

The Tesla Coil – An electrical resonant transformer

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This paper gives an introduction to an invention which produces high voltage, low current, high frequency alternating current electricity. It has been named after its inventor Nikola Tesla, who discovered this kind of functionality of wireless electricity transportation around the year 1891. To produce such high voltage, in this case several million Volts, from 230 Volts at 50 Hertz, he built an electrical circuit which first transforms the supply voltage into a very high voltage. The first step is that the transformed voltage forces charge to build up in a capacity that is serially connected to the transformer. The voltage across the capacity is proportional to the amount of charge it is holding, so that at some point the spark gap, that is parallel connected to the capacity and serially connected to the coil itself, will come to use, initiating the second step. With an active spark gap the charge can flow out of the capacity and swing back and forth many times in a second. By doing so the primary coil drives current up and down the second coil, finally causing the electrons to overflow in the torus, and by having nowhere to go the electrons dissolve them into the surroundings. As the system runs out of voltage, that is a little less than the initiate voltage for the spark gap, the first step of the circuit begins again.

Electricity is an interesting and unbelievable useful phenomenon in our today's world. But there is still one disadvantage left, that should and could be solved with an electrical resonant transformer – the dependence on wires to transport electricity.

In a time where electricity was still in its beginning, a radio still an invention to be made, Tesla invented his coil with the intention of solving above mentioned problem. He wanted to transmit electricity through the air, and conducted a lot of research to this area. Indeed he spent the majority of his career attempting to achieve wireless power, and his setup was rather simple. His purpose was to spread a few coils around the globe to transmit electrical energy through the earth, and wherever power was needed, a simple 'receiving coil' should convert this power into some useful form. His name for this kind of transmission was 'World Wireless System', and was stated first in an article in June of 1900 in the 'Century Illustrated Magazine' named THE PROBLEM OF INCREASING HUMAN ENERGY. [1] He went on and developed two theories related to his observations of the coil. First, by using two grounded Tesla coil transmitter-receivers positioned at distant points on the earth's surface, it is possible to induce a flow of electrical current between them. Second, by incorporating the Earth itself as a part of a coil transmitter an electrical

disturbance can be impressed onto the Earth and detected '*even all over the surface of the globe*'. [2] So Tesla made an assumption that the Earth is a charged object floating in space with an unknown capacity. We now know that the Earth is charged indeed, made so by processes related to the interaction between the continuous stream of charged particles from a solar wind that flows out from the Sun, and the Earth's magnetosphere including that it's upper atmospheric strata are conducting. We also know that Earth actually has a capacity of around 708 microfarad. [3] And according to theories it behaves just similar to the Tesla Coil as a resonant LC circuit when it is excited at certain frequencies. Although Tesla had huge success in this field, further research was not possible due to missing financial aids from his investors.

However the research was not a total loss at all, whereas Tesla used these coils to experiment in radio transmission as well. And indeed the basic principles of transmitting information over the radio haven't changed since Tesla.

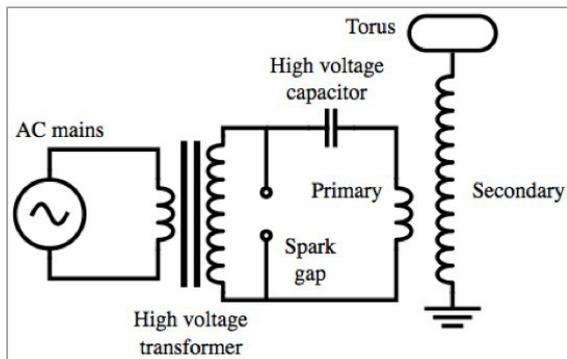


FIG.1. A Schematic drawing of a Tesla Coil circuit for creating high voltage, low current, high frequency alternating current electricity by stimulated resonance.

To get sparks, or generally said, emitted electrons from the torus at the top of the secondary (or inner) coil, high voltage (several million Volts) at a fairly exact frequency (several MHz) must be created. But the globally available current has a frequency of only 50 to 60 Hertz at a voltage of around 230 Volts. So to change the frequencies we must 'pluck' the primary coil. The secret to the 'plucking' or the excitation is to modify the circuit by using a so called 'spark gap', which generally speaking is nothing but a wire that has been cut in half. The properties of this spark gap are quite interesting. It has an essentially infinite resistance until a high voltage is applied, at which point they create a spark that itself is essentially ionized air.

