Tesla high frequency coil by George F. Haller and Elmer Tiling Cunningham

The use of the transformer in the Tesla apparatus is merely to charge a condenser, and thus it is seen that an ordinary induction coil or even a static machine of the proper dimensions could be used, but they are not nearly as handy.

Another important matter in connection with the construction of a transformer to be used for creating electric oscillations is to secure a sufficiently small resistance in the secondary. The reason for this is that the transformer is used to charge a condenser.

When an electromotive force is applied to the terminals of a condenser, the full difference of potential is not created between the terminals of the condenser immediately, but rises gradually. The time required to charge the condenser depends on its capacity (C) and the resistance {R) of the charging circuit. The product CR is called the time constant of the condenser, and practically the condenser is charged in a time equal to ten times the time constant. The time constant is to be reckoned as the product of the capacity (Q in microfarads and the resistance {R) of the charging circuit in meg-ohms. The time is given in fractions of a second.

The condenser, more than anything else, constitutes the essential part of the Tesla coil. It plays the same part as the mechanical interrupter in the ordinary induction coil. Its action, however, is purely electrical and its great advantage lies in setting up the currents of enormous frequency.

When any condenser is discharged, the discharge may take one of several forms, depending only on the three electrical constants of the discharging circuit — inductance, capacity, and resistance. The discharge may be either oscillatory or entirely unidirectional, consisting only of a gradual equalization of the potentials on the two plates.

This may be made clear by the following mechanical illustration. Suppose a glass U-tube to be partly filed with mercury, and the mercury to be displaced so that the level in one side of the tube is higher than in the other. There is then a force due to the difference of level, tending to cause the liquid to return to an equal height in both limbs. If the mercury is now allowed to return, but is constrained, so that it is released slowly, it goes back to its original position without oscillations. **If, however, the constraint is suddenly removed, then owing to the inertia of the mercury it overshoots the position of equilibrium and oscillations are created. If the tube is rough in the**

interior, or the liquid viscous, these oscillations will quickly subside, being damped out by friction.

What we call inertia in material substances corresponds with the inductance of an electric circuit and the frictional resistance experienced by a liquid moving in the tube, with the electrical resistance of a circuit.

If we suppose the U-tube to include air above the mercury and to be closed up at its ends, the compressibility of the enclosed air would correspond to the electrical capacity in a circuit.

The necessary conditions for the creation of mechanical oscillations in a material system or substance are that there must be a self-recovering displaceability of some kind, and the matter displaced must possess inertia; in other words, the thing moved must tend to go back to its original position when the restraining force is removed, and must overshoot the position of equilibrium in so doing. Frictional resistance causes decay in the amplitude of the oscillations by dissipating their energy as heat.

In the same way the conditions for establishing electrical oscillations in a circuit is that it must connect two bodies having electrical capacity with respect to each other, such as the plates of a condenser, and the circuit itself must possess inductance and low resistance. Under these conditions, the sudden release of the electric strain results in the production of an oscillatory electric current in the circuit, provided the resistance of the circuit is less than a certain critical value. We have these conditions present when the two coatings of a Leyden jar are connected by a heavy copper wire.

Professor William Thomson, titled Lord Kelvin, published in 1853 a paper on "Transient Electric Currents" in which the discharge of the Leyden jar was mathematically treated in a manner that elucidated important facts.

If we consider the case of a Leyden jar or condenser charged through a circuit having inductance and resistance, then in the act of discharge the electrostatic energy stored up in the condenser is converted into electric current energy and dissipated as heat in the connecting circuit. At any moment the rate of decrease of the energy in the jar is equal to the rate of dissipation of the energy in the discharging circuit plus the rate of change of the kinetic or magnetic energy associated with the circuit.

From these facts Lord Kelvin sets up an equation of energy, which leads to a certain class of differential equation having two solutions. The solutions in this case depend on the relation between the constants inductance, resistance, and capacity.

If Z = inductance, C = capacity, R = resistance, then the solutions are determined by the relative values of $\frac{L}{R}$ and LC.

