THE WIRELESS POWER TRANSMISSION SYSTEM OF NICOLA TESLA

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Historical Problems

Tesla described his wireless power transmission method by three characteristics: 1) the reduction or elimination of electromagnetic radiations, 2) that it operated through the earth, and 3) that the mechanism of transmission is an electric current - as contrasted with radiations. Modern analysts, on the other hand, model Tesla's transmission system on present day broadcast radio technology. This model assumes an antenna propagating electromagnetic waves into the air where these radiations either will not or will, depending on the presuppositions of the writer, bring about the effects claimed by the inventor.

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 modifying 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 signal generator 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 what he described as through-the-earth (or water) transmission with essentially the same type of apparatus and operating at ELF frequencies, it has been assumed by modern authorities that Tesla was mistaken about his method of propagation and was really witnessing earth-ionosphere cavity resonance at Schuman frequencies [1,2].

Tesla, though, 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 power 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. When he incorporated this discovery into a patent he differentiated the earlier technology dealing with "effects transmitted through natural media" from the new form of signaling that involved the transmission of energy. This is seen in his patent Art of Transmitting Electrical Energy Through the Natural Mediums, #787,412, applied for 11 months after the previous patent, in May 1900.

A great deal of detail about the apparatus for generating and receiving electrical signals (tuned resonant circuits that were recognized in 1943 by the Supreme Court as the basis of commercial radio designs) is given in **the patent** but it **assumes, or more likely, avoids revealing, the physics behind the mode of propagation**. Tesla does point toward his novel transmission technique when he notes in the patent that the "globe may ... behave ... as a conductor of limited size;"[3] and that low frequency oscillations keep the "radiation of energy into space in the form of hertzian or electromagnetic waves... very small."[4] These two claims, alone, indicate a technology different from today's.

The illustration (see **Figure 1** on the next page)for the patent is of a transmitter consisting of an elevated capacitance, a coil, a signal generator, and a single electrode in the earth. The receiver is pictured as having a mechanism to oscillate at the same period as the transmitter, a capacitor, a detector, and two earthed plates.

To understand Tesla's wireless transmission system it is necessary to look at his technical writings on the physics behind his engineering. One of his lectures on evacuated tube illumination provides a good example.

The published version of the talk illustrates a setup for illuminating the bulbs closely resembling the transmission configuration. (See **Figure 2**)