The Tesla Coil circuit is basically a combination of two circuits, a 'slow' one, and a 'fast' one. The purpose of the slow circuit is to charge the capacitor, until it is bursting with electrons. At some point the spark gap will spark and close the path to the fast circuit.

With an active spark the current can slosh back and forth out of the capacitor and back in millions of times in a second through the primary coil, creating a current in the secondary, that builds up until the capacity on the top of the secondary (the torus) is congested with electrons, causing them to dissolve into the surroundings, creating an air discharge, just because they have no particular way to go.

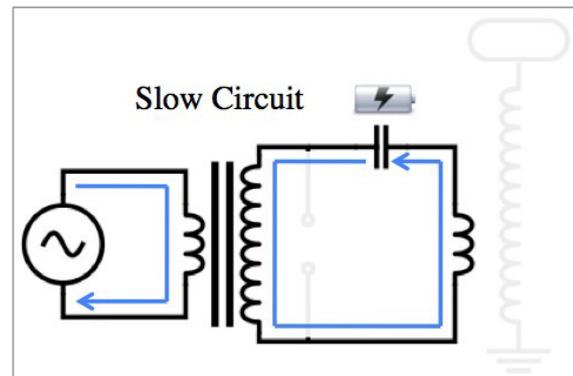


FIG.2. Slow circuit; the transformer on the left forces charge to build up in the capacity on the top. The voltage will at some point become high enough to switch the spark gap.

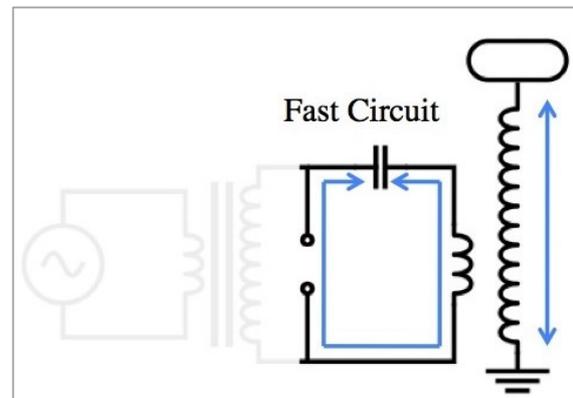


FIG.3. Fast circuit; with an active spark gap, the charge can flow out the capacitor and swing back and forth many times. The current through the primary coil drives current up and down the secondary causing the electrons to overflow.

The loop in FIG.3. forms an RLC circuit with a high resonant frequency that matches and is dictated by the secondary coil. As the fast circuit runs out of the voltage that is needed to maintain the function of the spark gap (which is usually much less than the voltage that is needed to initiate the process) the whole system returns to the charging phase, the slow circuit.

The Tesla Coil can also be used as a receiving unit, delivering the missing part in an wireless power transmitting system. It is called 'Tesla receiving transformer', and it acts as a step down transformer with a high current output. The parameters for a receiver and a transmitter are basically the same ones due to reciprocity. A Tesla receiving transformer can also receive electromagnetic pulses from atmospheric electricity and radiant energy besides electricity emitted by a Tesla transformer. Also Tesla stated that a variation of a Tesla coil could be used to deploy the phantom loop effect on to form a circuit inducting energy from Earth's magnetic field and other radiant energy sources. [4] While the coils can be used for above mentioned purposes, today's main usage of them is to fascinate people all around the world with the spectacular air discharges.

In consideration of all mentioned facts Tesla stated: 'Ere many generations pass, our machinery will be driven by a power obtainable at any point of the universe.' [5]

[1]Nikola Tesla; The Problem Of Increasing Human Energy; Filigran Publishing; 2007

[2]Thomas Commerford Martin; Inventions, Researches and Writings of Nikola Tesla; Kessinger Publishing; 1996

[3]James F. Corum et al.; Proceedings of the 1988 International Tesla Symposium; International Tesla Society; 1988

[4]Nikola Tesla; The True Wireless; Electrical Experimenter; 1919

[5]Nikola Tesla; Experiments with Alternate Current of High Potential and High Frequency; 1892