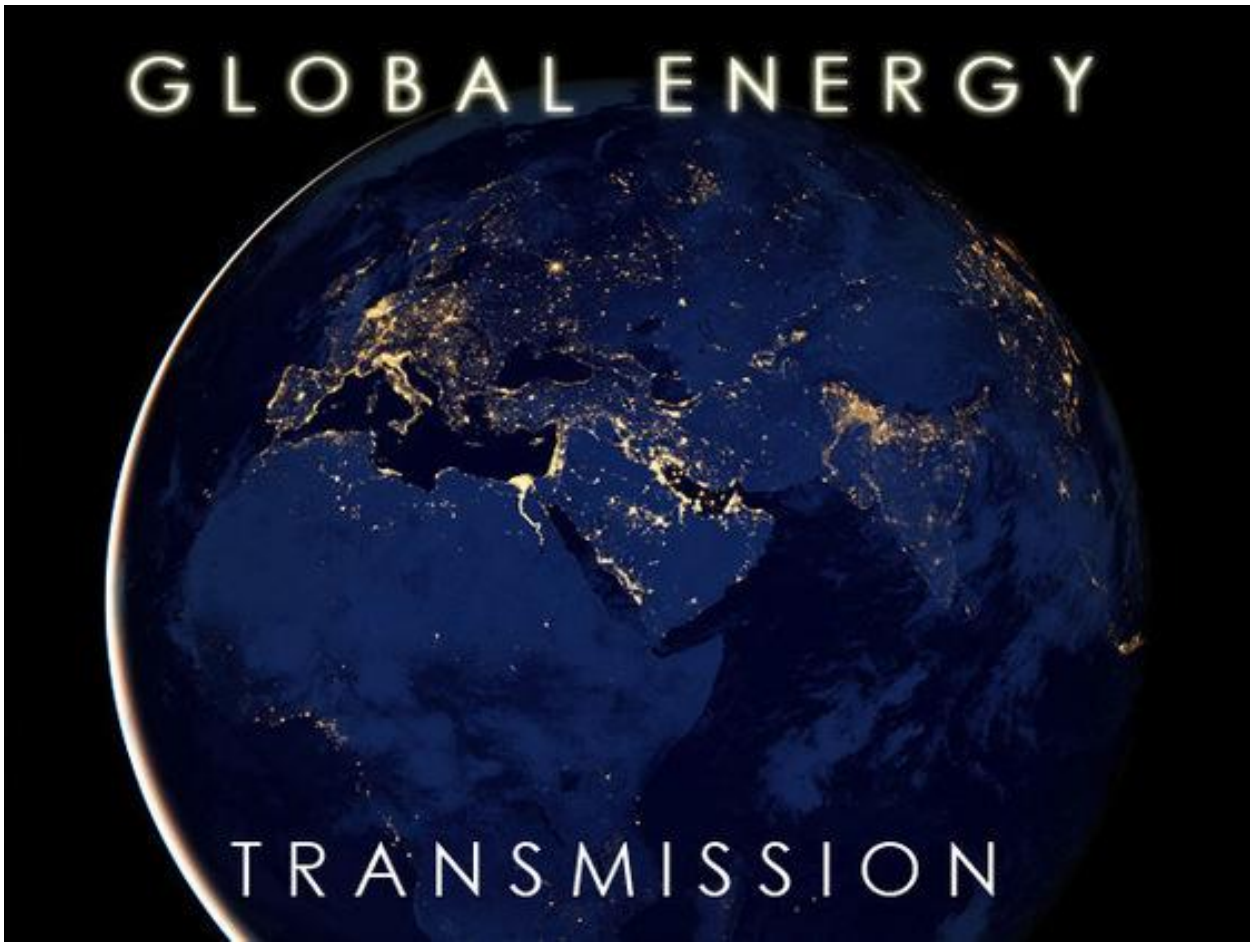

ANALYSIS OF TESLA'S PATENTS AND DIARIES CONCERNING «TESLA TOWER» AND ENERGY TRANSMISSION

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Introduction

This study comprises the information which is intended for the use by the individuals exhibiting interest in given topic. Therefore, the language of this study was simplified to a maximum extent so that it could be easily understood by those that do not hold degree in related area, that is, in physics. Nevertheless, corresponding links to appropriate research works with similar focus were provided for the purpose of assisting the reader in gaining better understanding of the aim of the present study as well as complementing this purely quantitative description.

As it is well known in related gatherings, Mr. Tesla discovered evidence of existence of standing wave of current oscillations arising in response to the lighting strikes while conducting the research in Colorado Springs. This phenomenon was very thoroughly described in his diaries. Below you can see extract from this diary:

The date I shall never forget - when I obtained the first decisive experimental evidence of a truth of overwhelming importance for the advancement of humanity. A dense mass of strongly charged clouds gathered in the west and towards the evening a violent storm broke loose which, after spending its fury in the mountains, was driven away with great velocity over the plains. Heavy and long persisting arcs formed almost in regular time intervals. My observations were now greatly facilitated and rendered more accurate by the experiences already gained. I was able to handle my instruments quickly and I was prepared. The recording apparatus being properly adjusted, its indications became fainter and fainter with the increasing distance of the storm until they ceased altogether. I was watching in eager expectation. Surely enough, in a little while the indications again began, grew stronger and stronger and, after passing thru a maximum, gradually decreased and ceased once more. Many times, in regularly recurring intervals, the same actions were repeated until the storm, which, as evident from simple computations, was moving with nearly constant speed, had retreated to a distance of about three hundred kilometers. Not did these strange actions stop then, but continued to manifest themselves with undiminished force. Subsequently, similar observations were also made by my assistant, Mr. Fritz Lowenstein, and shortly afterwards several admirable opportunities presented themselves which brought out still more forcibly and unmistakably, the true nature of the wonderful phenomenon. No doubt whatever remained: I was observing stationary waves

It is possible to find a great amount of Tesla's statements from his diaries, lectures,

articles and patents that confirm the fact of standing waves as not being related anyhow to conventional EM-waves. For instance,

The chief discovery which satisfied me thoroughly as to the practicability of my plan was made in 1899 in Colorado Springs, where I carried on tests with a generator of 1500 KW capacity and ascertained that under certain conditions the current was capable of passing across the entire globe and returning from the antipodes to its origin undiminished in strength.
source: World System of Wireless Transmission of Energy, *Telegraph and Telegraph Age*, October 16, 1927

