The Underwater Communication System of Nikola Tesla

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Historical Problems

Tesla described his wireless transmission method by three important characteristics:

- It did not use electromagnetic radiation.
- It operated through the earth or water.
- The mechanism of transmission is an electric current - not radiation.

Modern analysts, both those who believe Tesla had discovered something new and those who believe he was mistaken in his observations, see Tesla's transmission method the same as present day broadcast radio technology. The broadcast model assumes that there is an antenna propagating electromagnetic waves omnidirectionally into the air. The Tesla supporters propose many ingenious, but implausible, schemes that would account for Tesla's claims for his wireless system. The Tesla opponents simply point out that according to electromagnetic theory, Tesla's ideas are impossible. Both groups are incorrect in thinking that his wireless method is the same as the broadcast technology used today.

Anachronistic interpretation - applying the assumptions of today's electrical theories to Tesla's original turn of the century researches - is only half the problem of understanding the inventor's wireless method. The situation is further complicated by the similar sounding descriptions Tesla gave to his earlier and later transmission techniques.

In his early work, Tesla attempted electronic transmission by electrifying the atmosphere. This is the case in his patent entitled *Method of Intensifying and Utilizing Effects Transmitted Through Natural Media,* #685,953, applied for in June 1899. In this patent, he proposes a very powerful transmitter to ionize atmospheric gases and, by that, create a conductive path between the transmitter and receiver through which a current could be sent. Later, when Tesla disclosed his through-the-earth, and through water[1], transmission with essentially the same type of apparatus and operating at ELF frequencies, modern authorities have assumed that Tesla was mistaken about his method of propagation and was really witnessing earth-ionosphere cavity resonance at Schuman frequencies.[2] More recent scholarship, however, has shown that that Tesla was aware of the differences between conventional wireless transmission methods and the technology he was developing.[3]

Tesla was more than an engineer of conventional methods. He was an electrical researcher who investigated fundamental issues of the science. It will be shown that the three characteristics of Tesla's wireless transmission system describe an electrostatic wireless method that used the earth as a conductor and transmitted displacement currents. At moderate energy levels, the system could be used for communication. At greater levels, power could be sent by wireless.

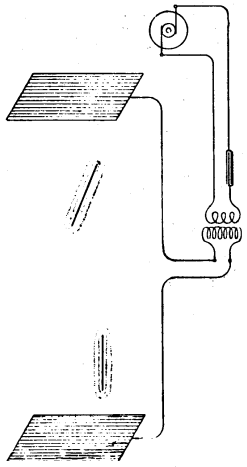
Non-Hertzian Transmission

During-1899 - 1900, Tesla set up a laboratory in Colorado Springs to investigate wireless signal transmission. It was during this period he discovered that a properly configured receiver could detect waves, initiated by lightning strikes, propagating through the earth. Many details about the apparatus for generating and receiving electrical signals (such as tuned resonant circuits that were recognized in 1943 by the Supreme Court as the basis of commercial radio designs) are given in his writings, but he never directly reveals the physics behind the mode of propagation. Tesla does point toward his novel transmission technique when he notes that his transmission method is "the diametrical opposite of a transmitting circuit typical of telegraphy by Hertzian or electromagnetic radiations."[4] This claim alone indicates a technology different from the transmission technology of today.

One of his early lectures on evacuated tube illumination provides a good example of physical effects he was using. Tesla describes a setup for illuminating bulbs. It consists of two plates on either side of the bulbs. The plates are connected to a transformer driven by an oscillator. The two plates are similar to a capacitor and the electrical activity between them is like the electrostatic field between two capacitor plates.

