All Things Digital

Amateur Radio for the 21st Century

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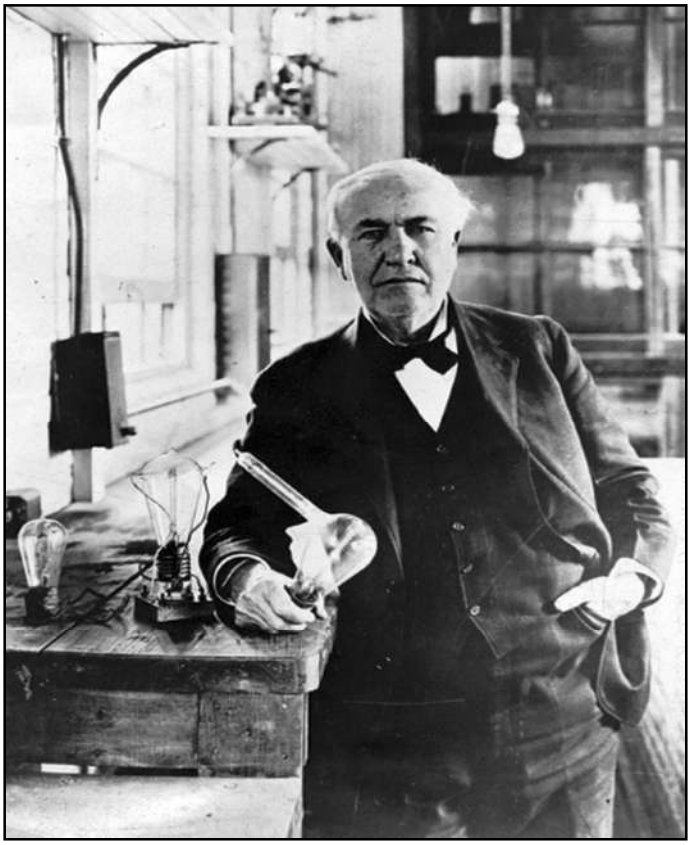
THE EFFECT OF EDISON "THE WIZARD OF MENLO PARK"—PART 1

This story tells the tale about how the invention of one seemingly unrelated device, combined with a chain of serendipitous events, plus a combination of inter-personal relationships created "six degrees of separation" from the electric light bulb to the smartphone.

Meet the Man

He's the greatest "blue-collar" inventor of all time with 1093 single and/or joint U.S. patents (400 in only 8 years!). Thomas Alva Edison (1847-1931) was home-schooled by his mother Nancy, but he had no formal academic education beyond grade school before he began working, in his early teens, as a railway telegrapher. He much preferred the "graveyard" shift because it gave him time for his two passions of reading and inventing things.



