

On the History of Telecommunication: Patents, Disputes and Rivalries that Shaped the Modern Telecommunication Industry

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ABSTRACT

From the smoke signals of Africa to the futuristic thought based mode of communication, the present research surveys an era covering hundreds of years of development that assisted mankind to overcome barriers of long distance communication. The research is conducted through the eyes of patents highlighting landmark inventions that shaped the modern telecommunication industry. Clearly, the later day inventors stood on the shoulders of their predecessors to develop their innovations. Patent laws that denied Samuel Morse a patent for his telegraph in the European market and the benevolence of Nikola Tesla to allow Guglielmo Marconi to use his radio patents thus costing Tesla to die in abject poverty are only some of the findings of the current research.

Keywords: History, Patents, Telecommunication

TÉLÉCOMMUNICATION

‘Europe and America are united by telegraphic communication. Glory to God in the highest, on earth peace and goodwill towards the men’ was the first telegraphic message connecting both the continents (Chapuis, 2001). Like such, there are a number of historical milestones highlighted in the present article. From the marathon run by Pheidippides to the present day text messaging services, different modes of communication have evolved to satisfy differing human needs. Communication primarily includes three elements, thought, mode to transmit thought and mode to receive thought. Coined by a novelist, Edouard Estaunié, in his 1904 book titled ‘Traité Pratique de Télécommunication Electrique (Télégraphie, Téléphonie), Estaunié further went on to define ‘télécommunication’ as ‘...remote transmission of thought through electricity’.

Create a system, or be enslaved by another man’s- William Blake

Fig. 1. Semaphore Telegraphy. (Wikipedia, 2014)



Torches, flags, smoke and heliographic devices were only some of the pre-telegraphic methods implemented for centuries. In the 18th century, the brothers, Claude and Ignace Chappe developed an optical telegraph to convey character based information (Victor, 2005a). The ‘Semaphore’ (illustrated in Figure F-1) was a wooden

structure mounted on top of buildings, church steeples and on hills which made them visible over great distances. Each wooden structure consisted of an arm arrangement whose positions were manipulated with ropes and pulleys to display different configurations. Robert Hooke, the English physicist made significant contributions in refining the semaphore telegraph by introducing a character based system. One important contribution from Claude was the introduction of a five bit binary code. Inspired by the works of the Chappe brothers, Abraham N. Clewberg - Edelcrantz set off to build his own optical telegraph (Victor, 2005b). Calling it a shutter telegraph, it was initially based on the semaphore telegraph but later Edelcrantz decided to move away to a matrix design with three rows and three columns of shutters with a tenth shutter built on top. The opening and closing of the shutters visually transmitted a code which on the receiving end was decoded into a message. The shutter telegraph found large military applications including setting up the first international network connection between Sweden and Denmark in 1801.

From the 1600 treatise by William Gilbert 'De Magnete' (Gilbert and Mottelay, 1958) to Benjamin Franklin's famous kite flying experiment in 1752, the discovery of electricity passed through the hands of a number of scientists (Joy, 1878). In a 1753 letter signed by 'C.M' to the editor of the Scot's Magazine includes the first ever mention of applying electric current to a telegraph. With the identity of 'C.M' shrouded in mystery this letter is often hailed as the most important document in the history of telegraphy (Sabine, 1867). The first ever electric telegraph working on static electricity was thus constructed by a nearly blind physicist, George Louis Le Sage in 1774. A Leyden jar invented in 1745 by Petrus van Musschenbroek at the University of Leiden, was a first of a kind receptacle to store static electricity. In 1678, Jan Swammerdam had demonstrated to the Grand Duke of Tuscany the contraction of frog legs in an electrical convulsion when brought in contact with silver or copper (Hegel, 1970) thus concluding on the presence of animal electricity. Questioning the claim of the presence of animal electricity (Verkhatsky *et al.*, 2006), Alessandro Volta conducted his own research to uncover the secrets of storing electricity. This effort led to building a voltaic pile for storing galvanic current. Eventually the voltaic cell took the form of a battery. Static electricity was a well-known phenomenon and efforts had been taken in the past to develop a messaging system using static electricity. A telegraph based on static electricity was built by Francisco Salvá y Campillo in 1795 (Yuste, 2008). Following Volta's invention of the voltaic pile, William

Nicholson and Anthony Carlisle discovered electrolysis of water. The discovery played a major role in constructing an electrochemical telegraph.