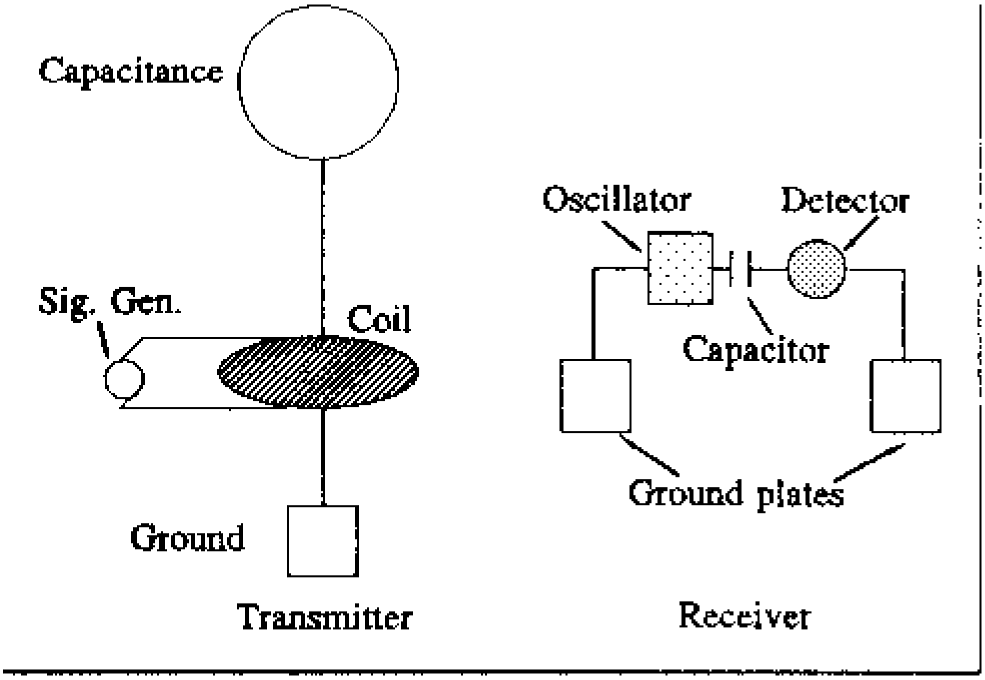


Figure 1 Tesla #787,412

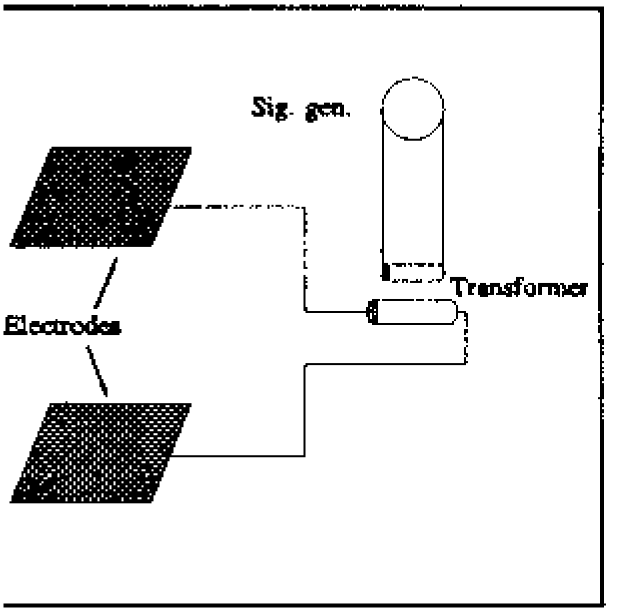


Figure 2 Illumination system

As he described it the evacuated bulbs were 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 electro- static 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 assumed by the patent involves setting up an electrostatic field of force between the 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]

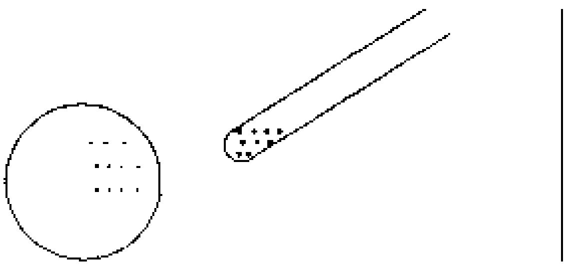
He advocated such a form of signaling long before submitting his design for patenting:

…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 practi- cable to disturb by means of powerful machines the electrostatic condition of the earth and thus transmit intelligible signals and perhaps power.[9]

The physics of Tesla's wireless transmission system is, in its basic form, is electrostatic induction. . (See **Figure 3**)

Instead of a charged body inducing an opposite charge on an uncharged body, as in the standard text book illustration, both the transmitter and receiver contain charge that establishes a field of force between the two. By oscillating these two bodies of bound charge at the same frequency, it is possible to signal between two points

Figure 3



In order 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 is 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 (see **Figure 4**), #3,964,051, issued June 15, 1976, describes a device

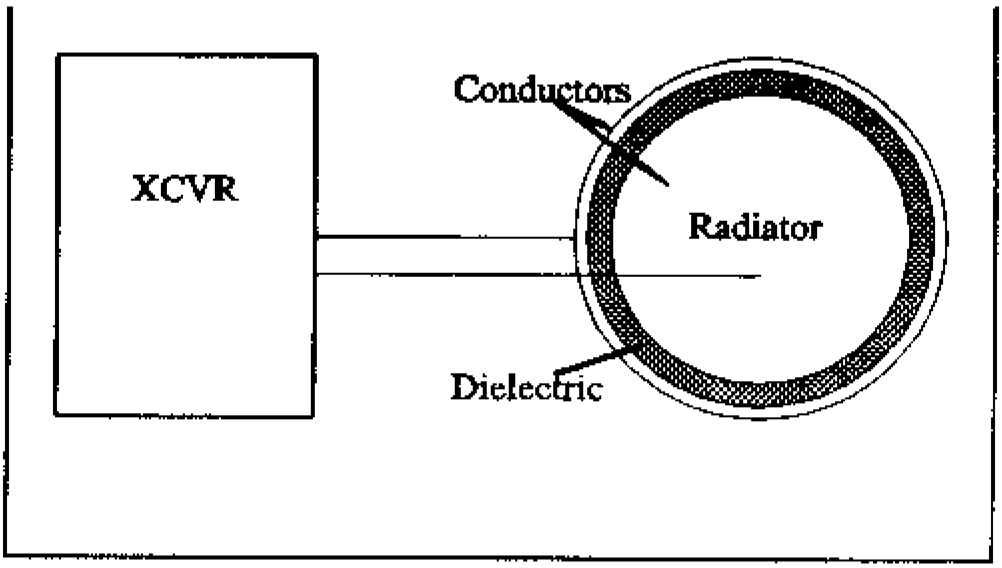


Figure 4 Gilstrap, #3,964,051

consisting of two concentric conducting spheres separated by a dielectric layer to form a monopole radiator for electrostatic waves.