That electrical energy can be economically transmitted without wires to any terrestrial distance, I have unmistakably established in numerous observations, experiments and measurements, qualitative and quantitative. These have demonstrated that is practicable to distribute power from a central plant in unlimited amounts, with a loss not exceeding *a small fraction of one per cent*, in the transmission, even to the greatest distance, twelve thousand miles—to the opposite end of the globe. This seemingly impossible feat can now be readily performed by any electrician familiar with the design and construction of my "high-potential magnifying transmitter," the most marvelous electrical apparatus of which I have knowledge, enabling the production of effects of unlimited intensities in the earth and its ambient atmosphere. It is, essentially, a freely vibrating secondary circuit of definite length, very high self-induction and small resistance, which has one of its terminals in intimate direct or inductive connection with the ground and the other with an elevated conductor, and upon which the electrical oscillations of a primary or exciting circuit are impressed under conditions of resonance.
source: The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace, *Electrical World and Engineer*, January 7, 1905

I finally vanquished all difficulties and succeeded in producing a machine which, to explain its operation in plain language, resembled a pump in its action, drawing electricity from the earth and driving it back into the same at an enormous rate, thus creating ripples or disturbances which, spreading through the earth as through a wire, could be detected at great distances by carefully attuned receiving circuits. In this manner I was able to transmit to a distance, not only feeble effects for the purposes of signaling, but considerable amounts of energy, and later discoveries I made convinced me that I shall ultimately succeed in conveying power without wires, for industrial purposes, with high economy, and to any distance, however great.
source: Talking With Planets, *Collier's Weekly*, February 9, 1901

since the first attempts the wave lengths have been increased until those advocated by me were adopted, in which this form of radiation has been reduced to one-billionth. When a circuit, connected to ground and to an elevated capacity oscillates, two effects separate and distinct are produced;

> Hertz waves are radiated in a direction at right angles to the axis of symmetry of the conductor, and simultaneously a current is passed through the earth.
> ....
> There is a vast difference between these two forms of wave movement in their bearing on the transmission. The Hertz waves represent energy which is radiated and unrecoverable. The current energy, on the other hand, is preserved and can be recovered theoretically, at least, in its entirety.

source: The Effect of Statics on Wireless Transmission, January, 1919, pages 627 and 658

And so on…

it is very obvious for professional that such statements are not anyhow related to conventional EMR. Moreover, Tesla separately points out that such emission is formed during operating process of the system (Hertz waves were considered as sort of conventional radio emission at that time). However, such radiation constitutes only part of entire energy being exhibited during this process. For instance, it is quite obvious that one of the common opinions about Tesla discovering Shuman's resonance is absolutely incorrect even despite the fact that it is stated so in Wikipedia and some other sources. It also becomes quite evident from the descriptions provided above that Tesla was performing all necessary operations employing the frequency with the values falling within the range of 200 kHz (and the biggest part of waves related to Shuman's resonance is concentrated within such frequency range). In addition, Tesla was not interested in the use of radio waves or so-called Hertz waves in that period of time. It is just very great pity that such wrong opinion can be observed everywhere, and even in Wikipedia. This is mainly because it is just making work of the scientists more difficult. However, logically this mistake can be quite easily understood because of the idea of Tesla regarding discovery of the Shuman's resonance seems to be quite obvious considering the fact that Tesla was working with big coils, that is, he was dealing with the great inductivity values that were implying ultra-low frequencies and existence of Shuman's resonance. But it is just seeming evidence like it will be shown below.

Therefore, the question arises which kind of process the resonance or standing waves, which were discovered by Tesla during his research work in Colorado Springs, were part of?

Our research objectives

The research objective was already predefined in one of the Tesla's patents under number US787412. In this patent, Tesla exclusively stated that the wave is capable of reaching the opposite end of the planet and getting back during definite period of time of 0.08484s. At that, an average wave propagation velocity should comprise 471240km per second. Let us assume that Tesla was referring to the wave that is traveling through the Earth's center with the velocity denoted as C (as exemplified by Tesla in his patent indicated above).

In this case, the values of the time frames in terms of the forward and backward travels of such wave in question will be calculated according to the following equation: t=4R/C=2*12735/300000=0.08490. As of calculation of an average phase velocity value of the wave traveling along the Earth's surface, we employ the following formula: V=PI*R/(2*R/C)=C*PI/2=471225. As a result, we obtained the data which strictly corroborate with those provided in Tesla's patent. Thus, we can conclude that Tesla was referring to the waves which are being distributed through the Earth's center along a straight line. At least, Tesla was obviously thinking of that phenomenon in

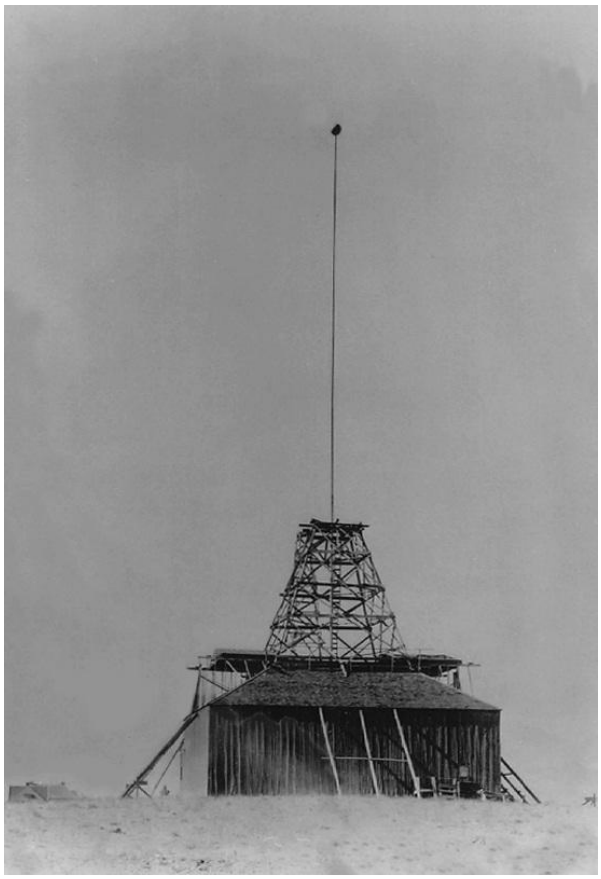
such a way. Conventional EM-waves are not capable of exhibiting such a behavior. As of classical physics (that is within "Occam's razor"), there are no doubts that Tesla was referring to the current and voltage waves. We assume that Tesla just aimed at presenting the information in a most efficient and somewhat "mystic" way. That is why he provided such interesting values in terms of an average velocity of the process.