In 1809, Samuel Thomas von Sömmerring, a German anatomist built the first electrochemical telegraph. Sömmerring's telegraph worked with contact points inserted into individual glass tubes signifying alphabetic characters and numbers. The contact points produced bubbles when the sender connected his end of the wire with electric current derived from the voltaic pile. This also marked the first demonstration of moving electricity over wires (Rudolph, 2014).

Hans Christian Ørsted's results in electromagnetism greatly influenced the work of Andre Marie Ampere. Ampere's vision of the telegraph consisted of individual setups of circuits circulating electric current with a deflecting magnetic needle placed within the magnetic field for every alphabet and number. In 1820, Johann Schweigger and Johann Poggendorf invented a galvanometer working on Ampere's discovered principles. Utilizing the multiplier principle, Schweigger later modified Sömmerring's telegraph. Building on Ampere's discovery, William Sturgeon, an electrical engineer from Whittington, United Kingdom (UK), successfully built the first working electromagnet. On March 12th, 1832, Michael Faraday, who had made significant contributions in the field of electromagnetism had submitted a sealed envelope containing a letter to the Secretary of the Royal Society which was left unopened for more than a century until 1937. The letter contained early ideas on wave propagation (Garratt, 1994). In 1832, Pavel Schilling invented the five needle telegraph (Burns, 1988).

THE BEST WAY TO PREDICT THE FUTURE IS TO INVENT IT. – ALAN KAY

In 1833, Carl Friedrich Gauss along with Wilhelm Weber invented an electromagnetic telegraph (Rodriguez *et al.*, 2010). The world's first telegraph line constructed between Gauss's workplace in an astronomical laboratory and Weber's laboratory consisted of an emitter- receiver system. The system further consisted of a coil wound around a magnetic needle at the receiver end and connected to a battery via a switch at the emitter end. The Gauss-Weber code consisted of '+' and '-' rather than '0' and '1'. A signal pulse consisted of movement of the magnetic needle to either side of a horizontal structure. The telegraph had reached a stage of being a single wire system. In 1844, Samuel Morse introduced a code system, a version different from the Morse code

we see today. The earlier version consisted of wavy lines traced by pendulums. Carl August von Steinheil had developed a telegraphic writing mode in the form of dots and dashes. Morse code was largely inspired from his work. On receiving sufficient funding from the House of Representatives, Morse built the first telegraphic line between Washington and Baltimore and transmitted the Bible quote 'What had God wrought?' on May 24th, 1844. Morse wanted to sell the invention to the United States government, but the Postmaster General rubbished the invention as a mere mesmerism. An English inventor William F. Cooke had an opportunity to witness Schilling's telegraphy apparatus. Cooke lacked scientific knowledge but was recommended to seek the help from a Charles Wheatstone who was already engaged in the development of his own telegraph (Bowers, 2001) and subsequently formed an alliance.

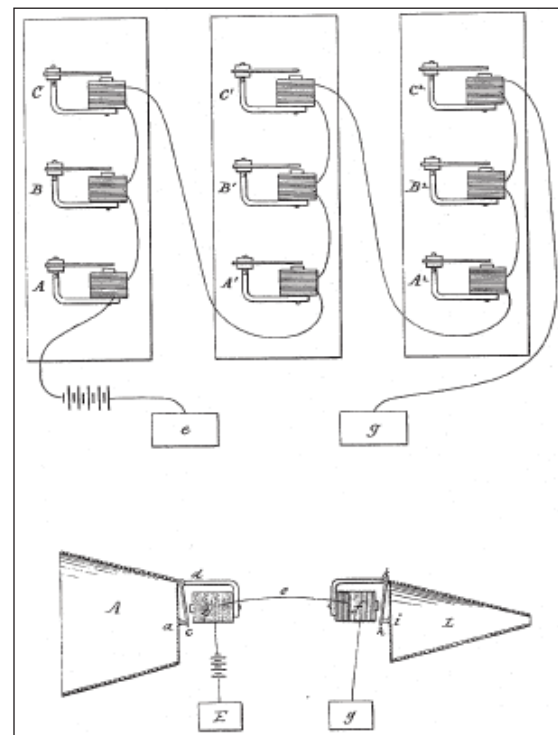
A Japanese politician Takahashi Korekiyo was sent to United States to study the patent system in the country, more particularly to find out 'What is it that makes the United States such a great nation? And we investigated and it was patents and we will have patents'. Patenting fees in the European countries were exorbitant and only a few wealthy innovators with influential backgrounds could afford to file one. Patent and novelty searching was almost nonexistent at the time and most often the patent document came with a statement 'The government, in granting a patent without prior examination, does not in any manner guarantee either the priority, merit or success of an invention'. It wouldn't be until 1844 that reforms in patent systems would set in France, in 1852 in Britain and 1877 in Germany (Khan, 2006). Though the British patent system was trying to emulate the US style patenting and examination system, one subtle difference was that a patentee in USA was able to obtain a patent on an idea previously published, while the British patent system disallowed such an action (Bowers, 2001). Morse, in his trip to England in 1838 wanted to obtain a British patent on the single needle telegraph, but met with opposition from Cooke and Wheatstone since the idea had been published prior its application for a patent in the British patent system. Morse rejected a proposal from Cooke and Wheatstone to collaborate. The collaboration between Cooke and Wheatstone too didn't last long with a bitter priority dispute ending their partnership in 1846.