If $\frac{R^2}{4L^2}$ is greater than $\frac{1}{LC}$, that is, if R is greater than $\sqrt{\frac{4L}{C}}$, or if $\frac{RC}{4}$ is greater than $\frac{L}{R}$, the charge in the jar dies away gradually as the time increases, in such a manner that the discharge current is always in one direction.

The ratio $\frac{L}{R}$ is called the time constant (T) of the discharge circuit, and the product CR is called the time constant (T') of the condenser circuit. Hence the discharge is unidirectional when the time constant of the inductive circuit is less than half the geometric mean of the time constants of the inductive circuit and condenser circuit:

If, however, $\frac{RC}{4}$ is less than $\frac{L}{R}$ the discharge current will be oscillatory, the current decaying in accordance with the law of a damped oscillation train.

When the discharge is so highly oscillatory that the current is not uniformly distributed through the cross-section of the conductor, then the ordinary resistance (R) and inductance (L) must be replaced by the high-frequency resistance and inductance of the circuit.

When the discharge takes the oscillatory form the frequency is given by the expression, $n = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$ If R is very small, then $\frac{R^2}{4L^2}$ can be neglected in comparison with $\frac{1}{LC}$, and then the frequency is given by the expression, $n = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$.

In this equation both the quantities C and L must be measured in electromagnetic units or both in practical units, viz., in henrys and farads.

In the majority of cases in which electric oscillations are practically used, the resistance of the oscillatory circuit is negligible, and the inductance is small and hence easily measured in centimeters or absolute C. G. S. units, one millihenry being equal to a million centimeters (10^6).

Also the capacity is best measured in microfarads; one microfarad being the one millionth part of a farad or IO^{-15} of an absolute C. G. S., unit (electromagnetic) of capacity.

Hence when L is expressed in centimeters and C in micro-farads, the expression for the natural frequency of the circuit becomes $n = \frac{5.033 \times 10^6}{\sqrt{CL}}$.

The energy storing capacity of a condenser is given by the expression $\frac{1}{2}CV^2$, where C is the capacity of the condenser and V the charging voltage.

The oscillation transformer is nothing but a modified transformer with an air core. The only important facts about its construction are that it should be built to withstand great voltage differences between the turns, and that the primary should have as small an inductance as is practicable, in order to make the frequency as great as possible. No advantage is gained by having many close turns in the primary, because the increase of inductive effect on the secondary, due to an increase in the number of primary turns, is about exactly annulled by the decreased current through the primary due to its own greater inductance.

The function of the interrupter is to destroy any arc that may be formed across the terminals of the primary spark-gap, for if this arc is not wiped out there will be no true oscillatory discharge in the condenser circuit or only a feeble one. The reason for this is that as long as the arc discharge continues, the secondary terminals of the transformer are reduced to nearly the same potential, or at most differ only by a few hundred volts.

The function of the primary spark-gap is to regulate the voltage to which to charge the condenser. Since the potential difference between the spark balls is almost equal to the potential difference across the condenser, the condenser will discharge at a voltage determined by the length of the air gap. Now there is a certain length of spark-gap which is best suited for each coil and it can easily be determined by trial.

As a rule it is best to start with a rather short spark-gap, gradually lengthening it out until a point is almost reached, when opening it out any further would cause it to cease passing. This spark length almost always gives the best results.

The main reason for the difference between the two cases is to be found in the fact that a high-frequency current does not penetrate into the interior of a thick solid conductor of good conductivity, but is merely a surface or skin effect.

When traversed by an alternating current, there are five qualities of a circuit to be considered.

1. The resistance of the conductor, which is always greater for high-frequency currents than for the ordinary currents; that is, direct currents and alternating currents up to about a frequency of loo per second.

2. The inductance of the conductor depends on its geometrical form, material, and the nature of the surrounding insulator. The greater the frequency, the smaller the inductance becomes.

3. The capacity of the conductor, depending on its position with regard to the return circuit and other circuits and on the dielectric constant of the surrounding insulator.