Based on the information obtained from Tesla's diaries and patents as well as being bounded by the fundamentals of traditional classic physics such as Maxwell's equations, we came to the conclusion that the question is concerned with the ripple effect of the currents and voltages in the depth of our planet. That is, Tesla literally meant the currents as such when he was talking of the currents flowing through the body of the planet. At first, this kind of thought seems to be crazy because it is well known that the Earth has quite poor conductive properties. The average parameters of the ground conductivity vary within the range from 10 up 1000 Ohm×m3. Earth surface can be considered as a dielectric, not conductor. However, it shouldn't be forgotten that dielectric and conductor are only some tentative concepts in terms of a division according to the type of prevailing process. Nevertheless, each dielectric exhibits the properties similar to those of conductor's although dielectric's conductivity can be considered as much more complex concept than that of the conductor's due to the fact that there are many principally different processes related to the charge transfer happening in dielectrics. The conductivity of the dielectrics is also topologically different in terms of volumetric and superficial constituents.
Therefore, even at high electrical resistivity value of 100 Ohm×m3 and in a case when depth of a conductor wit such parameters comprises hundreds of kilometers, the total resistance value won't be big. Thus, total resistance value of entire Earth as a conductor can extend over hundredths of Ohm's just due to the rather large area of a section of such conductor.
At that, current losses in terms of active resistances are proportional to the square of current (I^2*R), therefore current resistivity value is very small (much less than 1A) and square from such value will be even smaller in terms of its value. That is why in case of ultra small currents distributed over large surfaces of the Earth, ohmic losses can be of very insignificant value.

Thus, even when conducting superficial qualitative analysis, we may come to conclusion that current and voltage resonance in the body of planet is quite feasible phenomenon. Later we will move towards more precise modeling of such process.

Based on our reasoning above, starting point of our research is that Tesla was literally referring to the CURRENTS when he was talking of them. The latter is quite accordant with qualitative results and his all prior statements as well as with constructive execution of the prototypes executing energy transmission described in the patents of the scientist.

Investigation of the Tesla tower's working mode by means of analyzing the patents



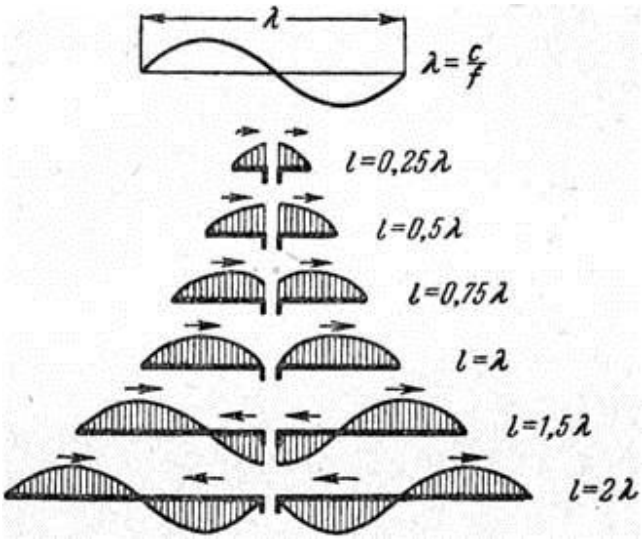
Let us to proceed with more detailed analysis of the model features of this process. Final version of the Tesla's patent concerning wireless transmission of electrical energy over large distances is provided below.
In patent US787412 precise parameters, which are related to the processes exhibited in the prototype, were provided. There are few such parameters:
1) cable length calculated from grounding point to the point of upper inductivity, which is evenly divisible by one fourth of wavelength of the reference generator
2) pumping frequency of the circuit with the value being not more than 20 kHz, and preferably less than that. This stands in contrast with the parameters obtained from the experiments conducted earlier. In such experiments, Tesla was using frequencies with the values being of 200 kHz. Reasons of using such values will become obvious based on the explanations provided below. Let us notice that vast majority of the enthusiasts performing scientific investigation of the working principle of the Tesla's tower do not take into consideration the fact that required working frequency of the circuit should have value below 20kHz according to Tesla, therefore they are not able to come to correct conclusions.
3) pumping duration is such that light should manage to reach opposite end of the globe and get back during one series of generator's impulses.

While thoroughly studying the patent US1119732 , we have also been able to observe series of some crucial technical moments resulting in increase of a stability of the prototype as well as its safety in use according to Tesla's statement:
1) Wire of main coil should be wired on wire-by-wire basis;
2) Semi-spherical "pimples" are required in the surface of upper toroid;
3) Main coil should be connected to upper toroid via thick pipe. At that, a value of the pipe's diameter should be greater than that of a diameter of the "pimples";
4) Coil should be connected with the pipe via special cap with wide mouthpiece and vertical gashes;
5) There should be "safety-valves" installed in the upper toroid for the purpose of achieving controlled charge (discarding of excessive amount of energy of prototype's framework) in a form of sharp pimples emerging in relation to common surface area.

Let us undertake an attempt to bring together the technical parameters and constructive features of the prototype, which were indicated in the Tesla's patents.

As it is well known, granted that length of coil's winding is close on its value to one forth of a wavelength value of the reference generator, processes in coil have undular nature. That is, the coil is not considered anymore like classical inductivity but

becomes a system with distributed parameters such as capacity and inductivity, therefore it should have been described in other way round.

