

RADIO MAGIC

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Magic, Myth and Marconi: Part 1

"I do not think that the wireless waves I have discovered will have any practical application."—Heinrich Hertz

The 'Magic' Begins

In 1865 James Clerk Maxwell, in his magnum opus "A Dynamical Theory of the Electromagnetic Field", mathematically interrelated the electric and magnetic laws of Ampere, Gauss and Faraday and proved that the thought to be two separate electric and magnetic forces were components of one unified and universal electromagnetic (EM) force; that *changing* electric and magnetic fields generate self-propagating EM radiation (as transverse waves) travelling at light speed through the "luminiferous ether" (in a vacuum), and that light, itself, was an EM wave. But his theory was way too complex and too abstract to understand or even believe by most of his peers so it was largely ignored and almost forgotten. That is, until 1884, when Oliver Heaviside simplified Maxwell's convoluted 20 equations with 20 variables(!) by reworking the theory in terms of electric and magnetic forces and magnetic flux resulting in the famous four equations with four variables still used today and probably for all time. Then he humbly refused to have them renamed in his honour or even have his name hyphenated alongside Maxwell's—forever forfeiting immortality. As a result of his extreme altruism, Heaviside is often called "the forgotten genius of the Victorian Age".

In the late 1880's, Heinrich Hertz was the first person to experimentally prove the existence of Maxwell's theoretical EM waves, just beating out Oliver Lodge who decided to take a short vacation beforehand, and got scooped! In his laboratory, Hertz designed a series of ingenious experiments to test the theory using a high voltage "spark gap" (damped wave) transmitter attached to two equal length horizontal "wings" with end plates (a capacitance loaded "Hertzian dipole"), and he used a simple open-ended metal loop as the detector/receiver (see Figure 1).