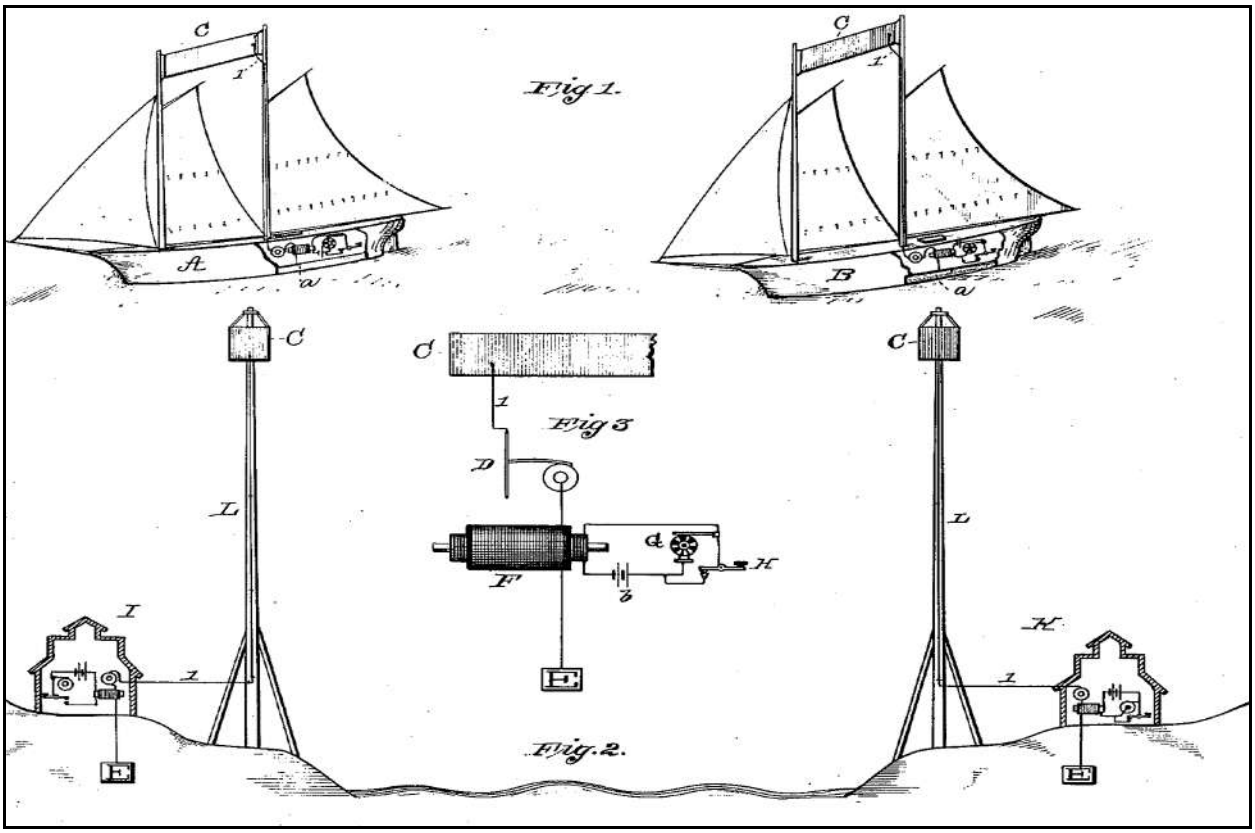
As a child, he developed early onset hearing loss (possible caused by scarlet fever), and it just progressively worsened as he aged, and eventually forced him to find other work that didn't require acute hearing. Fortunately, his early telegraph inventions had earned him enough seed-money to kick-start a new career as an inventor/entrepreneur. Years later, because of his humble background, his mother developing a mental illness before she died (he was 24), and his on-going hearing difficulties (three societal strikes against him), many of his "frenemies" credited his achievements to his more educated, and talented team of employees (including Nikola Tesla) who worked at his Menlo Park, New York, research and development laboratory called "the factory". This was and is the concept of "work for hire" whereby any and all "fruits" resulting from the labour of any employee belongs the boss (or company) and everyone involved signed on to this to work for him, so it was rather unfair criticism often made by jealous competitors because he wasn't one of "us"—the elite of society and academia.

While Edison didn't have a piece of parchment with an academic standing of some kind, he was born with that very rare combination of wide-ranging genius and business acumen. He was a natural "general" who knew how to lead his "troops" into "battle", and he won more times than he lost; his "battlefields" encompassed the electrical, electronic, communication, entertainment, chemical, and mining industries to name just a few. Edison achieved success by spending long and hard hours at work, eating and sleeping in his lab, while leaving his wife and children home alone for months on end. He defined his kind of genius as *"One percent inspiration and ninety-nine percent perspiration."* and added *"I haven't failed. I've just found 10,000 things that won't work!"* Edison always made carefully dated notes of his experiments (successes and failures), and he usually patented many of his "10,000 things that won't work"— just in case, which would later prove to be very fortuitous. When asked how or from where he got his ideas, he simply said *"I find out what the world needs. Then I go ahead and try to invent it."* As a result, he was wealthy and world-famous by his late 30's (think Steve Jobs and Steve Wozniak wrapped into one person).