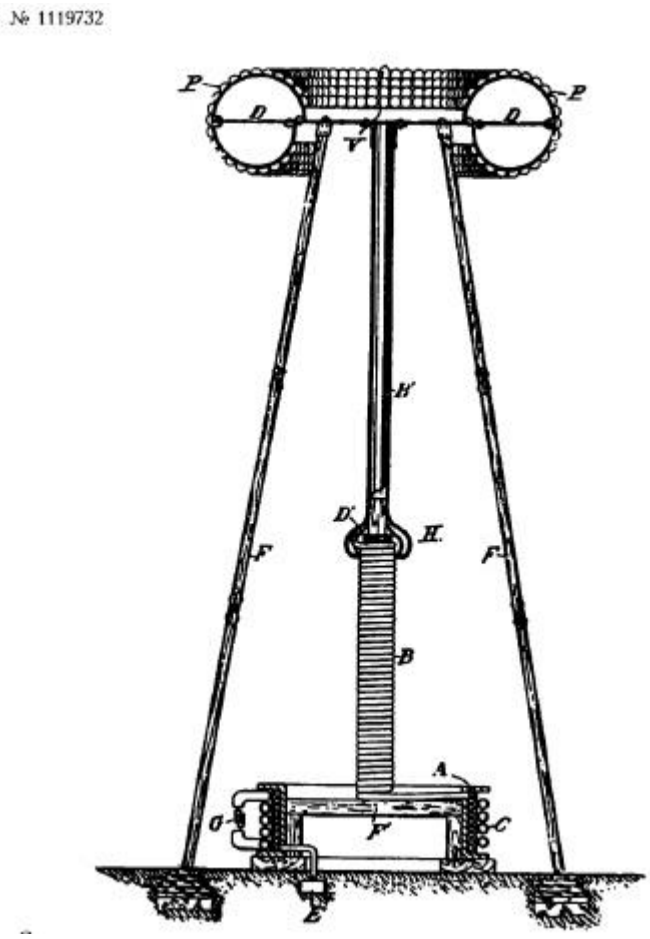


Current distribution in symmetrical oscillators of different length

Rigorous analysis of behavioral pattern of such system based on electrodynamics of Maxwell locates obvious evidence of such coil resonance acting in a similar manner to that taking a place in conventional LC-circuit. However, Q-factor of such resonance can reach very high values in comparison to that of conventional LC-circuit designed from concentrated elements. Such values can vary within a range of 1000-10000 and this fact can be proven experimentally. At that, grounding point can be described by maximum amplitude of the currents and constant zero voltage. In addition, upper point of coil is exemplified by zero current and maximum amplitude of voltage (i.e., maximum charge density distributed unevenly along height of a coil). Herewith, an amplitude of alternate current is decreasing in a sinusoidal manner from grounding point up to the upper end of a coil and oscillatory amplitude value of a density of a charge distributed along coil conductor is increasing from zero in the grounding point up to the maximum value in the upper end of a coil. In other words, a charge pumped out the ground is being unevenly distributed along the coil's conductor with zero charge density in the grounding point and maximum density of a charge in the upper point of a coil.

As of experimental setup conducted by Tesla, it becomes obvious that in a case of implementation of the quarter-wavelength resonance (see condition 1 above), behavioral pattern of the prototype in terms of the currents' and charge' distribution along conductor will completely coincide with that of the helical quarter-wavelength resonator described in the work indicated above.
Namely, oscillatory amplitude of charge density will increase with the subsequent increase of a height and will reach maximum value in the upper toroid.

Based on this fact as well as on that of air puncture, resistance value is relatively small (around 30 kV/cm), all constructive features of Tesla's prototype become obvious and clear to us, which is especially important for the purpose of gaining clear conscience and conformance of the fact that our analysis is conducted in correct manner.



In the patent US1119732, Tesla clearly and concisely describes the danger occurring granted the fact of electrical puncture of the prototype in a form of spark. Тесла knew that there might arise a possibility of globe lightning (GL) in a case of such puncture. In this case, all energy accumulated in the setup would shift into such lightning during very short period of time, in a form of reactive power. The latter might cause very powerful explosion.

... if the point of maximum pressure (*he means maximum density of charge on the surface of the tower obviously*) should be shifted below the terminal D, along coil B, a **ball of fire** might break out and destroy the support For anything else in that way. ..... the destructive action may take place with inconceivable violence. .... the entire energy accumulated in the excited circuit, instead of requiring, as under normal working conditions, one quarter of the period or more for its transformation from static to kinetic form, may spend itself in an incomparably smaller internal of time, at a rate of many millions of horse power.

We will discuss this issue in more details a bit later. Let us now to outline that according to Tesla's diaries written during conducting first experiments in Colorado Springs, the scientist was regularly observing GL phenomenon and later learned to initiate it in purpose. So, he was surely knowing everything about the phenomena, which were indicated in his patent. Our understanding of a nature of such GL being evoked during the course of Tesla's experiments is quite similar to the Tesla's way of thinking described in his diaries (of course, it doesn't imply that all such GLs have similar nature, however these meant by Tesla are really simple on its initial origin).

Tesla particularly points out series of technical features, which may increase safety of a prototype, that is, to decrease probability of accident formation of spark originating from puncture. This implies that actually sparks, which were initiated by Tesla in the prior experiments, should be completely eliminated during energy transmission process (of course, in case when we wish to really perform such transmission and not just uselessly admire these beautiful lightings like some enthusiasts do).

Special reference is made to coil B and conductor B'.

- The latter is in the form of cylinder with smooth or polished surface of a radius much larger that that of the half spherical element PP, and wodens out at the bottom into a hood H, which should be slotted to avoid loss any eddy currents

In case when we expect increase of density of a charge in the Tower along with increase of height (according to the working concept of helical resonator indicated above) obtained as a result of conducting precise analysis of Maxwell's equations and well corroborating with the experiments) then it becomes obvious that two types of an energy will exist in such circuit during its oscillations. They will be the following: energy of magnetic field of the coil B (in a case when the current in coil B has a maximum value and charge value will be equal to zero in the upper inductivity) and the energy accumulated in electrostatic field strength (when the current values in the coil will be equal to zero and a charge pumped out of the ground and distributed along the coil will be of maximum value). Correspondingly, energy gets accumulated mainly in an area of localization of the coil B within "currents' phase". Based on consequences, which may arise due to puncture of the setup, the necessity of elimination of such puncture in fields adjacent to the coil B is becoming obvious. That is, puncture should happen as far from the coil B as it is possible in case when unavoidable. Technical feature described above assists in fulfillment of such objective. Field strength near surface is defined by the radius of its curvature granted that surface charge density has constant value. In case when surface of pipe B' is less abrupt than surface of semi-spherical elements PP in upper toroid then a risk of puncture will be partially eliminated due to its relocation to the area of pipe B' and into localization area of PP (that is, maximally removed from coil B). In his patent, Tesla especially outlines that presence of the semi-spherical surfaces PP in upper toroid makes sense only in such case when other parameters are adhered like, for instance, radius value of the pipe B' is significantly greater than that of the radius of semi-spheres PP. This explains a necessity of presence of such semi-spheres PP otherwise curvature of toroid surface will appear to be smaller than that of a surface of pipe B' so that there is a high risk existing that the puncture will happen rather in undesirable proximity from the coil B than in an area close to upper toroid. In addition, a necessity of elimination of the losses for the Foucault currents is also outlined in this patent. This should be done by means of making vertical cuts in the cap connecting coil B with pipe B'. The latter fact is obvious in terms of referring to the big current values in the system (that is great flow of a charge pumped out the ground).

- The coil B is wound on a frame or drum D of insulating material, with its turns close together. I have discovered that when so wound the effect of the small radius of curvature of the wire itself is overcome and the coil behaves as a conductor of large radius of curvature, corresponding to that of the drum.