CONNECTIVITY IS MORE IMPORTANT THAN CONTENT (ODLYZKO, 2001)

The telegraph caught the world's attention with the announcement of the birth of Queen Victoria's son

Prince Albert and catching the murderer John Tawell. A new challenge was to establish a telegraphic connection with cables laid under the sea. This required the need for insulating the cables especially when being laid across the ocean floor. In 1847, Werner von Siemens constructed the first gutta-percha press to insulate the copper wires. The first marine telegraph cable was laid between London and Paris in 1851. Following the success of a UK-France telegraph line, an Englishman Frederick Gisbourne proposed to construct a telegraph line across the Atlantic (Read, 2001). Designed to cover a distance of 3800 km between Valentia in Ireland and Heart's content near Newfoundland, after a series of early failures the final installation was completed in 1866. The transmissions carried a lot of distortion. Wheatstone's nephew, Oliver Heaviside suggested attenuating the inductance of the cable, a suggestion which was sidelined for decades until 1904 when AT&T implemented it.

Fig. 2. Drawings from 'Improvement in Telegraphy'. (Bell, 1876)



At this time a young dentist named Mahlon Loomis was experimenting with kites carrying metallic wires to explore possibilities of wireless communication. His efforts finally paid off when on July 30, 1872, he was awarded the patent (US129,971). With the success of the trans-Atlantic telegraph services, the British Empire established telegraphic communication with its colonies. For efficient and economical transmission of messages

over the telegraph there arose a need to replace the Morse code. Baudot code, named after a French inventor Émile Baudot used a five bit binary system (Britannica, 2013).

WHAT USE COULD THIS COMPANY MAKE OF AN ELECTRICAL TOY?

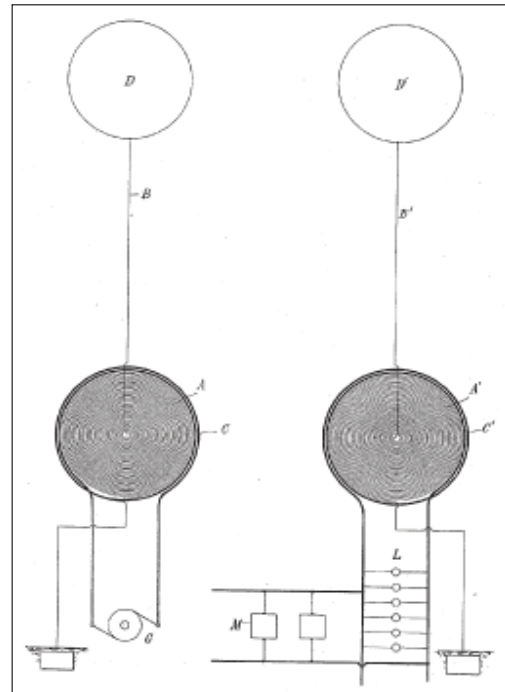
The telegraph offered a restriction on the number of messages that could be transmitted at a single time. In 1874, Baudot introduced a multiplex telegraph capable of sending multiple messages using a single cable. During the same year Edison too introduced a quadruplex telegraph capable of simultaneously sending and receiving four messages. Alexander Graham Bell filed the patent specification for world's first telephone on February 14, 1876 (patent drawings illustrated in Figure F-2). The specification was filed without a working model, allowed under the US patent laws. The filing took place just a couple of hours before Elisha Gray filed his caveat for a telephone which used a water transmitter. Surprisingly, Bell wanted to sell the main telephone patent to Western Union for a paltry sum of \$100,000, but the sale was rejected. Though the rudimentary designs allowed only sounds to flow rather than voices, it would take the efforts of Francis Blake Jr. to invent a transmitter which would significantly reduce the noise in the transmission lines and improve voice clarity. The original telephone transmitter included a parchment membrane which caused voice degradation. In 1877, Edison introduced a carbon transmitter which included compressed carbon inserted between metal plates subsequently improving sound transfer quality.