The patent does not give details how "longitudinal electrostatic or capacitive waves, also called scalar or polarization waves because of their relationship to the Maxwell wave equations" differ in their method of propagation 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."[10]

That this design was not effective, according to a report, is due to the configuration of the radiator. The electric field is confined to the region between the two conducting spheres. 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 discusses communications by electrostatic induction. (See **Figure 5**)

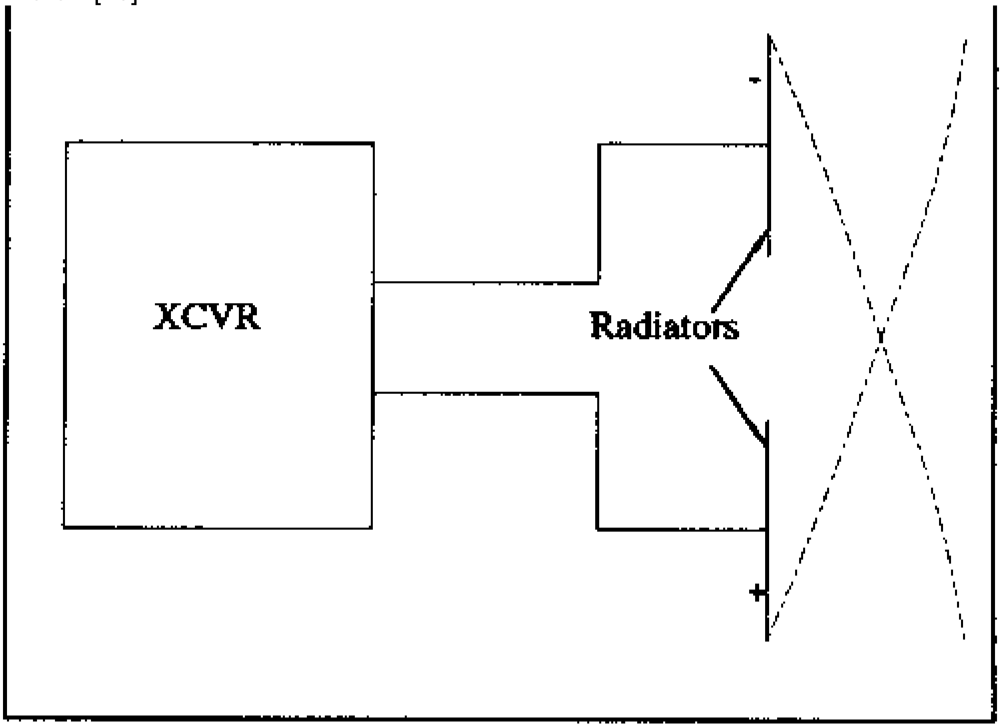


Figure 5 Curry #3,265,972

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.[11]

Further on he adds:

…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.[12]

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.[13]

The method of propagation, then, is to cause electrical changes in the two plates resulting in the launching into the medium of sinusoidal carrier waves - as illustrated by the dotted lines in **Figure 5**.

In a detailed analysis of forces involved 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.[14]

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 x 10-5 dynes. Each dipole having a capacitance of .0053 microfarads produces a system capacitance of .00265 microfarads. The voltage developed in the receiving network is given by

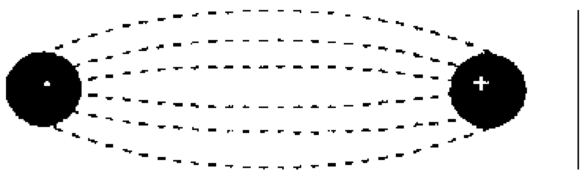
$$e = \text{square root } (F/(C \times 10^7)$$

which in this case equals .02 volts. As noted "this is substantially above the minimum requirements of signal intensity for the detection of electrical signal energies."[15]

With such a great amount of operational detail it would seem that this design should perform as claimed. The device, however, is not in widespread use 25 years after the issuing of the patent. This forces the conclusion that the device did not successfully propagate signals through the water. Why it would not will be made clear by examining the Tesla design for wireless communication. It will be shown that the dipole nature of the radiator and the inability to state the amount of attenuation over a given distance (it was simply given as a billion times weaker than the transmitted signal) point to a fundamental misunderstanding of the nature of electrostatic induction.

The shortcoming of the Curry design for an electrostatic communication system can be seen in the basic nature relationship existing between two points of charge.(See **Figure 6**)

Figure 6



Because lines of flux exist between two opposite charges a dipole transmitting antenna is not needed. Curry proposed a dipole in order to create a wave of the proper length to be propagated through the medium. However, in electrostatics it is not necessary for flux lines to detach and close upon themselves to propagate an electric field. The field is established by the flux lines between the two points of charge. Curry misunderstood the nature of the electrostatic field. Once the field is established, a change in pressure on the charge will cause a variation in charge at the other end of the field - a displacement current.