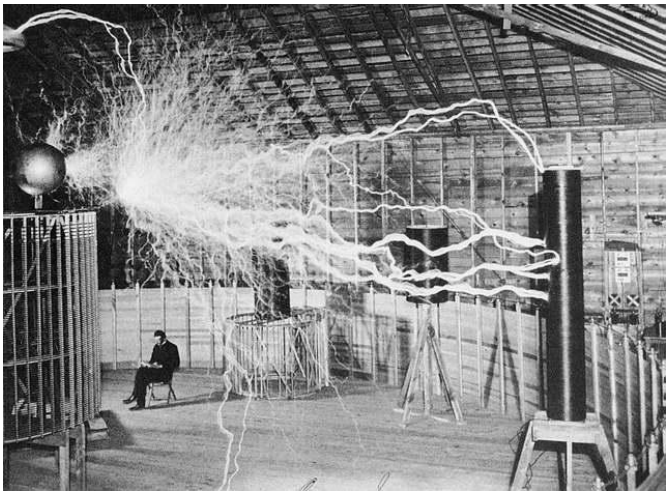
We have to take into consideration that great charge, which is pumped out the ground, is distributed along turns of a wire. This sentence makes strong sense: at the great step of coil winding (i.e. at the great distance between neighboring turns of the coil as it was accomplished in earlier Tesla's experiments for the purpose of isolation of such turns from each other, the air is used as an isolating substance) electrostatic field strength produced from such charge in proximity to wire itself depends only on thickness of a wire and has quite high value. However, in case when turns are located close to each other, the behavioral pattern of system resembles rather that of a cylinder which is unevenly charged along its height. In this case, electrostatic field strength near conductor of winding acts like it is created by means of charged cylinder with the radius value being equal to that of the radius of coil. And, that is what Tesla was writing about (the coil behaves as a conductor with a large radius of a curvature, corresponding to that of the drum). The latter roughly decreases electrostatic field strength near coil and, therefore

subsequently decreases the risk of puncture happening with the circuit.

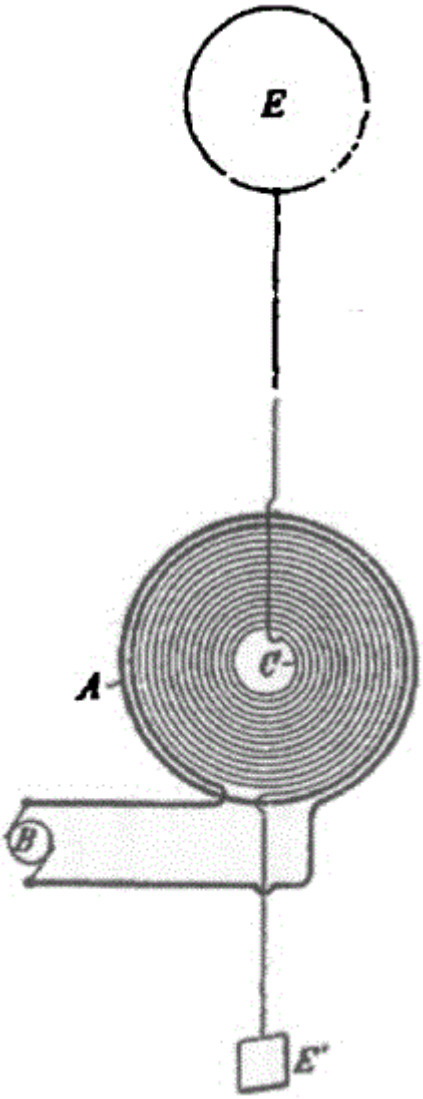
- The lower end of the coil B... should be somewhat below the uppermost turn of coil A. This, I find, lessens the tendency of the charge to break out from the wire connecting both (*coils B and A obviously*) and to pass along the support F'

Similarly, in case when our only goal is to perform large transfer of a charge from the ground, we have to take all possible measures in order to eliminate its reverse leakage to the ground. From this point of view, aforementioned Tesla's comment is quite obvious and does not require any additional explanations.

Thus, we come to conclusion that based on strictly classical picture, the only one thing that is possible to achieve during functioning of such prototype is literal "dragging out" of the charge from the ground onto upper toroid as well as "getting back" such charge to the ground at the frequency of reference generator. This process will be accompanied by conventional EM-emission (from vertical current constituent in coil), however energy of such emission won't be by many times greater than that of the energy being saved in a form of reactive power (that is what Tesla is talking about as it was indicated earlier in the above). No any other effects (except of uneven distribution of the currents and charges along conductive parts of the prototype) are going to take place during operating process of such system granted that we take only Maxwell's equations and nothing else into consideration etc. Such point of view completely complies with everything that Tesla was describing in his patents concerning his system including technical features depicted in the patent. Therefore, we will try to remain within boundaries defined by strict classical points of view. At that, let us note that prior Tesla's experiments were conducted at the very high frequencies in terms of normal energy transmission as well as helical resonator was not designed in the most optimal way. The latter led to great sparkling, however it was not the goal of work itself as it is thought to be so now. Thus, obtaining the long sparks was the primary goal which was transformed into investigations in a field of energy transmission along practical work of Tesla. And in such case, these sparks were serving as unfavorable effect from which it was necessary to get rid of by any available means.



In addition, we would like to clarify the following moment. For some reasons, the vast majority of the amateurs-enthusiasts takes into consideration not the information provided in last Tesla's patens but rather refers to his earlier prototypes, which were designed by Tesla in order to check out such idea. Here, we refer to prototypes with helical form of coil B as it is indicated in such earlier patents as the one under number US787412.



Next things that these enthusiasts do is trying to discover some specific properties of such helical coil, which would allow to transmit energy to some distances.
We assume that this kind of search does not make any sense and the model of such transmitter with this kind of coil is much less efficient. We will explain now why it is so.
It is true that if length of winding of such helical coil fulfils the requirements posed by quarter-ripple effect (i.e. divisible by the quarter of wavelength of reference generator B in the picture above) then ripple effect in terms of the currents and voltages will take place in such coil adhering the laws similar to these of a screw-shaped resonator (references to its work are provided above). That is, such system will somewhat efficiently create resonant process of charge oscillations in the sphere E. However, in order to make such system working, it is necessary to make circuit A - source of EMF to induce ED mainly in the external turns of such helical coil. The latter is outlined by Tesla in his notes and patents. He is referring to necessity of maintaining weak inductive connection between the coils A and C. At that, in any case the coil A will induce EMF with small value in the rest of turns (not only external ones) of the coil C in a strictly cophased manner with EMF in external turns (while for the purpose of achieving ripple effect it is necessary to achieve EMF phase shift along length of conductor of helical coil). This will result in significant decrease of Q-factor value of such resonance. Next, charge distribution along turns of such helical coil (i.e. increase of charge density for internal turns) will exhibit negative consequences in terms of Q-factor value of such resonance due to location of turns of a coil in one platitude. Therefore, such coil will have parameters which are quite similar to that of conventional concentrated inductivity than vertical coil would have (this is due to the fact that field formed from charge in the sphere E will merely affect turns of the helical coil while for conventional coil such situation won't take a place - field of charge will affect whole coil and, thus, exhibit additional EMF).
In other words, achieved charge amplitude in the sphere E for the same power of reference generator for such circuit with helical coil will have much lower value than in case of final prototype scheme provided in patent US1119732 (and being last in the series of the patents describing such topic). Thus, this version of the prototype appears to be less effective than the final one.