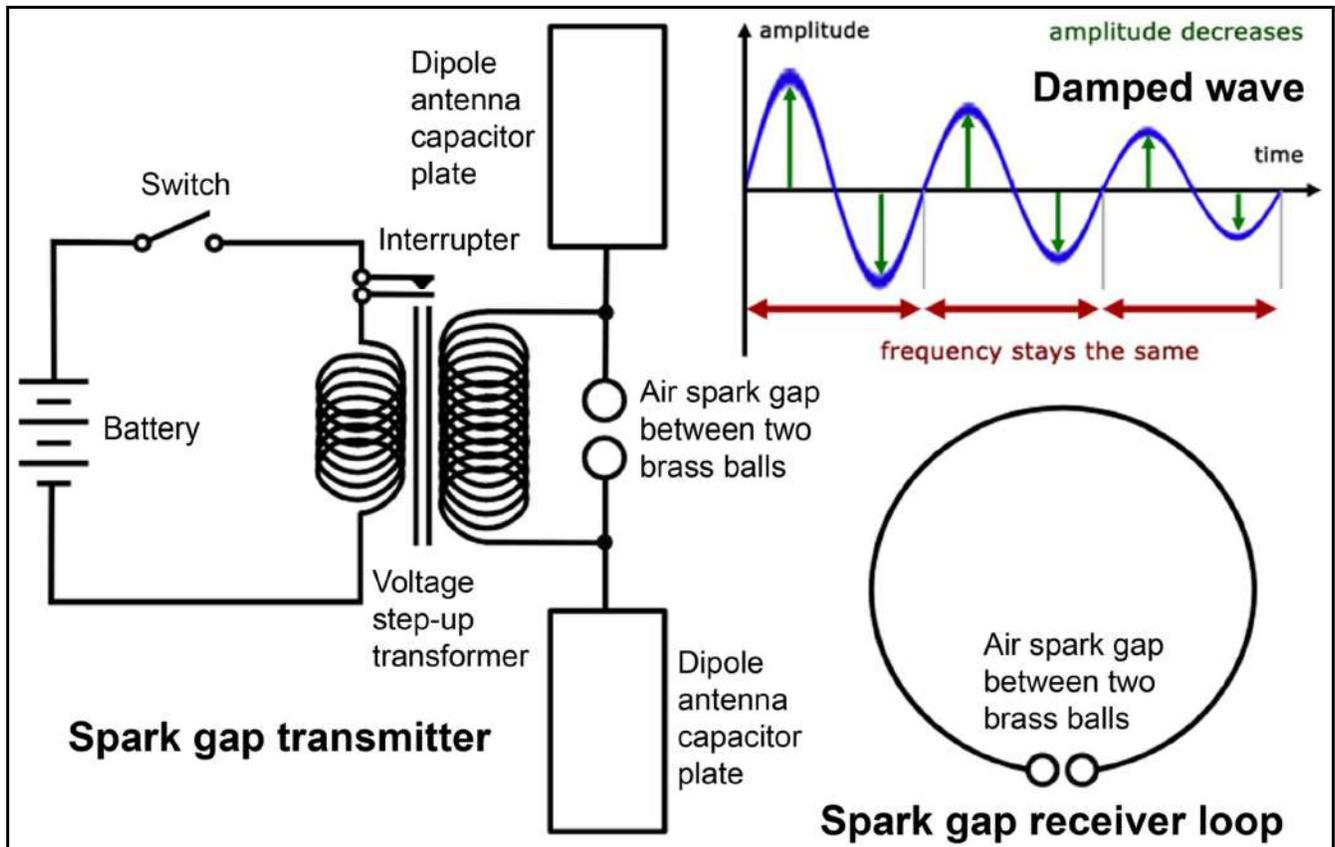


Figure 1: Hertz's Wireless Equipment (1886)

A high voltage spark across an air gap releases a damped radio frequency (RF) wave instantly creating a duplicate spark in a nearby open loop. Credit: Wikipedia and A-Level Physics Tutor.

He generated very short wavelength EM radiation from about four metres (m) to centimetre (cm) then studied their various properties: reflection, refraction, diffraction, interference, polarity, velocity, etc. Hertz also noticed that EM radiation could magically penetrate non-reflective inorganic (a wooden door) and organic (his lab assistant) objects, which would later lead to "electric photography" ("X-rays").

The experiments and their results were published in his own magnum opus “Electric Waves”, yet for some inexplicable reason Hertz disparagingly said of his great work: “It’s of no use whatsoever. This is just an experiment that proves Maestro Maxwell was right.” (He had what Victorians called “melancholy”). Hertz died at only 36, never living to know what he had wrought upon the world because 15 years later the 1909 Nobel Prize for physics was jointly awarded to Guglielmo Marconi and Karl Ferdinand Braun “in recognition of their contributions to the development of wireless telegraphy”. Here’re some of Braun’s contributions for those readers who don’t recognize his name: the cathode ray tube (CRT) and CRT oscilloscope; a transmitter-to-antenna syntonistic (tuned/resonant) coupling circuit; the phased-antenna directional array; the galena crystal “cat’s whisker” detector. But, I digress...

The Wireless Whiz Kid

Guglielmo Marconi was born in 1874 to a wealthy Anglo-Italian aristocratic family, and in his teenage years he was home schooled. His first tutor taught him about physical phenomena and the latest electrical theories, and with his and his mother’s encouragement (see Figure 2), he built a well-equipped attic laboratory to pursue his “amore elettrico”. His next door neighbour, physicist Augusto Righi, taught him about the works of Hertz and Lodge (“Modern Views of Electricity” including “Hertzian Waves”, 1889), and let Guglielmo audit his university lectures on the topic. This possibly planted the seed question in his fertile young mind: “If you can transmit Hertzian waves across a room then why can’t you transmit them across an ocean?”



Figure 2: Marconi Family Portrait

Family photograph of a very young Guglielmo (left) with his dotting mother Annie Jameson Marconi (of the politically powerful and wealthy Jameson Irish whiskey clan) and older brother Alfonso. Credit: “My Father, Marconi” by Degna Marconi, 1962.

But at the time it was widely believed that short wavelength Hertzian or “ether waves” were limited to short range use because they travelled out in straight parallel rays (lines) and were rapidly attenuated by atmospheric and the inverse square law as they travelled outwards to the horizon (like light wave did). Transmitting them across an ocean was just as impossible as flying to the moon was because it would require a mystical, magical “sky mirror” to reflect waves over the earth’s curvature to the other side, and something like that only existed in science fiction and not in the real world—foolish young man!