But Edison often went far beyond “mere” invention; in many instances he also created or financed any required secondary supporting industry to go with the invention. For example: one phonograph cylinder endlessly playing a scratchy recording of him shouting “Mary had a little lamb…”was of no commercial value beyond being only a novelty because once the novelty quickly wears off, people will want a wide range of new and different recordings, so now you need sound recording studios, thousands of wax cylinders, a marketing and sales force, and the talent to produce product for this new medium created by side-effect of a an invention like the phonograph. Constant improvements must be made to it to keep one step ahead of the competition, and successful idea(s) will be illegally copied and sold so you need lawyers to defend patent rights in often lengthy low to high court battles over years, with many of them resulting in expensive Pyrrhic victories. Marconi once wryly joked (or not) that he had spent far more money defending his wireless patents than he had ever made from them.

Because of his poor hearing, Edison made improvements to the early telephone giving it much clearer and louder audio, compared to Bell’s scratchy and tinny weak sounding version; then he went into direct competition with him (their companies later merged under the Bell name). Strangely, Bell wanted people to shout “Ahoy, ahoy!” when answering the phone, but Edison preferred a simple “Hello?”—so did the public. Edison also experimented with a new form of telegraphy without wires using the magnetic induction method. The “new telegraphy” or “wireless” was becoming all the rage among scientists around the world, except that most didn’t see any practical use for it outside of the laboratory (including Tesla) because wireless appeared to be limited to line-of-sight and would never replace landlines or underwater cables.

Edison managed to install and test his system on several passenger train lines, which allowed trains on the roll to inductively connect to and exchange two-way messages by using the existing wires strung on telegraph poles that ran parallel and close to railway tracks. The system showed its future potential during the "Great Blizzard of 1888" when stuck fast in snowdrift trains wirelessly called for help. However, most passengers saw no need for nor had the desire to send and/or receive wireless messages (it was also expensive). "What's the rush, can't it wait till the next train station?!" This was the classic case of a paradigm shift arriving well ahead of a society's ability to understand and to adapt to it. Edison had got it backwards this time; the world didn't want what he had invented—not yet. It would take another century before we wanted to be connected (24/7) to a wireless world and send/receive messages from trains, planes and automobiles. He still patented this "failure" but changed how he envisioned its future use. Here's the introduction of Edison's 1891 patent application: *"I have discovered that if sufficient elevation be obtained to overcome the curvature of the earth's surface and reduce to the minimum the earth's absorption, electric telegraphing or signalling between distant points can be carried on by induction without the use of wire connecting such distant points. This discovery is especially applicable to telegraphing across bodies of water thus avoiding the use of submarine cables, or for communicating between vessels at sea, or between vessels at sea and points on land, and distant points on land."*



Edison's 1891 ship-to-shore-to-ship wireless communications concept

Then he went on to explain how wireless telegraphy can assist vessels with navigation in poor weather or difficult sailing areas by signalling their presence and/or intentions to other vessels in the area thus preventing collisions. He also suggested the relaying of messages from land to ship, ship to ship and ship to shore spanning oceans, and perhaps even the world! His innovative concepts are all used today in the international maritime mobile service.

Let there be Light!

Contrary to popular belief, Edison did not outright invent the electric light bulb (or more properly called the incandescent electric lamp as it was called). He never actually made the claim, but he also didn't discourage the myth that he was its one and only true inventor. What he actually did do was improve upon existing designs and manufacture a commercially successful American version. At the time, there were at least 22 documented variations, including a viable commercial British version invented earlier by Joseph Swan.