Currents in the Earth as an outcome of functioning process of the Tesla's tower

So, what do we have: prototype which "gets the charge out and puts it in" the ground that surrounds the prototype.
What it will lead to?
It is obvious that when selecting existing electrons of conductivity from the ground, the "local plus" will be formed in there. This will result in evoking concentration of electrons from the surrounding areas so that conventional current will occur like it happens in usual conductorsx. The latter will result in great ohmic losses due to great values of the current and quite small section of conductor-dielectric. Therefore, in order to increase efficiency of Tesla's prototype, it is necessary to arrange great grounding field of the lower end of the tower's conductor. Thus, distribution of current and voltage waves close to spherical on its form will occur as a result of periodical process of getting charge out and in to the ground. However, it is not all what is going to happen.

The thing is that a charge, which is collected out the ground, is not going to flow away to some indefinite place but is going to remain in local proximity from the ground, that is, in the upper toroid otherwise there would be still currents of indicated origin left in the ground. Let us to evaluate value of such charge in order to understand whether we should consider it during conduction of our analysis. Based on the frequency with the value of 200 kHz and active value of the current being 1000 A (such parameters were provided by Tesla in the part related to his early experiments conducted in Colorado Springs), we will perform evaluation of the charge value in the upper toroid. Current with the value of 1000 A is equivalent to charge transfer with the value of C per second. Herewith, at the value of 200 kHz, charge with the value of 1/200 C will be transferred to the sphere. According to fundamentals of electrostatics, this is a very big value and obviously a field of such charge cannot be considered in our research in terms of the currents and voltages being in the ground under prototype. At that, value of such charge finely complies with general parameters of the Tesla's prototype: if we will use the sphere as a upper capacity instead of toroid (which won't change own isolated capacity of such object) as well as total charge of the sphere having such value that it will create field gradient near sphere on its value close to that of air puncture voltage (30 kV×cm) then charge value will be around 0.001 C. Of course, Tesla was using the sphere of much smaller diameter and, therefore it was evoking air puncture and unfavorable sparks. Thus, it is necessary to note once again that spark excitation in Tesla's prototype was not the main purpose of his work but unfavorable effect which Tesla tried to eliminated by means of attempting all the approaches which were described above.

So, now we know that it is very important to consider the charge value in upper capacity due to its greatness in terms of tasks posed in a field of electrostatics.
The question is: what kind of field will be formed by means of such charge? In terms of electrostatics, the answer would be obvious - the charges would get redistributed in the ground in order to compensate static field of such charge affecting conductivity of the electrons in the ground. However, in our case we are not talking of static physics. This is pulsating charge, therefore we have to know what is going on with a field of such charge in order to commence exploration of influence of such charge onto the currents/voltages in the ground.

In terms of the Maxwell's equations, such field can be obtained based on well known dynamics of the currents' and charges' densities in the coil+upper toroid and in the ground. It is enough just to integrate late potentials on its volume (vector and nonvector) from the densities or charges and togs and get the description of the field

(i.e., vectors of gradient of the field E and magnetic fields B) at any point of the space including surface of the Earth.

The most challenging thing is that actually we are just aware of the features of charges and currents distribution only in the prototype while the same process in the ground, which occurs due to the pulsating charge of the prototype, should yet be detected as it is not known. The latter will be done after a while.
Final process of the currents and voltages in the ground under prototype consists of two components. One of them corresponds to the process of getting the charge out the ground, another is related to the reacting process of the ground to the field that occurs due to operating process of the prototype. These processes are happening in a simultaneous manner and are of superpositional nature (in other words, any of these processes is independent on its nature and they do not have any effect on each other).

Later we will analyze each process separately as well as we will simulate total mode of the current and voltage waves in the space around the prototype according to the model described above
It is obvious that two conditions should be adhered in terms of establishing as well as distribution and reflection of the currents and voltages in the body of planet:

1) frequency of the process should be such that it could be possible to disregard the losses of polarizing origin in the ground (as in terms of conductivity it still remains dielectric with the dielectric transmittivity values being in the range from 1 up to 100). At polarization of the dielectric, the losses related to the work of external field in terms of polarization with final velocity take place. The slowest polarization mechanism of the polar dielectrics amongst all known ones is referred as *relaxation losses* related to dipole polarization of dielectric. Such kind of the losses can be observed in polar dielectrics - polymers and ferroelectrics and is usually occurring in a field of the frequencies with quite high values at the emergence of hysteresis effect which implies lag in polarization velocity P from the velocity of changing electrical field E. In this case, dipole molecules are not "able" to get oriented in viscous medium of the dielectric upon change in polarity (direction) of electric field. Let us remind that relaxation times t have the values varying within range of $10^{-10}...10^{-6}$ s at dipole polarization. Therefore, relaxation losses can be observed in polar dielectrics within frequency range $f=10^{6}...10^{10}$ Hz corresponding to radio-frequency range. Amount of losses depends on the work performed by alternating electrical field for the purpose of creating polarization of the volume unit of dielectric. As of other polarization mechanisms, relaxation time denoted as t has even smaller value, therefore it doesn't make any difference within our frequency range. Thus, the upper boundary of the frequencies, at which the significant losses take place for the slowest polarization mechanism or polar dielectrics comprising significant part of the volume from the total volume of the Earth, is around 1000 kHz. Considering gigantic distance at which our standing wave is existing, we have to be located far enough from such boundary in order to avoid attenuation of the current and voltage waves in the ground depth. Primary frequency value used by Tesla during his experiments comprised 200 kHz. Such value will be too low to ensure sufficiency of Q-factor value of resonance of current and voltage waves in the planet body for establishing standing waves.
Therefore, it is necessary to find some kind of range up to the upper allowed frequency with the value of 20 kHz (in this case qualitative assessment is possible but elaboration of more precise concept is not likely to happen at the moment).
Namely, this frequency range (at most 20 kHz) is indicated by Tesla in his patent US787412. Despite of the fact that Tesla was conducting his first experiments at quite high frequencies with the values being of 200 kHz, later he was trying to use frequencies with much lower values and he

was stating such thing in patent US787412 as well as in the other sources (for example: since the first attempts the wave lengths have been increased until those advocated by me were adopted The Effect of Statics on Wireless Transmission, January, 1919, pages 627 and 658). Now we can understand why he'd done it.