As he described it, an evacuated bulb was place between the electrodes:

> ... when we excite luminosity in exhausted tubes..., *the effect is due to the rapidly alternating electrostatic potential*; ... the medium is harmonically strained and released.[5]



He also noted:

> It might be thought that electrostatic effects are unsuited for such action at a distance. ... It is true that electrostatic effects diminish nearly with the cube of distance from the coil, whereas electromagnetic inductive effects diminish simply with distance. But when we establish an electrostatic field of force, the condition is very different, for then, instead of the differential effect of both the terminals,
> we get their conjoint effect.[6]

To make sure that the difference between the type of fields he intended and those of Hertz was understood he explained:

> As the term electrostatic might imply a steady electric condition, it should be remarked, that in these experiments the force is not constant, but varies...
> When two conducting bodies are insulated and electrified, we say that an electrostatic force is acting between them.[7]

Tesla's emphasis on the non-Hertzian nature of his signaling process, particularly when taken within the context of his work with electrostatics, indicates the mode of propagation involves similar electrostatic effects between a transmitter and receiver. As he often insisted, this mode of transmission differs significantly from that of Hertzian waves in that this one is a form of conduction:

> So far, I have considered principally effects produced by a varying electrostatic force in an insulating medium, such as air. When such a force is acting upon a conducting body of measurable dimensions, it causes within the same, or on its surface, *displacements of the electricity, and gives rise to electric currents*[8]

Also:

> Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practicable to disturb by means of powerful machines *the electrostatic condition of the earth* and thus transmit intelligible signals and perhaps power.[9]

Tesla believed that the earth was not just a sink into which electrical energy can be poured, but that it is a reservoir of charge. The capacity of the earth is determined by the standard formula for the capacitance of an isolated sphere of radius R:

$$C = 4\pi\varepsilon_0 R$$

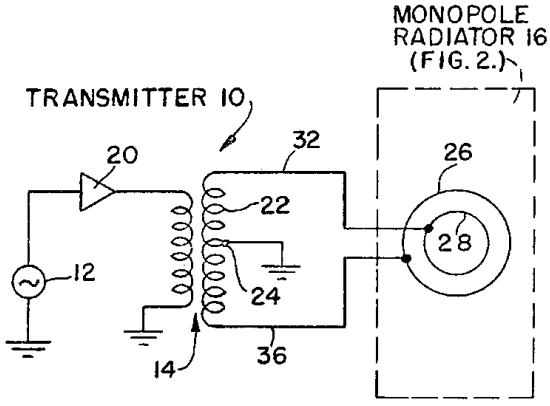
For the earth, this works out to 708 microfarads.[10]

Tesla's idea was that his high power transmitter he could cause the earth's charge to oscillate and that these oscillations could be detected anywhere on the globe. He further noted that these oscillations were changes in pressure, "the energy will be economically transmitted and very little power consumed so long as no work was done in the receivers.[11]

To differentiate Tesla's wireless method from contemporary understanding of the technique, and from the misunderstandings arising from the chronology of Tesla's research into the nature of electrical communication, his method can be contrasted with modern patents for electrostatic submarine communication and the inventor's earlier work in this field.

Contemporary Patents

L. Gilstrap's patent for an *Electrostatic Communication System*, #3,964,051, issued June 15, 1976, describes a device consisting of two concentric conducting spheres (#26 & #28) separated by a dielectric layer to form a monopole radiator for electrostatic waves.

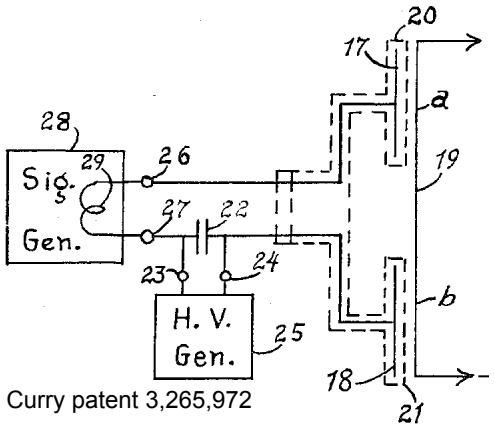


Gilstrap patent 3,964,051

The patent states that "longitudinal electrostatic or capacitive waves, also called scalar or polarization waves because of their relationship to the Maxwell wave equations" are the means of propagation but the patent does not explain how these waves differ from conventional forms of electromagnetic radiation. It simply states that as the spheres are subject to voltages of opposite polarity the "outer sphere then appears as an ideal monopole radiator to the external dielectric medium, in this case water."[12]

In this configuration, electric field is confined to the region between the two conducting spheres of the transmitter. Little energy, if any, is available to stress the external dielectric medium, the water.