A major boost to wireless communication came in 1887 when Heinrich Hertz proved the existence of electromagnetic waves. Nathan B. Stubblefield, a resident of Murray, Kentucky claimed to have demonstrated wireless communication in 1892 long before the world would hear the name of Guglielmo Marconi (Hoffer, 1971). Another inventor was Alexander Popov who on March 24th, 1896 demonstrated a wireless apparatus by transmitting the words 'Heinrich Hertz' (Zolotinkina, 2008). Popov was awarded patents for his apparatus in Russia (No. 6066), France (No. 296,354) and England (No. 2797). In 1904, Siemens and Halske adopted the wireless technology set forth by Popov.

Nikola Tesla was too trying out experiments in the field of wireless technologies. In 1893 he presented a series of lectures at the National Electric Light Association on his inventions and later in 1898 was awarded a patent (US613,809) for inventing a radio control for maneuvering

moving objects. The telegraphy improvements made by Guglielmo Maconi were largely influenced by the works of Tesla to an extent that the United States Patent and Trademark Office (USPTO) passed the judgment stating

Fig. 3. Drawings from 'Apparatus for Transmission of Electrical Energy'. (Tesla, 1900)



Most of the claims cannot be patented because of Tesla's patent number 645,576 and 649,621 (patent drawings illustrated in Figure F-3). The endeavors to bypass these references, along with Marconi's allegedly unawareness of the Tesla's oscillator are almost absurd. The term Tesla's oscillator is a common expression all over the world since his lecture on the alternating high frequency electric current in front of the American Institute of Electrical Engineers in 1891.

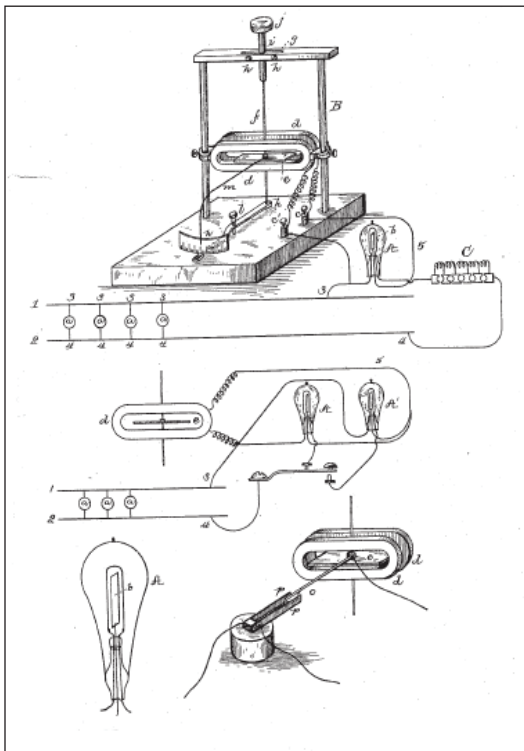
But Tesla was in public praise of Marconi and allowed him to use his patents (Kuzle *et al.*, 2008). In 1904, USPTO had ruled the priority in favor of Marconi. Following Marconi's growing influence Tesla filed a suit against him in 1915.