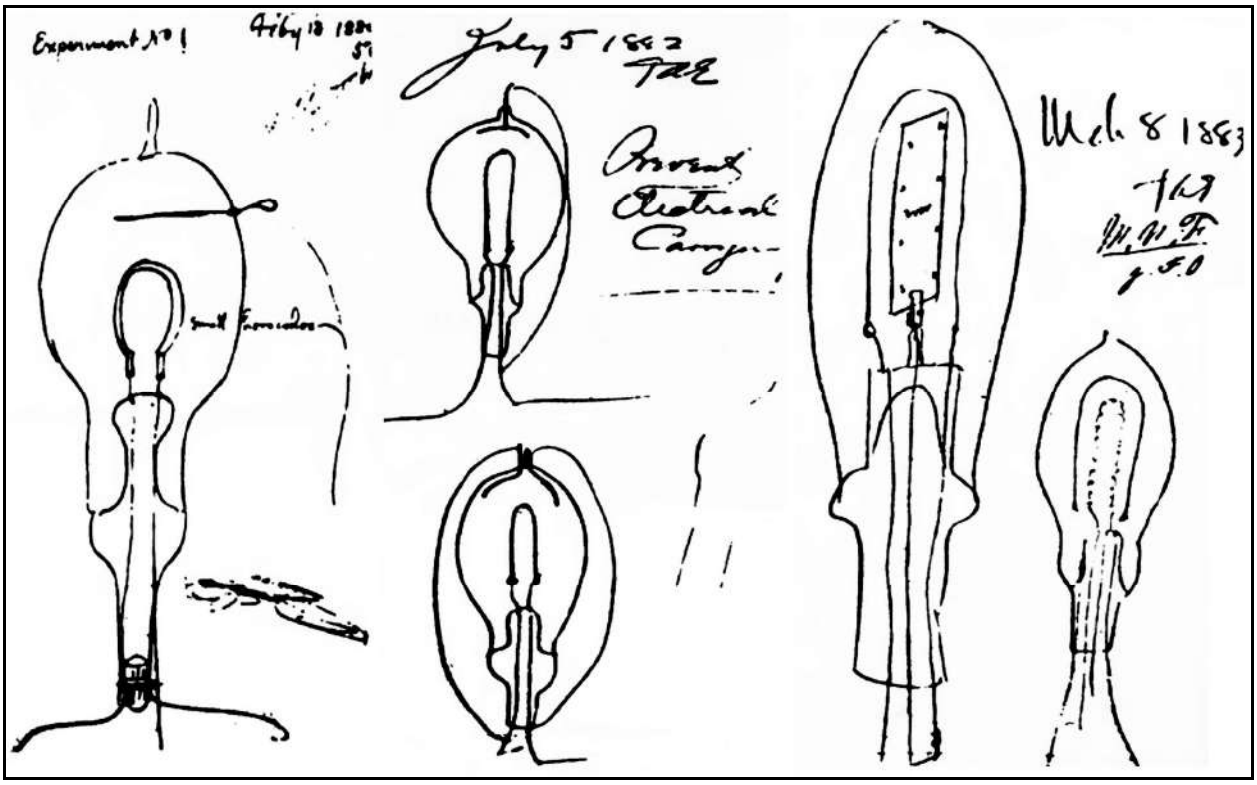
Edison was very much aware of Swan's work, and each was busily buying up other competing light bulb patents to narrow down the playing field. To be fair, Edison's much improved bulb burned for over 1200 hours while most others lasted less than 20 hours. But in 1883, the U.S. Patent Office ruled Edison's patent was based on the work of one William E. Sawyer, and it took six years of very expensive litigation to have the ruling overturned on a technicality. Then George Westinghouse (Westinghouse Electric) bought another inventor's electric light patent and then used it to go head-to-head against the Edison Electric company, forcing Edison to lower his prices as Westinghouse lowered his in turn. To avoid a concurrent court battle with Swan (who had filed suit for patent infringement), Edison swallowed his pride, settled out of court, and demonstrated how to turn a possible devastating defeat into a stunning victory by striking a deal to fund the formation of jointly owned Edison/Swan American/British electric light companies—called "Ediswan" by the media of the day. Then, in 1892, the "knife" went into Swan's back when a sudden corporate takeover merged the Ediswan patents and companies a new company called General Electric (GE). Swan was blindsided and forced out (Edison happened to be one of GE's four founders). But there's another fascinating story behind this story…

The Effect Discovered

Between 1879 and 1883, everyone involved in developing an incandescent electric lamp was trying to solve a major problem with direct current (DC) powered organic bulb filaments (carbonized bamboo) because they gave off soot and blackened the inside of bulbs reducing their light output (tungsten filaments eventually solved this problem). At the time, DC power distribution systems dominated, and Edison had invented his own very profitable system, which was doing very nicely until his former employee (Tesla) invented his way more commercially viable and practical alternating current (AC) power distribution system in partnership with Westinghouse. Edison had earlier rejected Tesla's AC concept, telling the younger genius (who worshipped the elder genius) that he was a fool to believe in such "nonsense". Tesla was deeply hurt by this rebuke, and quit on the spot, vowing vengeance.