2) for the purpose of establishing currents and voltage resonance, it is necessary that wave would manage to go through all the conductor (in our case it is a planet) forth and back. This fact is indicated by the Tesla in the patent US787412 as well.
3) external emission losses of the current waves traveling inside of the planet should be minimized. This is possible only in case when the greatest part of energy of the EM-waves emitted by such currents will be reflected from the planet's ionosphere like from the conductor and "recuperated" further into the currents' energy in the planet. It is noteworthy that dependency of the ionosphere's conductivity from the frequency is of nonlinear nature. In addition, ionosphere is not acting as a "mirror" in case of high frequencies. The latter points out at necessity of using only low-frequency oscillations. We will provide more detailed description of such process later on.

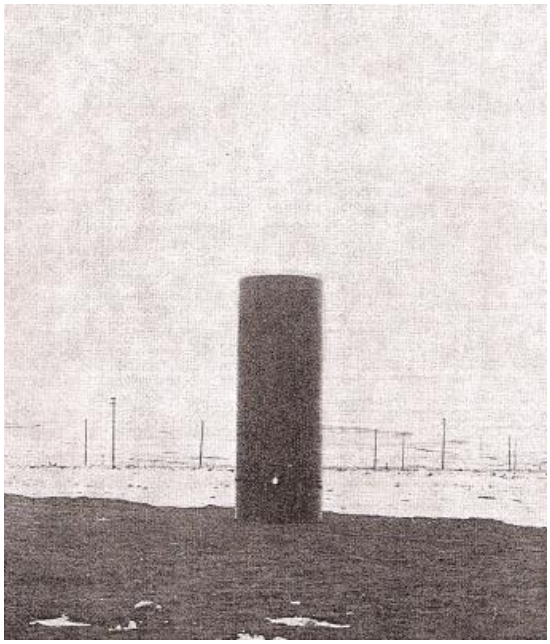
Thus, we come to conclusion that Tesla was referring to the possibility of arranging current and voltage waves and their resonance in the body of planet. For this purpose, Tesla tower fits finely along with its technical features.

In other words, it would be just sufficient to build toroid on top of the ground and on which the electrons would be going in and out in compliance with harmonic law. At that, frequency value would be around 10 kHz and required voltage would have value of dozens of MV (according to the Tesla's calculations). Of course, such parameters can be reached without use of Tesla's scheme, on the basis of modern components only. However, it will be much more complex task to perform than designing the scheme "big inductivity coil plus toroid". At that, this experiment will not bring great results at the frequencies with big values based on reasoning provided above.
Correspondingly, classical understanding of "Tesla booster" is radically different from what Tesla really meant while patenting his tower. It is obvious that this is not a means for creating meters long sparks. This is the wireless means for performing energy transmission over long distances with high value of an efficiency coefficient. Sparks can be considered as unfavorable effect. Therefore, we can see that in reality Tesla prototype should have been made of thick cable with the quarter-wavelength of the reference generator (while classical "Tesla boosters" are made of thin cable with great number of turns and not well thought cable length with pumping frequency of the circuit, required pumping duration is not sustained and the work is performed within high frequency range instead of low one with the values being of 10-20 kHz, i.e. conventional booster designed in unconventional manner is being built).

Computational simulation

So, it is obvious that it is possible to transmit energy via excitation of current and voltage waves in the body of planet. The question is, what kind of value will transmission efficiency coefficient have and how such value will depend on distance to the prototype. This is the issue that has to be thoroughly explored by means of computational simulation as well as conducting of experimental research. Tesla thought that the value may be around 96% and the distances can be endless in terms of energy transmission within planet. However, actual experimented implied energy transmission over 20 miles. Therefore, there is no guaranty that such high efficiency coefficient value will remain same if energy transmission is attempted over longer distances than that pointed out above. It mostly depends on the

conductivity type of the ground (superficial or volumetric), which was really used and was "working out" in Tesla's experiments. The parameters of such prototype are also the subject of great importance (pumping frequency and a value of charge being directed towards upper toroid area). That all has to be checked out. Nevertheless, this kind of transmission can be done via small distances of about 10 miles. At that, if it is true what Tesla was talking about 96% value of efficiency coefficient achieved during energy transmission for such distance then it means that attenuation of the currents in the ground is very small and resonance can be established in extended part of the Earth shell (otherwise energy transmission through radially-directed currents in the ground over distance of 20 miles with efficiency coefficient value being of 96% is not possible as the currents flow from the prototype over all directions and even minor attenuation of the currents' energy would result in almost complete loss of current wave energy in such great distances.

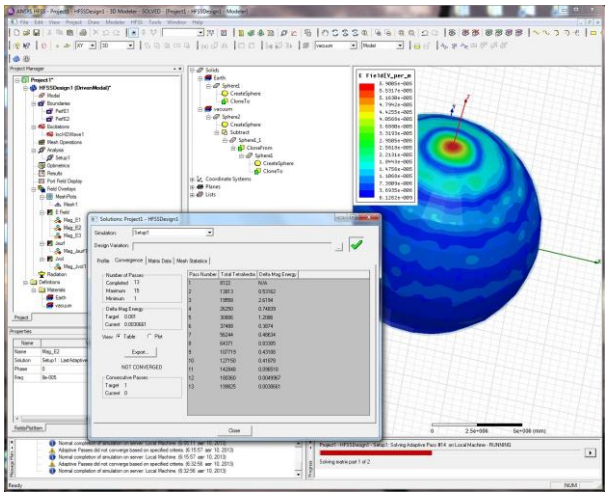


A coil outside laboratory with the lower end connected to the ground and the upper end free. The lamp is lighted by the current induced in the three turns of wire wound around the lower end of the coil.

Ansoft HFSS was employed for the purposes of performing computational simulation of interaction between the tower and the Earth. This is due to the fact that such a tool should be used for the purposes of performing the research analysis of the fields/currents for the dynamic processes in case when the objects' geometry can be commeasured or is significantly exceeding the wavelength.