The years following 1916 saw a sharp decline in the number of patent applications filed by Tesla. In his final days, Tesla was living on a pension given by the government of Yugoslavia. On the other hand Marconi filed a law suit against the US army for patent violation. The US Supreme Court, having realized the damages that it would have to pay Marconi, reversed its decision and

awarded Tesla his prized patent stating ‘Tesla’s patent number 645,576 precedes all other radio patents’. On July 18, 1892, a patent was filed (US500630) by Elihu Thomson. The disclosure highlighted a method for producing high frequency oscillations. Like Tesla, who had started his career working for Edison, another from Edison’s staff, Reginald Fessenden, was also interested in developing wireless communication (Kimmel, 2009). The problem Fessenden wanted to solve was to create a continuous series of statics which were required to get a series of signals to transmit a note (Belrose, 2002). One way it could be achieved was with a rotating cylinder, for which he opted to use Edison’s phonograph cylinder. On December 23, 1900, Fessenden sent the world’s first wireless message. By 1904, Fessenden was able to establish radiotelephony for a distance of 40 m, but Christmas day 1904 saw Fessenden offer the United Fruit Company’s ships at sea fitted with crude transmitter receiver systems as special gift, the tune of Handel’s ‘Largo’ and ‘Oh Holy Night’. This marked the first radio broadcast.

Usually, the innovator is an entrepreneur, not an inventor (Lochte, 2000)

Fig. 4. Drawings from ‘Electric Telegraphy’. (Lodge, 1898)

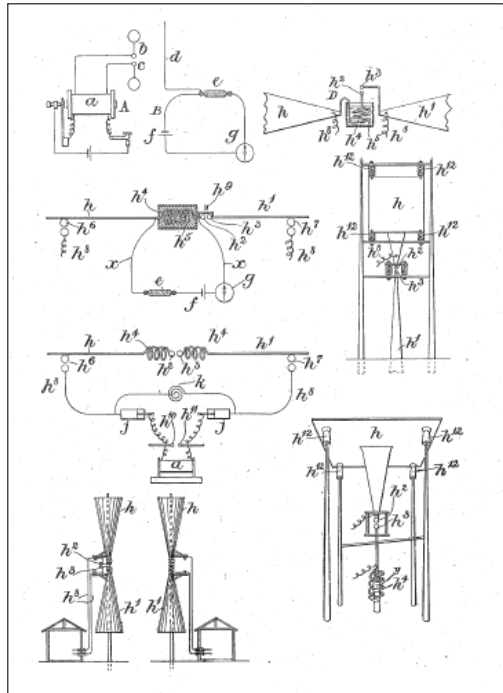


Research in wireless communication was still in the rudimentary stage when James Clerk Maxwell’s treatise on electromagnetism provided the vital ingredient proving

the existence of electromagnetic radiation. In the autumn of 1879, David Edward Hughes, a professor of music at the St. Joseph’s College at Bardstown, Kentucky was experimenting on a telephone when a loose contact generated a strange effect which was later recognized to be electromagnetic oscillations. The effect was rubbished by the scientific society as mere inductance and Hughes abolished his research without recording any of his findings. Hughes had accidentally invented a device that could transmit and receive radio signals but the invention was not recognized until years later. The invention of the coherer, a device to detect radio signals, is largely attributed to Temistocle Onesti and Edouard Branly with further refinements provided by Oliver Lodge. The early coherer worked on the principle of metal filings placed in a gap between two conducting points conduct electricity in the presence of radio signals. The refinement provided by Lodge included a ‘tikker’ which periodically randomized the filings. Lodge along with Alexander Muirhead developed a Lodge-Muirhead syndicate. The system was first licensed by the Indian government to establish communication between Andaman and Burma. Realizing the problem of interference faced when transmitting multiple radio signals, Lodge had invented a tuning device called ‘syntony’ and was granted the patent (US609,154) (patent drawing illustrated in Figure F-4). On April 26, 1900, Marconi was granted his famous patent on ‘Improvements in Apparatus for Wireless Telegraphy’ (No. 7777). On December 12th, 1901, Marconi transmitted the wireless message (Morse signal ‘S’) across the Atlantic from Poldhu in Britain’s Cornwall to St. John’s Newfoundland in Canada. Marconi’s wireless telegraph was nothing more than a combination of ideas patented by his fellow inventors including Lodge’s syntony. In a landmark ruling by the U.S. Supreme Court in 1943, most of Marconi’s patents were overturned (Brenner, 2009). In 1889, Marconi had invited John Ambrose Fleming to be a scientific adviser to the Marconi Company. Fleming had explored a phenomenon earlier identified as the ‘Edison effect’. The effect describes the flow of electrons from a heated surface which in the case of an incandescent lamp were the filaments to a cooler metal surface. The findings were recorded, studied and published by the British physicist Owen Richardson in 1903. Edison had actually filed a patent for an electrical indicator (US307,031) (patent drawings illustrated in Figure F-5) which makes it the first ‘patent in electronics’ but with no commercial value. By realizing the importance of the findings, Fleming in a letter to Marconi stated ‘found a method of rectifying electrical oscillations’ (Dylla and Corneliusen, 2005). Marconi’s system of wirelessly transmitting messages worked on the principle of sending a single signal at a time. This was due to a spark gap arrangement in the transmitter. Valdemar Poulsen, a Danish inventor invented the arc

generator (later termed as thermionic valves) in 1903 with the intention of wirelessly transmitting continuous notes (Jorgensen, 1999).