This would become known as the “War of the Currents” (in the literal sense), and it wasn’t “just business”, it was very, very personal, and the “war” raged on for years, leading to the invention of the infamous electric chair (Edison provided funds to the inventor), and the equally famous but less lethal Tesla coil. To demonstrate just how dangerous AC was compared to DC, Edison had animals (stray dogs and cats, but in one extreme case an elephant!) shocked using both forms before large carnival-like crowds, with AC naturally killing the animals and DC “only” stunning them. But the superior Tesla/Westinghouse AC system eventually won out, and Edison’s DC system went down the drain taking with it millions of dollars. Ironically, Edison’s DC power consumption meter was adapted for AC use, and a wireless mesh network version of it is attached to most homes. But, I digress…

Back to the electric light bulb problem where a white “shadow” was also noticed inside bulbs as if the positive DC side of the filament had somehow blocked the soot particles emitted from the negative side. When evacuating air from bulbs to create a “soft” vacuum, Edison’s assistants passed DC current through the filaments to burn off any residual gases causing a bluish glow between the positive and negative leads of the filament. This was something Edison had noticed back in 1875, but he was too busy working on something called the “phonograph” so it slipped his mind until one of his electrical engineers (William J. Hammer) pointed it out again, in 1880. Edison was now free to work full time on the problem, and in initial tests he pasted a small piece of metal foil to the outside of his electric light bulbs, and connected it to a galvanometer (current meter) in series with the positive side of the filament’s DC power. When the light was turned on, the galvanometer indicated a current was flowing through the outside shunt circuit, but when connected to the negative DC power side no outside shunt current flowed.



Edison's notebook sketches of various incarnations of the experimental electric light bulbs to solve the "white shadow" mystery

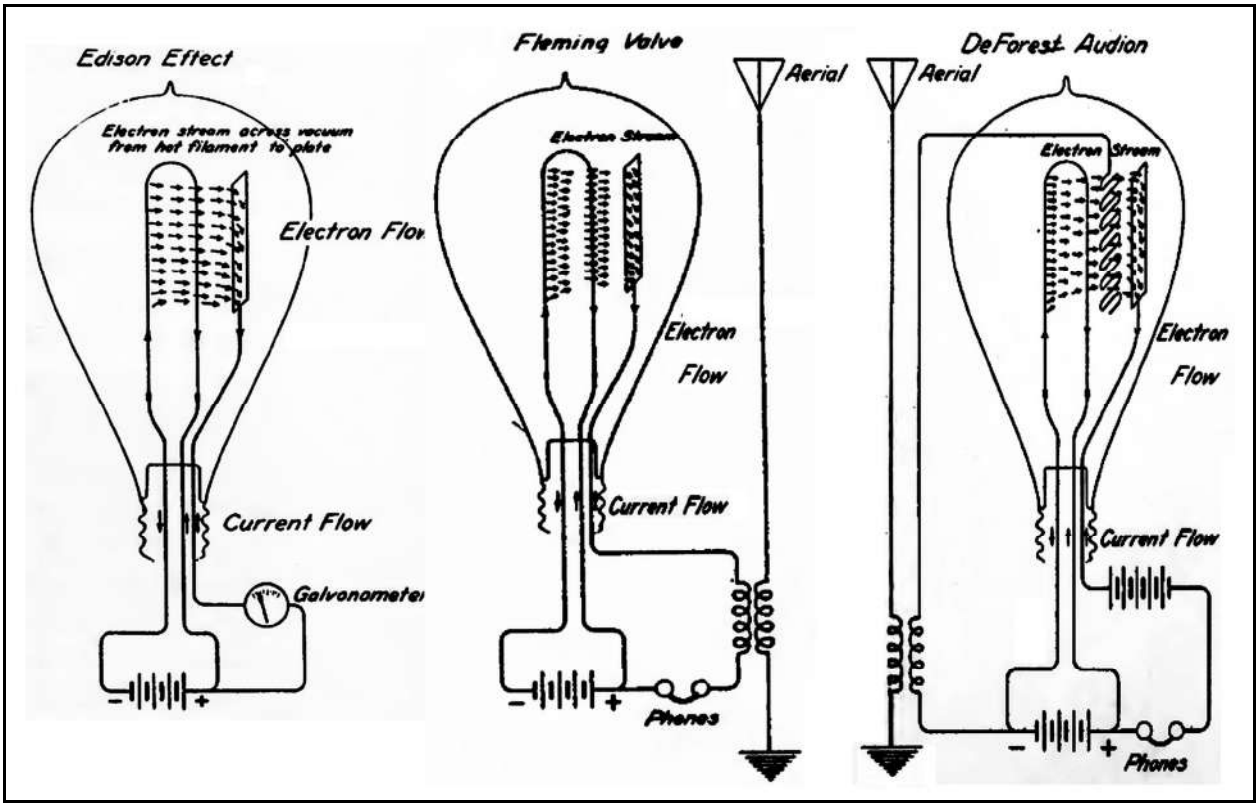
Over the next few years, he made more variations with electrically isolated metal wires then metal plates placed inside bulbs, and the same effects were observed, but the current flow was now stronger. In his 1883 patent application Edison wrote: *"I have discovered that if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent electric lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conductor or candlepower of the lamp."*