Instead of just shrugging his shoulders and accepting the scientific status quo, Guglielmo did something way beyond his years—he took the inside experiments of Hertz out to the open Italian countryside of his family’s large estate and conducted wireless experiments with the help of his older brother Alfonso. He used a variant of Hertz’s spark gap transmitter and initially the Hertzian dipole or “aerial” (the British term), but then he decided to hang wires from tall wooden poles fed from the bottom using an earth/ground system connected to the transmitter, and discovered that vertical wireless waves could travel farther. Perhaps they were somehow “anchored” and “glided” along the ground more easily than horizontal waves did? And so was born the Marconi vertical “antenna”, a term Guglielmo coined from the Italian *l'antenna centrale* to describe the center “big top” circus tent pole with support wires to hold it in place. As a result, he increased spark gap Morse code distances to nearly 2.5 kilometres (km), which was about three times farther than any academic had done. Now I don’t know what you were doing when you were 19 or 20 years old, but I certainly wasn’t making history out in my backyard!

Near the tail-end of the 19th century, a supremely confident twenty-two year old Guglielmo Marconi, oblivious to the impossibility of the task before him (the ignorance of youth at its arrogant best), single-handedly sparked the wireless revolution that still reverberates to this day—or did he really? The devil is in the details because his mother’s nephew, Henry Jameson Davis was an already well-established engineer who happened to know the distinguished British scientist William H. Preece, who happened to be the chief electrician (electrical engineer) of the British Postal Service (BPS), which happened to control all British landline and cable telecommunications systems and licensing thereof (telephone and telegraphy).

In February 1896, Annie took “William” (his first name anglicized for easier pronunciation and to sound less foreign) to England having arranged for Henry to introduce her son to Preece, who was also experimenting with wireless at the time. Both Henry and Preece were very impressed with what the whiz kid had been able to do, and I can just imagine the astonished side-glances the two bearded middle-aged *professional* engineers must have exchanged with each other as Marconi casually sent spark gap Morse code through the ether to a distant detector they couldn’t even see with the naked eye! William also met Professor Oliver Lodge, who proudly showed off his “coherer” wireless wave detector (an enhanced version of Édouard Branly’s original design), which he used for wireless experiments and *al fresco* demonstrations for his physics students. Marconi immediately realized that it was the last piece of the puzzle he needed (Guglielmo was using the less sensitive Branly version), and secretly tinkered with Lodge’s design to further maximize its sensitivity and reliability (see Figure 3).



Figure 3: The Coherer

Modern replica of Marconi’s optimized coherer that can actually “catch lightning in a bottle”. A piezoelectric (BBO) lighter can be used as a spark gap “transmitter” along with an ohmmeter for simple experiments. In 2008, it was finally discovered how it actually worked its magic: “Electrical conductivity in granular media and Branly’s coherer: A simple experiment” by Eric Falcon and Bernard Castaing.

He really didn’t understand the complex maths and physics involved (and never would), but like his idol Thomas Edison, Marconi kept on “finding the 10,000 ways that won’t work” until he found the one(s) that did. With the funding and support of the BPS, which gave him a huge advantage over everyone else, he kept tinkering on and he kept on dazzling engineers and wealthy potential investors alike by incrementally increasing spark gap Morse code messaging to unheard of distances—thanks to the enhanced coherer and vertical antenna combination.

The Travelling Sideshow

In December 1896, Preece and his young protégé began a series of travelling public lectures throughout the British Isles called “Signalling through Space without Wires”. ‘Marconi’s “magic” box’, as the press dubbed it, would mystify and awe everyone—everywhere—as he carried it high above his head and walked among the audiences while the prestigious Preece, who did most of the talking, tapped out spark gap Morse code (see Figures 4 and 5, next page). Without any connecting wires, a small battery operated electric bell inside the box would signal in sync with short or long rings—as if by magic! “Any sufficiently advanced technology is indistinguishable from magic.”—Clarke’s Third Law.



Figure 4: Marconi’s Wireless Equipment (1896)

Left is a portable spark gap transmitter; right is the magic box with the hidden inside coherer detector with signal bell receiver with Hertzian dipoles; a Morse code tape register (printer) is sitting on top of the receiver. Credit: “Signalling through Space without Wires” by W. H. Preece; Scientific American supplement No. 1124, June 17, 1897.