Fig. 5. Drawings from ‘Electrical Indicator’. (Edison, 1884)

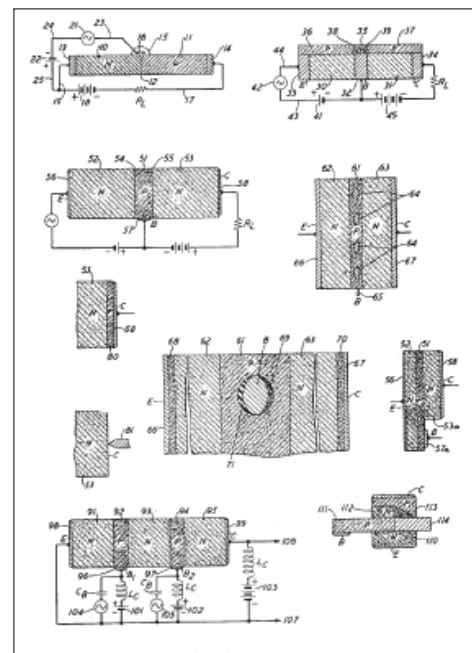


RADIO HAS NO FUTURE –LORD KELVIN

The invention was hailed as the beginning of the age of electronics. This was followed by the invention of the triode in 1906 by Lee DeForest (Chipman, 1965). Steve Maas states ‘DeForest’s most important contribution came from a misunderstanding of the operation of the Fleming valve’. The invention of the triode helped the telephone industry alleviate the problem of voice amplification. One of Fessenden’s important inventions was a heterodyne (US706740, US1050441 and US1050728). With this invention Fessenden attenuated the clicking noise. Heterodyning involved combining two frequencies to derive their sum and difference frequencies. Edwin H. Armstrong, the inventor who would revolutionize the radio industry is primarily remembered for his work on four inventions regeneration, super regeneration, the superheterodyne and the frequency modulator. A rather parsimonious attitude displayed by Armstrong’s father for funding one of his earliest patents cost Edwin to enter a 20 year lawsuit against DeForest over claiming priority of the invention of the regeneration circuits (Maas, 2013). Building on Lucien Levy’s invention of the superheterodyne (French patents 493660 and

506297) (GHN, 2013b) which Levy used for military encoding, Armstrong adopted it for commercial radios. For easy amplification, superheterodyning converted received signals into an intermediate frequency. This helped solve the tuning problem and reducing sensitivity to oscillator drift. But his most famous invention on Frequency Modulation (US1941069) would be subject to a number of lawsuits eventually forcing Armstrong to commit suicide in 1954. In 1920, Heinrich Barkhausen, a German physicist along with Karl Kurz had invented the Barkhausen-Kurz oscillator (GHN, 2013a). Also known as velocity-modulated vacuum tube, the oscillator produced continuous wave oscillations at ultra-high frequencies (greater than 10MHz). In 1921, Albert Hull developed a Magnetron, a vacuum tube oscillator generating electromagnetic signals in the microwave frequency range (greater than 30 kHz). In 1940, John Randall and Henry Boot invented the Cavity Magnetron. The Cavity Magnetron which is hailed as the ‘most important invention that came out of the Second World War’ was almost lost in the hands of a porter during its transfer to United States (Hind, 2007). It drastically reduced the size of the radar equipment by making centimeter band radar practical. It also helped in developing the microwave radar during the war. In 1931, Andre Clavier and Dr. George Southworth demonstrated the first microwave transmission across the English Channel. In 1937, Alec H. Reeves invented the pulse code modulation thus digitizing communication (Cattermole, 1995).