The Earth's prototype was designed in the form of a ball-dielectric with the diameter of 60km. Unfortunately, it was impossible to create a ball of greater size while using such tool. The ball has basic parameters such as conductivity, dielectric permeability etc, which correspond to those of the real foundations of the ground surface. The real features and parameters of the atmosphere acting as a air layer-dielectric were also taken into account. So were considered these of the ionosphere which is acting as a kind of "mirror" of the energy of EM-waves that are being induced by the current waves in the planet. It is also noteworthy that the date regarding the Earth's properties on the great depth are not of presumable nature. In fact, there is not any generally accepted Earth's prototype existing in terms of its properties at the great depth. However, it is quite obvious that EM-field as well as currents in conductors (and in our case the Earth-dielectric is acting as such conductor) do flow only in superficial layer due to so-called skin-effect. As of the main and the most probable range of the Earth's surface parameters as well as the most used frequencies with the value of 10 kHz, the depth value of a skin layer can account kilometers. Thus, actual process of the current waves' distribution (in case if it really takes a place) happens only in relatively thin superficial layer of the Earth shell. Hence, there is no necessity to make any kind of assumptions regarding internal structure of the Earth and parameters of the materials in the great depth.

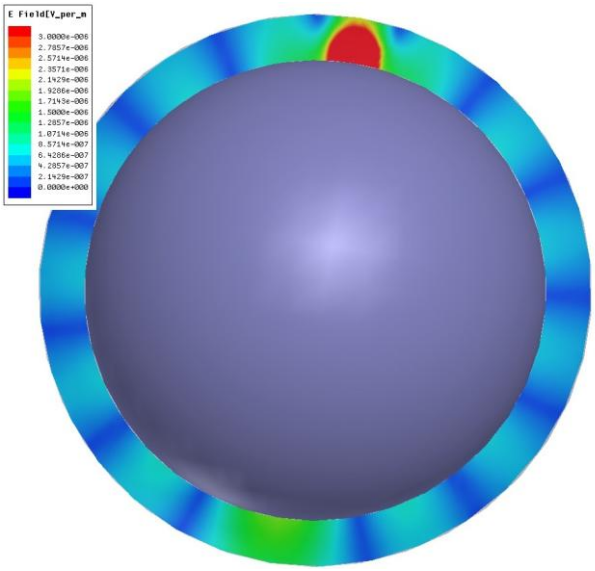
Let us examine the distribution process of the currents' wave in the ground in case when the Tesla's tower is acting as a source under condition of complete absence of an atmosphere and ionosphere. In this case, the wave will progressively travel and quite quickly attenuate, that is, all the wave's energy will be gradually emitting in a form of EM-waves into external space regarding the Earth.



This figure illustrates the pumping source (Tesla's tower), which is located in the red-colored loop. Dielectric field intensity value in the surface of the Earth the ball was derived as well.

However, the situation can radically change given that we add external screen acting as a mirror (please, kindly notice that ionosphere is acting as such mirror for such low-frequency emission range as 10 kHz): reflected energy will interact with the Earth's surface in a form of EM-waves. The latter will result in induction of the currents so that this energy will be transformed back into the currents' energy. Therefore, standing resonance wave of the currents and voltages will appear. The latter can be well seen from the figures provided below.

Volumetric distribution of the amplitude of the electrical field in the air surface between ionosphere and the Earth's surface is shown below.



Cutoff is similar to that shown in the previous figure.

Thus, full-fledged computational model, which considers all basic parameters/geometric features/medium properties involved during functioning process of the Tesla tower, directly conforms a fact of existence of the resonance of standing currents' and voltages' waves in the Earth that are evoked by the operating process of the Tesla Tower. It is also obvious that such resonance allows not only an efficient energy transmission to the planetary distances due to its high Q-factor value, but also its subsequent reception by similar device at any point of the planet.

Globular lightning and Tesla tower

Let us now discuss in more details the mechanism of existence and occurrence of globe lightning which Tesla was observing during his early experiments (there was constant puncture happening in prototype). Tesla was writing next things about it (pages 368-370):
It is clear that such phenomenon really took place. However, what is really such mechanism of
forming and quite lengthy existence of such type of GL about? We think similarly to what Tesla's thoughts were concerning this issue. There is pulsating electrical field of very

high value (around 30 kV×cm that results in air puncture) and sufficiently high frequency value of 200 кHz in local proximity to the prototype as it was indicated in early Tesla's experiments during of which he was frequently observing GL phenomenon. If there is going to happen discharge or puncture in air zone of an external field with such parameters then there is going to occur plasma due to ionization and air warming. Plasma has better conductivity than air does and therefore has inductivity distributed over air volume. In other words, air part transforms to the conductor with restricted dimensions. In locally conductive area, external field will "move" conductivity currents at the field's frequency. The latter will result in heating of plasma and, thus, keep it burning. As a result, field will increase up to sizes at which EM-waves emission, which is proportional to the field size will be of same energy (proportional to the square of radius field - that is, section area of plasmic sphere). Growth of plasmic sphere radius value will stop at this point and plasma will be transformed into quite stable substance (which will be stable while external field is oscillating and GL is still within close distance from field source). Real process has much more complex nature and it is necessary to consider such plasmic area as globe resonator for EM-waves and try to discover all possible resonance modes of such resonator (which are divisible by external field frequency value) etc. However, these GM result from ohmic heating of plasma by alternating electrical field of setup as described by Tesla.

It is noteworthy that some enthusiasts already conducted experimental evaluation in terms of possibility of generating such kind of GL and all basic ideas similar to Tesla's description were completely conformed as well as stable controlled generation of GL of such kind was achieved and conditions, under which such GL occurs, were also identified.
For our Russian reader, we can suggest to kindly take a look at the results obtained upon completion of same series of experiments, which were published in UFN proceedings.
And getting back to the analysis of the Tesla prototype on energy transmission, we come to conclusion that Tesla considers simultaneously few features for the purpose of eliminating risk of puncture formation (discharge arc) in a field of concentration of main reactive energy of the prototype (coil-resonator). So, it becomes obvious that in case of formation of such unit in a coil's proximity (where electrical and magnetic fields are of large size) it is probable that all accumulated reactive energy will move from the prototype to the energy of plasmic formation during short period of time, which will result in explosion. It is especially clear considering specific methods of generating GL in performed experiment, which was described above and main purpose of which was to arrange quick "discarding" of all the energy of resonance circuit into discharge which will result in formation of GL. At that, as such GL appears to be in a field of working prototype, life time of such GL is quite long (measured in seconds) and will be longer the smaller GL will move away from the source supporting its burning (that is, prototype). In case, when the setup is completely deenergized immediately upon formation of such kind of GL, its life time will decrease by many times. The latter has to be examined during upcoming experiments, though.