4. The dielectric conductance of the insulator surrounding the conductor.

5. The energy dissipating power, due to other causes than conductance, such as dielectric hysteresis, which exist in the dielectric. Under this heading comes the loss of energy from the brush discharges through the air between the conductors.

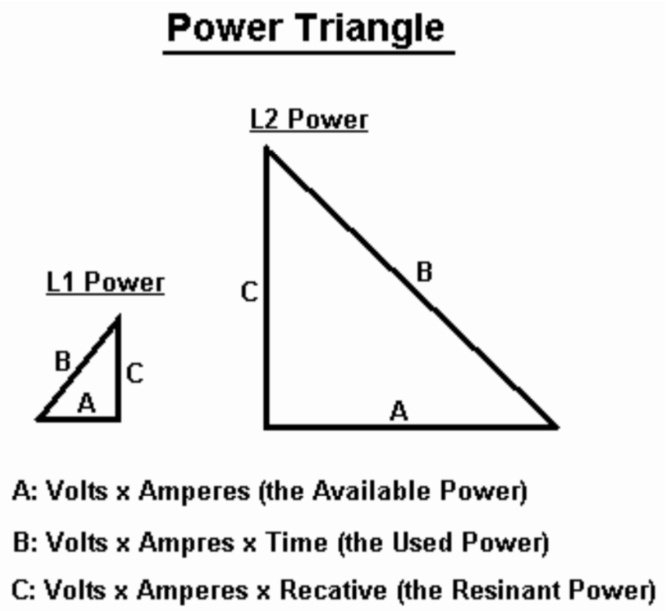
The condenser is connected in series with the secondary of the transformer and thus is being continually charged.

When the potential difference between the plates of the condenser reaches a certain critical value determined by the length of the primary spark-gap, the diameter of the spark balls, etc., a discharge takes place which oscillates through the primary of the oscillation transformer and back and forth across the primary spark-gap.

The frequency of the current depends entirely, as shown before, on the constants of the circuit. On first thought, one would think that the condenser would discharge through the closed circuit in the transformer secondary rather than jump the air-gap, but a little consideration of the matter will show that the inductance of this circuit to electric oscillations of this nature is so great that no discharge can take place. Another matter that might be touched on here is the resistance of the spark-gap. Before any discharge has passed and under normal conditions the resistance of the spark-gap is very great: the voltage required to break down one centimeter of air being about 10,000. After the initial discharge has passed and the air becomes heated and ionized the resistance may drop as low as two or three ohms. This fact plays an important part in the damping of the oscillation trains.

The discharge from the condenser which oscillates through the primary of the oscillation transformer sets up a rapidly alternating magnetic field, which being linked with the secondary induces an electromotive force in it. The law for the induction in this case is not nearly as simple as in the case of the ordinary transformer, the capacities of the circuits playing an important part. If the capacity of the circuits is below a certain critical value, the induction is in the ratio of the capacities of the circuits, while if greater the induction depends on the relation between the number of turns in the primary and secondary.

Don Smith



1. Random movement of electrons in "A" and "B", mostly cancel each other out. This dampening, or wasteful concept of energy, is a source of much pleasure for the establishment.

2."C"(Volt, Amperes, Reactive "V.A.R."), **is the situation where all of the electrons move in the same direction at the same time**. This results in near-unity energy output by resonant induction transfer.

3. Resonant induction transfer from one isolated power system, allows other resonant induction systems to duplicate the original source, which in no way diminishes the original source. Air-core coils (isolation-transformers) confirm this when they are a part of one of these functioning systems

4. Resonant induction transfer, disturbs a large number of adjacent electrons which were not a part of the original input power source. The pulsating-pumping effect then draws in the newly available additional electrons into the on-going energy generation system. A near unity energy system of resonant air-core coils and the extra acquired electron-energy source constitute an over-unity system.

Electrical Power Generation / Points of Reference

Useful Electrical Power is generated when Electrons from Earth and Air Groundings are disturbed by the movement of coils and magnets with reference to each other. The resulting electrical and magnetic energy is then changed to joules [watt-seconds: Volts x Amps x Seconds]. Each forward electron movement results in a magnetic impulse and each return movement causes an electrical impulse. The composite of the electrical energy impulses from these electrons yields useful energy [Power].