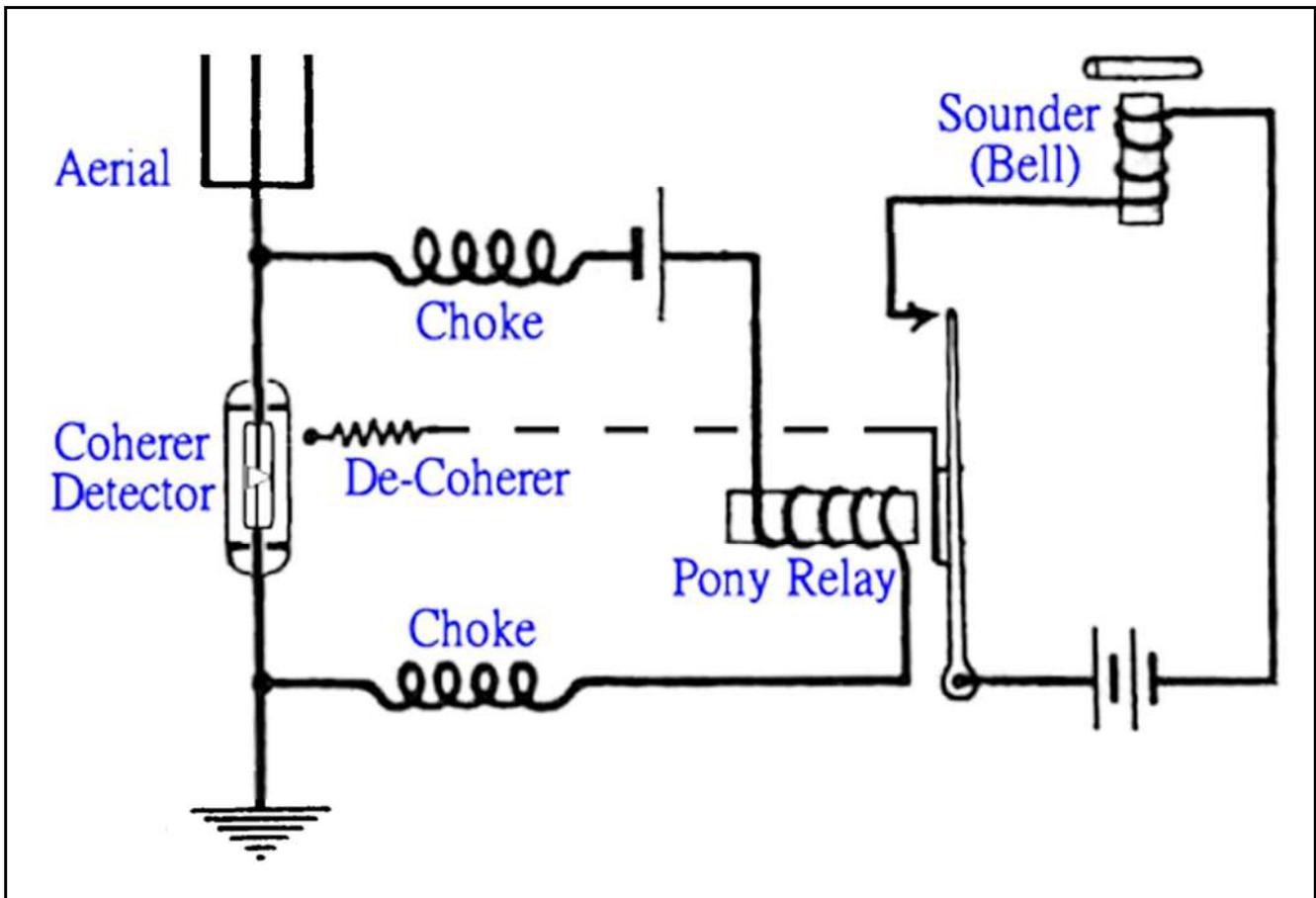


Figure 5: Coherer Detector/Receiver (Schematic)

RF energy caused a coherer's metal filings to bond or cohere (Branly effect, 1890) conducting current (its resistance went low), activating a relay that rang a bell or triggered a Morse code register. A connected rod tapped it to "decohere" or reset it, cutting off current (its resistance went high). The coherer had poor weak signal sensitivity, broadband selectivity, slow turn-around time limiting Morse code receiving speed, plus it couldn't detect voice transmissions. By 1907 it had been replaced by superior detectors. Credit: Elements of Radiotelegraphy, 1919.

Quoting portions of Preece's concluding promotional pitch:

"The distance to which signals have been sent is remarkable. On Salisbury Plain Mr. Marconi covered a distance of four miles. In the Bristol Channel this has been extended to over eight miles, and we have by no means reached the limit. It is interesting to read the surmises of others. Half a mile was the wildest dream... There are a great many practical points connected with this system that require to be thrashed out in a practical manner before it can be placed on the market, but enough has been done to prove its value and show that for shipping and lighthouse purposes it will be a great and valuable acquisition."