P. Curry's patent for an *Underwater Electric Field Communication System*, #3,265,972, issued August 9, 1966 proposes a radiator of a different configuration and presents a detailed discussion of communication by electrostatic induction.



Curry patent 3,265,972

Curry states:

> The antenna system for an electromagnetic emission into space circulates energy in accordance with the laws governing electrical current in motion. Since the field strength produced by

an antenna is proportional to the alternating currents circulating in it, its optimum structural relationships are directed to a reduction of the total antenna resistance, thus to increase the total current for a given power input to a radiator.[13]

He adds:

> Being a current-actuated device, such an [electromagnetic] antenna will not operate in any physical conducting medium such as water or earth.[14]
>
> While a radiator for electromagnetic emission produces its field strength by the effect of changing currents; the radiator for electrostatic emission of the type here to be described produces its field strength by the effect of changing potentials.[15]

Curry proposes "the electrical potentials of the signal to be transmitted to two equal metal plates (#17 & #18) each of which is hermetically sealed within insulating material (#20 & #21) … immersed in a conducting fluid such as sea water."[16] By applying a varying potential to the plates of the radiator, charge of opposite polarity accumulates on the two plates such that a charge gradient exists in the region between the radiators. The patent explains:

> ... a phase displacement of 90 degrees exists the wave of charge potentials induced by an alternating current signal upon the water ... and the resulting wave of charge displacements occurring in the water body between the segments.[17]

The method of propagation, then, is to periodically alternate electrical charges on the two plates that will launch sinusoidal carrier waves into the medium. When one plate is positive, the other will be negative; then the first will be negative and the second positive. This action, the patent states, will create the sinusoidal waves.

In a detailed analysis of forces involved in this type of transmission Curry shows that radiators with a capacitance of .0053 microfarads operating at 100 kHz with signal generator output of 200 volts coupled with a biasing potential of 1000 volts will produce a force from its charge displacement of 26,500 dynes.[18]

On the receiving side, Curry states that the charge gradient can be expected to attenuate substantially at even moderate distance from the point of transmission. As an example he notes that if a signal intensity of 10,600 dynes at the point of transmission is reduced one billion times the "standing wave of the signal energy will therefore be charged with a force differential of 1.06×10^{-5} dynes. Each dipole in his example has a capacitance of .0053 microfarads with a system capacitance of .00265 microfarads. The voltage developed in the receiving network is .02 volts. As noted "this is substantially above the minimum requirements of signal intensity for the detection of electrical signal energies."[19]

This detailed analysis, however, overlooks the important point that electrostatic waves do not propagate into the medium in the same way as electromagnetic waves. In an electromagnetic transmission system, charge is accelerated in an elevated conductor, an antenna, to launch waves omnidirectionally into the air. At a receiver, the electromagnetic waves induce a current in the antenna. The variations in the current are processed by the detection circuitry to replicate the transmitted information.

In electrostatics, it is not necessary for flux lines to detach from an antenna and close upon themselves to propagate a wave that is received at a distant point. The transmitter, in Tesla's plan, oscillates the earth's charge and the receiver is connected to that same charge reservoir. Signals are not launched, but exist as pressure variations in the earth's oscillating electric field. Because the field already exists at the point of transmission and at the point of reception, the propagation characteristics are different from electromagnetic waves.