Let the above electron movement be represented by a room full of ping pong balls bouncing randomly. Most of the energy present cancels out by random impacts. This is the Classic Under-Unity approach to Electrical Power Generation, sanctioned by the Establishment.

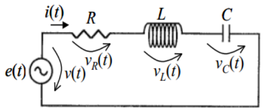
In contrast to that, in the Electrical Energy Generation System presented here, the resonant Electrons are **all moving in the same direction at the same time**. This allows Near-Unity Electrical Power to Develop. This is the room-temperature equivalent of super conductivity.

The Energy System presented here, consists of a properly-adjusted and functional resonant air-core coil tank. The magnetic energy is stored in the coil system and the Electrical Energy is stored in capacitors. From Maxwell and others, we know that electrical-related energy has an equal amount of magnetic energy associated with it.

In the Resonant Tank Induction Energy Transfer System presented here, Impedance [system resistance] replaces the conventional ohm's usage. **At Resonance, impedance becomes zero** and the full force and effect of the Energy Transfer occurs. This is superconducting conditions at room temperature. **At radio frequency the Electrons do not pass through the conductor as they do at lower frequencies. Instead, these Electrons encircle the conductor and are free of the conductor's resistance.**

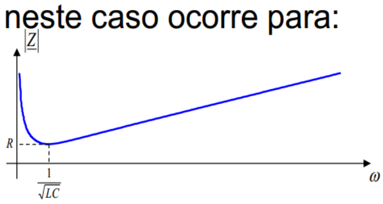
Ressonância

- O circuito RLC série:



$$\underline{Z} = R + j\omega L - j\frac{1}{\omega C} \qquad \underline{Z} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}\, e^{j\operatorname{arctg}\left(\frac{\omega L - \frac{1}{\omega C}}{R}\right)}$$

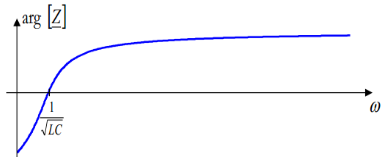
A **situação de ressonância** neste caso ocorre para:



$$\left|\underline{Z}\right| = R$$

$$\arg\left[\underline{Z}\right] = 0$$

$$\Rightarrow \omega L - \frac{1}{\omega C} = 0 \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

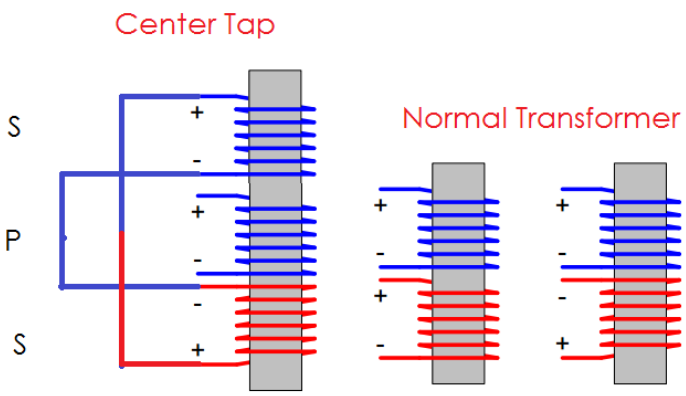


Ressonância

Nesta situação de ressonância temos então que:

- A corrente está em fase com a tensão;
- A impedância assume o seu valor mínimo, *R*;
- O valor eficaz da corrente assume o seu valor máximo, igual a *V*/*R* (o que pode ser perigoso se *R* for pequeno!);
- A tensão na resistência é igual à tensão aplicada;
- As tensões na bobina e no condensador são, em qualquer instante, iguais mas de sentidos contrários, anulando-se mutuamente.

“Impedance assumes its lowest value, R;”



Depending on how the coils are wound, the polarity of the voltage on the secondary to the primary has either direction. I.e., we have the voltage on the secondary in phase (left image) or in opposite phase (right image) with the primary voltage.