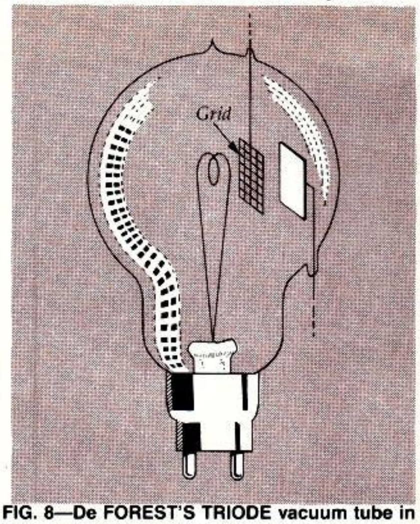



FIG. 8—De FOREST'S TRIODE vacuum tube in its final form. The tube was designed for both signal rectification and amplification.

filament behaved in a different manner than the other side. As a result, the glass envelope of the light would blacken. Edison tried various schemes to eliminate the problem. In 1883, as an experiment, Edison inserted a metal plate between the filament wires. By connecting the plate to the positive terminal of a battery he was able to measure the current between the filament and that plate. Although the information did not lead to an answer to the blackening problem, he deemed the discovery significant enough to obtain a patent for it.

Fleming felt that Edison's discovery might be the answer to the ongoing problem of signal detection. In 1904, Fleming modified Edison's design by replacing the metal plate with a metal cylinder that completely surrounded the filament. Also, the filament was designed to carry a larger current than was required by Edison's bulb. That was made possible by the development of the thoriated tungsten filament by Irving Langmuir in 1900. (adding theorium to a filament improves a filament's emission.)

## The triode

De Forest's invention of the triode vacuum tube was a major step forward for radio. It was the first device that had the ability to amplify. De Forest tried many approaches before finally meeting with success. In one of the earliest designs tube was actually a duo-diode—two diodes within a single envelope. In another approach, de Forest tried to influence current flow by wrapping wires around the outside of the envelope.

Eventually the design shown in Fig. 8 took shape. That tube was actually a diode/triode, since the device was used to both rectify and amplify. Rectification was done by using the grid and the filament as a diode.

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## EARLY RADIO

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### The end of spark

Another important milestone in the de-elopment of radio was the developmen generator capable of producing high-frequency, continuous-wave carrier That is, a carrier that could be modulate by sound.

Early radio transmitters were of th spark type. They could produce only damped wave, which is very broadban and electrically noisy. Because of thos characteristics, spark was suitable onl for wireless telegraphy.

In 1889, Elihu Thomson of Gener Electric produced a high-frequency dyna mo. Later, Nikola Tesla also produce such a dynamo. However, both had a ma imum frequency of only about 5,000 c cles.

By 1903, Charles Steinmetz had built 10,000-cycle alternator. In 1904, R ginald A. Fessenden conceived the idea an alternator that would be capable reaching a frequency of 100,000 cycle Assigned to the project by General Ele tric, Ernst F. W. Alexanderson attempt to build such a device. He was eventual successful, although only after repeat failures.

The first transmission of a human voi took place on Christmas Eve, 1906. Th continuous-wave carrier was generated b an alternator with an operating frequen of 50,000 Hz and a power of 1 kW. Th m phone was a water-cooled unit. Th historic event was not accompanied b much publicity, and 14 years would elap before the beginning of scheduled rad broadcasting in the U.S. in 1920.

### Tuned circuits

Spark did have one advantage: r ceivers did not need any type of tunir mechanism. For continuous-wave signa to be useful, some means of tuning wou be required. Sir William Crookes' articl "Some Possibilities of Electricity" pu lished in the *Fortnightly Review* in 189 called attention to the need for tuned ci cuits. He wrote, "What remains to b discovered is a means of generating wav of any desired wavelength, and receive which will respond to wavelengths b tween certain defined limits and be sile to all others."

That idea was put into action by S Oliver Lodge, who started experimentin with tuned receivers and transmitters 1897. He called his method "syntonize tuning achieved through the use of capac tors." With the development of contin ous-wave transmitters, and tuned r ceivers that could receive their signal the first stage of the electronics revolutio was complete.

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