In addition to the mode of propagation being different, what travels between the transmitter and receiver is different. In electromagnetic transmission waves are sent out that are picked up by the receiving antenna. These waves induce a current the antenna. In an electrostatic system a current passes directly between the transmitter and receiver.

This current is the same as that which exists in a capacitor, that is, it is a displacement current. In a standard inductor-capacitor-resistance circuit, when it is energized and oscillating, it is understood that the current that passes through the conductors is completed through the non-conductor of the capacitor's dielectric through a displacement current. As charge is changed on one plate of the capacitor, an opposite but equal change in charge is seen on the other plate of the capacitor. In Tesla's system the transmitter and receiver act as the capacitor plates and what passes between them is a displacement current.

Displacement current, today, is seen as something of a virtual current, something different from a "real" or conduction current that flows through a wire. Tesla, however, understood what is meant by an electrical current in the same sense as Maxwell - that "all charge is the residual effect of the polarization of the dielectric"[20] and that "the variations of electric displacement evidently constitute electric currents."[21] As a Maxwellian, Tesla was correct in describing his transmission system as one using true electric currents.

Tesla's wireless electrical energy transmission system differed in all three characteristics he claimed - it was not electromagnetic, it operated through the earth or water, and conveyed electrical energy by a current. Once Tesla's communication method is better understood as a new branch of electrical science that was started over 100 years ago, it will not only have an impact on terrestrial technology, but will have applications in the future for space communications.

NOTES

[1] Tesla states that his transmission system is an "apparatus for submarine signaling" in Tesla, Nikola, "The True Wireless," *Electrical Experimenter*, May 1919, pg. 30; in the same article he also states that "transmission thru sea-water is more efficient" with his wireless method, pg. 87.

[2] Wait, James R., "Propagation of ELF Electromagnetic Waves and Project Sanguine/Seafarer," *IEEE Journal of Oceanic Engineering*, vol. OE-2, no. 2, April 1977, pgs. 161-172.

[3] Tesla, Nikola, "Nikola Tesla on his Work with Alternating Currents and their Application to Wireless Telegraphy, Telephony and Transmission of Power, An Extended Interview," transcripts with legal counsel given in 1916, Leland I. Anderson, Editor; Sun Publishing, Denver, 1992, pgs. 132-133.

[4] Tesla, Nikola, "The Transmission of Electric Energy Without Wires," originally in *The Electrical World and Engineer,* March 5, 1904, reproduced in *Nikola Tesla: Lectures * Patents* Articles,* published by the Nikola Tesla Museum, Nolit, Beograd, (hereafter, *LPA*) 1956, A-156.

[5] Tesla, Nikola, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination" (1891), *LPA* , pg. L-42. Emphasis added.

[6] *LPA,* pg. L-43.

[7] Tesla, Nikola, "On Light and Other High Frequency Phenomena" (1893), *LPA,* pg. L-121.

[8] *LPA,* L-127, emphasis added.

[9] *LPA,* pg. L-138, emphasis added.

[10] See :"The Earth as a Condenser and Its Role in Wireless Telegraphy," *Scientific American Supplement, No. 1451*, October 24, 1903, pg. 23248.

[11] Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, February 1919, pg. 732.

[12] Gilstrap #3,964,051, Column 2, lines 34 - 48.

[13] Curry #3,265,972, Column 1, lines 21 - 28.

[14] Curry, Column 1, lines 29 - 31.

[15] Curry, Column 1, lines 44 - 48.

[16] Curry, Column 1, lines 49 -54.

[17] Curry, Column 4, lines 8 - 38.

[18] Curry, Columns 5 - 6.

[19] Curry, Column 7, lines 35 - 75 to column 8 line 2.

[20] Maxwell, James Clerk, *A Treatise on Electricity and Magnetism,* Volume One, Part I, Electrostatics, pg.167.

[21] Maxwell, pg. 65.