Edison's remarkable discovery totally baffled all physicists of the time because the atom was then the smallest known particle of matter, and an electric current simply couldn't travel/jump cross a vacuum because there was no conductive path for it. In 1884 Edison demonstrated two new patented devices at the Philadelphia Electrical Exhibition using modified light bulbs as voltage regulators for use with telegraph sounders, and as governors to control the output of DC dynamos (generators). He also showed off these new devices overseas to mystified scientists and engineers, including one John Ambrose Fleming who worked at the Edison/Swan British electric light company. After seeing a demonstration, the British electrical/civil engineer William Henry Preece named the effect in Edison's honour. Unfortunately, high quality "Edison effect" electric light bulbs with consistent characteristics couldn't be manufactured to the specifications required so his applications for it weren't commercially successful. Anyway, Karma had other plans because Marconi's mother was good family friends with Preece, and she had him introduce her son to Edison, and it was "bromance" at first sight (Edison sold his wireless patent to him). Marconi was very well-educated, extremely gifted and brilliant, but was no genius, and he admitted this publically saying that he was more an amateur engineer/inventor rather than a scientist, adding that he didn't understand Hertzian (radio wave) theory.

However, Marconi was a ruthless business man like Edison when he had to be, with the political connections and clout, and lots of his family's money at his disposal. His Irish "stage" mother Annie (a Jameson daughter of the famous, powerful, and wealthy whiskey clan). Edison must have seen much of himself in the younger man because he became Marconi's mentor, investor, and consulting engineer. Marconi would also go on to illegally use many of Tesla's patents in developing the first commercially viable and successful wireless telegraphy system. No one knows for certain if Edison urged him on to do so, but I'd wager that Tesla's very public and financial victory in the War of the Currents probably really stuck in Edison's craw.

The Birth of "Electronics"

Electronics is defined as the behaviour and movement of electrons in a vacuum, gas, semiconductor, or conductor.



Evolution of the Edison effect electric light bulb to the electronic vacuum tube

At the end of the 19th century, the first sub-atomic, negatively charged particle named "electron" was discovered (J. J. Thompson, 1897), and the Edison effect could now be explained in terms of electronic "thermionic emission". When an electric current is applied to a lamp filament, at a certain temperature it "incandesces" and electrons break free of the electromagnetic (EM) force binding them to atoms and off they go into the "ether". The "luminiferous" ether or "transcendental matter" was believed to encompass all free space in the universe not otherwise taken up by molecular matter. It was thought to be the medium through which all particles, and perhaps even gravity needed to travel in the form of "ether waves" from point A to point B.