Fig. 6. Drawings from ‘Circuit Element Utilizing Semiconductive Material’. (Shockley, 1951)



Those were the years of the Great War. Radio communication had found its right applications especially with wirelessly guiding torpedoes. Radio frequencies were a very precious commodity and working on only a single frequency while guiding missiles and torpedoes, they were subject to tinkering from the enemy. It would take the genius of a Hollywood golden girl Hedy Lamarr and a musician George Antheil to invent the spread spectrum transmission (US2292387). Though meant for military application during the Second World War, it was never used but found wide commercial application with digitizing some of its key components (Couey, 1997). In England, the government had commissioned Robert Watson Watt, of the Radio Department of the National Physical Laboratory at Slough to research on 'radio death rays'. Though the effort did not yield any results, Watson Watt was able to demonstrate detection of airplanes using radio waves. Seeing the potential of the invention the government funded for further development of such radar devices across England and thus helping the allied powers to win the war.

I HAPPEN TO HAVE A FEW OF THEM HERE IN MY POCKET

At a conference for the Institute of Radio Engineers (IRE), Gordon Teal, at Texas Instruments announced the production of silicon based transistors (Riordan, 2004). The invention of the transistors is credited to William Shockley (US2569347) (patent drawing illustrated in Figure F-6), John Bardeen and Walter Brittain (US2524035). In a need to replace bulky vacuum tubes and replace germanium with silicon, the transistors evolved from Shockley's decade old research to mass production in the 50s and finally to market domination in the 60s. As early as 1945, research was conducted towards placing satellites in the geostationary orbit. The year 1957-1958 was marked as the International Geophysical Year and to commemorate this occasion, the Soviet Union launched the world's first artificial satellite Sputnik 1 on October 4, 1957. United States launched its own satellite Explorer 1 on January 31, 1958. On February 7, 1958, the Department of Defense, USA, Directive 5105.15 established the Advanced Research Project Agency (ARPA). The one objective of ARPA was to conduct research in automating the process of exchange of radar information (Lukasik, 2011). Subsequently, ARPAnet was established by its Information Processing Technique Office with the vision of connecting computers. In the 1980s, a National Science Foundation initiative to create a network of university computers led to the formation

of NSFnet. ARPAnet and NSFnet led to the formation of the modern internet. The ARPAnet introduced the concept of packet switching which allowed the breaking up of message into packets and result in full bandwidth utilization. Following the introduction of ARPAnet a series of protocols were developed for information sharing including Telnet in 1972, File Transfer Protocol (FTP) in 1973, Transmission Control Protocol (TCP) in 1974, Internet Protocol (IP) in 1981 and finally the TCP/IP protocol suite in 1983 (Microsoft, 2005).

Elias Snitzer invented a fiber laser in 1961 which used fibers to produce laser beams. This invention also marked the beginning of a decade long research in developing commercial optic fibers. During this period the glass fibers were suffering losses to the account of 1000 dB/km. It would be in 1966, that Charles K. Kao and George A. Hockham demonstrated optical transmission through a developed pure glass fiber (Gregersen, 2013). Manufacturing glass fibers from a highly pure compound of silicon tetrachloride, Kao achieved a loss rate below 20 dB/km (Dianov, 2011). The introduction of the concept of Wavelength Division Multiplexing in the 1970s compounded the bandwidth provided by the optical fibers (Davis and Murphy, 2011).

While the first mobile telephone call was made on June 17, 1946 (AT&T, 2014), it would be Martin Cooper, an employee of Motorola on April 3, 1973, to make the first cell phone call using a truly portable device. In 1994, Alon Cohen and Lior Haramaty at VocalTec communications developed the first Voice over IP (VoIP) application. This set a new milestone in telecommunications where users could transmit multimedia data including voice and video over the internet. With increasing use of internet over mobile devices, VoIP gained increased popularity in the last few years. Though it is hard to predict the next big step but we definitely seem to be heading towards thought based communication. A patent (US 8,350,804) filed by Edward Moll on April 9th, 1997, explores the use of Magnetic Source Imaging (MSI) towards stimulating brain interaction with electronic devices. The discovery of electroencephalography (EEG) in 1929 by Hans Berger (Tudor *et al.*, 2005) and the developments in the field over the last century have hinted in the possibility of communicating with thoughts. Currently, experiments are being conducted in India and France allowing brain to brain communication covering distances of thousands of miles (Prigg, 2014). But to profit from their inventions, scientists need to acquire the necessary skills of being innovators rather than just inventors.

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