Of course it was all carefully staged managed and designed to spark the public's investment interest—the “steampunk” equivalent of today's social media, and it worked because huge amounts of start-up capital was raised to form “The Wireless Telegraphy & Signal Company” in the summer of 1897, with Marconi as technical director in partnership with his much older (by 20 years) first cousin as financial director.

The Critical Critic

When the press and others began to write glowingly about Marconi's amazing “new telegraphy” and “Marconi waves” the not-so-very-amused Lodge wrote a polite but definitely backhanded letter to the editor of the London Times newspaper to set the record straight for posterity, and because he also realized Marconi had “stolen his thunder”—literally.

“Sir,

It appears that many persons suppose that the method of signalling across space by means of Hertzian waves received by a Branly tube of filings is a new discovery made by Signor Marconi, who has recently been engaged in improving some of the details. It is well known to physicists, and perhaps the public may be willing to share the information, that I myself showed what was essentially the same plan of signalling in 1894. My apparatus acted very vigorously across the college quadrangle, a distance of 60 yards, and I estimated that there would be some response up to a limit of half a mile. Some of the hearers of Mr. Preece's recent lecture at the Royal Institution seem to have understood his references to these previous trials to signify that I had asserted or prophesied that more powerful apparatus would always be limited to some such distance: whereas my statement was a scientific one, concerning the small and early apparatus which, with the help of my assistant, Mr. E. E. Robinson, I had at the time devised and constructed.

My apparatus was substantially the same as that now used by Signor Marconi—there was a row of sparking spheres; the sparks were taken under oil sometimes, as suggested by M. Sarasin; there were iron and brass filings in a high vacuum and likewise in hydrogen: there was also my own coherer with a single contact, which is more sensitive, but less manageable than a filings tube; and the restoration to sensitiveness was effected by an electrically-worked hammer. Signor Marconi uses nickel and silver filings in a lower vacuum, and by employing greater power he has obtained signals over much greater distances; moreover, instructed primarily by Professor Righi, and aided in his trials by the British Post Office, he was worked hard to develop the method into a commercial success. ”

“For all this full credit is due—I do not suppose that Signor Marconi himself claims any more—but much of the language indulged in during the past few months by writers of popular articles on the subject about ‘Marconi waves’, ‘important discoveries’ and ‘brilliant novelties’ has been more than usually absurd. The only ‘important discovery’ about the matter was made in 1888 by Hertz; and on that is based the emitter of the waves; the receiver depends on cohesion under electrical influence, which was noticed long ago by Lord Raleigh and has been re-observed in other forms by other experimenters, including the writer in 1890.

Yours faithfully,

OLIVER LODGE

University College, Liverpool, June 17, 1897.”

But the “keep a stiff upper lip” Lodge was a bit too polite and a bit too academic while “Signor Marconi” was putting on his spectacular razzle-dazzle magic light show for the public, now totally mesmerized by and enamoured with the young wireless “wizard”. And we all know who always wins in a battle royal of “plain-Jane” facts and truths versus glitz and glamour.

My Final

Part 2 looks at the events leading up to a cold and blustery December day in 1901 on Signal Hill, St. John’s, Newfoundland, when the Old and New Worlds were first connected together by a wireless signal; when a young man’s rendezvous with destiny went “viral” and took on mythic proportions. And once a myth is written into the fabric of society it can’t be unwritten whether it’s true or not.—73

Addendum 30 September 2021

I just watched History Channel's "The Machines that Built America, S:1, Ep:7 Tesla vs. Marconi". Last year, I researched and wrote a three-part article about their epic wireless "battle". I knew that Marconi stole from others without credit or paying royalties, but what I didn't know and discovered from the TV show was that Sir William Peerce, head of the British Postal Service, which controlled all forms of communications in the British Empire, had met with Tesla, who foolishly revealed the secrets of his "Tesla coil" and wireless test successes! But he saw no future in "etheric" wireless telegraphy, even though he had transmitted messages up to 50 km (Marconi was at 4 km). Tesla believed that the Earth, itself, was the best medium to use along with using it to transmit electrical power.

Shortly after, Marconi met with Peerce and showed him that a lot of money could be made using "etheric" wireless telegraphy between shore and ships at sea, but his limited transmitting range was the issue. He needed a more powerful transmitter so Peerce gave Marconi the information on the Tesla coil plus Tesla's lack of interest and alternate plans. The rest is history.