Also, Tesla points out that a dipole is not needed to receive even low frequency signals in an electrostatic system. Tesla pictured his receivers with electrodes spaced a quarter wavelength apart but this was to charge an unpowered receiver as rapidly as possible. The receiver's capacitor would see maximum voltage changes, and, thus, would gain sufficient charge to power a device, if the ground electrodes had such a spacing. If, though, "the impulses are... are alternating, but sufficiently long in duration" they can be received by a single electrode that is turned on and off with the same period as the transmitter. Because the field's flux lines do not radiate but start at the transmitter and terminate on the receiver, the receiving structure does not have to be a specific shape or length.

His patent, then, also describes a through-the-earth, compact ELF communication system. Today's ELF antenna arrays, by contrast, require hundreds of square miles for their deployment.

Proof of Principle Test

This method of electrostatic communication can be tested by using a grounded, resonant electrostatic detector coupled to a standard communications receiver, encased in RF shielding to receive a signal. For demonstration purposes a commercial station transmitting on 1.16 MHz at 50KW, 40 miles away from the receiver could be used as the test source.

If the transmitter's antenna is feed at 50ohms impedance, the antenna current is:

The quarter wavelength period for 1.16 MHz is:

$$P = 1/4f$$

$$P = 1/(4)1.16\times10^6$$

$$P = 2.16\times10^{-7} \text{ sec.}$$

The amount of charge in the antenna during the quarter period is:

$$i = q/s \text{ and } q = is$$

$$q = 31.6 amps \times 2.16 \times 10^{-7}\ s$$

$$q = 6.8\times10^{-6}\ coulombs$$

If 100 watts is assumed for the detector circuit, the current at 50 ohms is:

$$I = \text{square root } (100/50) = 1.4\ amps$$

and the charge:

$$q = 1.4\ amps \times 2.16 \times 10^{-7} = 3 \times 10^{-7}\ coulombs$$

Using Coulomb's law to calculate the force on each charge separated by the given distance:

$$F=(q_1q_2)/(4p\ e\ _0r^2)$$

$$F=(3\times10^{-7})(6.8\times10^{-6})/(4p\ (8.9 \times 10^{-12})(6.4\times10^{4})^2)$$

$$F = 4.5\times10^{-12}\ nt. = 4.5\times10^{-7}\ dynes$$

Assuming, finally, that the detector circuit uses a 100 microfarad capacitor, the force of the field will result in a voltage as such:

$$\mathbf{e} = \text{square root } (F/(C \times 10^{7}))$$

$$\mathbf{e} = \text{square root } ((4.5 \times 10^{-7})/(100\times10^{-6}\times10^{7}))$$

$$\mathbf{e} = 21 \times 10^{-6}$$

A change of 21 microvolts would be well above the 5 microvolt level required for a radio receiver to capture a signal from the electrostatic detector circuit. It should be remembered, too, that Tesia worked at higher energy levels than used in this example. He used hundreds of amps at lower frequencies(more charge) and potentials of millions of volts.

This analysis of Tesla's wireless transmission method is preliminary, but does indicate the type of field of force and distance calculations that have to be made in order to have a successful electrostatic communication system. Issues dealing with the optimum frequencies, the earth as a dielectric, and the function of the earth's charge in power transmission have to be investigated. This is in addition to the questions yet to be discovered. However, it is clear that 100 years ago Nikola Tesia began a branch of communication technology that differs significantly from that in use today.

If you have questions to the author, please, do not shame email to:

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Notes

1. 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.

2. Corum, James F., and Corum, Kenneth L., "Disclosures Concerning the Operation of an ELF Oscillator," *Tesla '84: Proceedings of the Tesla Centennial Symposium,* Dr. Elizabeth Rauscher and Mr. Toby Grotz, editors, International Tesla Society, Inc.. Colorado Springs, 1985, pgs. 41-49.

3. Tesla #787,412: page 1, lines 53 - 56.

4. *Ibid.,* page 3, lines 35 -41.

5. Tesla, Nikola, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination" (1891), reproduced in *Nikola Tesia: Lectures * Patents* Articles.* published by the Nikola Tesla Museum, Nolit, Beograd, 1956, pg. L-42.

6. *Ibid.,pg.* L-43.

7. ________, "On Light and Other High Frequency Phenomena (1893), *ibid.,* pg. L-121.

8. *Ibid.* L-127, emphasis added.

9. *Ibid., pg.* L-138.

10. Gilstrap: Column 2, lines 34-48.

11. Curry: Column 1, lines 21-28.

12. Curry: Column 1, lines 44-48.

13. Curry: Column 4, lines 8 - 38.

14. Curry: Columns 5-6.

15. Curry: Column 7, Imes 35 - 75 to column 8 line 2.

Nicola Tesla