In 1900, Marconi hired John Ambrose Fleming (remember him?) as a research scientist/engineer to plan the strategic locations of commercial wireless stations, develop high AC voltage power plants required for spark-gap (damped wave) transmitters (early spark-gap was mechanically generated). He also wanted Fleming to try and improve the reception of the "coherer" receiver in combination with the Morse code register he had added to his earlier design. The coherer the first "solid state" radio frequency (RF) detector used in lieu of the "liquid state" and highly toxic mercury detector. Fleming vividly remembered Edison's earlier demonstrations and he ordered a supply of Edison effect light bulbs from Menlo Park, thinking these, coupled with the coherer, could provide a better quality signal to drive the Morse register (probably thinking of Edison's telegraph sounder application). But because he was working with AC voltages, Fleming immediately discovered that Edison effect light bulbs converted or "rectified" low (audio) and high frequency (radio) AC into pulsating DC, and therefore it could directly detect wireless signals without the need for the coherer. However, the still existing manufacturing problems plagued production of reliable Edison effect light bulbs, and again prevented their viable commercial use (it would take another decade).

Marconi decided to move on and replaced the coherer and Morse register with the magnet detector or "Maggie", but Fleming was smart and sly enough to patent "his" invention calling it the "oscillation valve" by neglecting to mention any prior knowledge of Edison's work. Legally it was Marconi's "fruit" since it was a work for hire discovery, but Marconi would have never stabbed his mentor (Edison) in the back, but Fleming could on behalf of his former mentor (Joseph Swan). Edison was not amused by Fleming's subterfuge and he immediately sued, but the lower courts ruled against him because he had never stated that Edison effect light bulbs could detect Hertzian waves (!) therefore Fleming's valve was ruled to be a separate, new and unique invention because it could!! In 1906, Lee DeForest (after reading Fleming's paper on the oscillation valve) added a wire between the filament and plate and called it the "Audion" (later changed to a wire mesh or "grid" and renamed "triode").

A small changing grid voltage controlled electrons flowing between the high voltage positive plate (“anode”) and filament (“cathode”). Because of this subtle addition, RF detection and amplification, plus audio amplification became possible in one tube. This was “regeneration”, discovered and patented by young engineering genius Edwin H. Armstrong, but DeForest sued and won a long, drawn out legal battle (it adversely affected the burgeoning electronics industry) in another inane court ruling. The triode ended mechanical spark-gap generation with the creation of the electronic RF “oscillator” by introducing the world too a new form of Morse code transmission called “continuous wave” (CW). Even so the early triodes became highly unstable when “pushed” too hard, often going up in flames and burning down more than one wireless station, and “tune for smoke” [only] became a very common wireless operator expression. By the end of the First World War, many of the earlier problems with them were resolved, plus many of the electronic circuits we still use were created. By the late 1920’s, commercial “amplitude modulation” (AM) radio “broad casting” (meaning to no one in particular), combined with the sales of millions of simple and easy to use by anyone receivers (the superheterodyne invented by Armstrong), plus the record player (phonograph) sparked a world-wide sensation. Broadcast radio became the “internet” of its day and forever changed the world.

Postscript

In 1943, the U.S. Supreme Court ruled in favour of Edison’s (died 1931) estate and invalidated Fleming’s oscillation valve patent because of “an improper disclaimer” [he lied] “and that the technology in the patent was known art when filed” [he stole]. Fleming was still very much alive but probably not very much amused. In 1944, the U.S. Supreme Court invalidated many of Marconi’s (died 1937) later wireless patents in favour of Tesla’s (died 1943) estate. The court noted that while it didn’t dispute Marconi’s many notable accomplishments, it ruled the affected patents were “questionable” in nature. Years earlier, Edison was at least “honest” enough to admit, and without apology that *“Everyone steals in commerce and industry. I have stolen a lot myself, but at least I know how to steal!”*

My Final

And there you have it. A simple electric light bulb burning brightly in the laboratory of the wonderful “Wizard” (possible inspiration for L. Frank Baum’s character in Oz?) started a cascading chain reaction of ripples in the ether (the “butterfly effect”). It turned the world upside down with its mysterious one-way valve-like behaviour (the “Edison effect”). It was the first electronic “diode”, and the diode is the basic building block of all things electronic including your smartphone. More in part 2.