

Nikola TESLA's Radiations and the Cosmic Rays

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Without doubt Nikola TESLA was one of the greatest experimenters in the field of electricity. With his inventions of the alternating and polyphase current with all his components for generation, transmission and consumption devices TESLA has become famous around the world. TESLA was not much interested in the world of business. He rather continued experimenting for many years after his success with the alternating current systems, while his experimental capabilities has only be restricted by his always tight funds. Especially in his second part of life TESLA has elaborated and realized experiments which have not been reconstructed until these days. Some of them seems to be very promising to overcome the increasing challenges of our society in a better way. By studying many original papers of TESLA this essay tries to reconstruct the visions and conclusions he has got from his experiments.

Introduction

It is astonishing how little can be found in literary about the work of the world-wide known Serbian inventor and experimenter. And this is even more astonishing because all the today used electricity polyphase power systems has been invented in its basic characteristics by Nikola TESLA at a time, whereas the whole world only did know the expensive and very limited direct current systems of Thomas EDISON.

But after this inventions of alternating current systems TESLA has published many, many papers, which are almost forgotten. This papers will be summarized and analyzed. It is shown very impressive that TESLA with his experimental knowledge in physics was far ahead of the theoretical physics of his time. Still today many phrases in this papers have never been understood, has seldom be commented and some have become a mystery.

Almost all publication of the modern world only look at TESLA's work with high frequency and high voltage transformers, better known with the summary term „TESLA coil“. But after his successful work with the magnetic rotary field TESLA has discovered a new kind of rays which he called *radiations*.

It is characteristic for an experimental discoverer that he finds unexpected and new facts and results due to measurements and experiments based on some new conceptual ideas. Because TESLA's practical know-how was so far ahead of the theoretical know-how, the communication to the established science was almost impossible. They didn't simply understand! Probably because of this and also because of financial interests TESLA almost stopped his publications in scientific newsletters since 1899 and since then he only published some material in popular weekly or daily newspapers. Only in the patents some deeper information can be found.

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The Radiations

TESLA has used the term *radiations* for more than 40 years. From different statements and interviews with TESLA always some pieces of information can be found about that, what has kept him busy for the whole second part of his life. From the publications listed in the appendix the following summary about the nature of the radiations can be given:

1. They are small particles of „*infinitesimal*“ size [57], [58].
2. They carry a small, positive charge, which is only a fragment of the elementary charge [58], [65], [66].
3. They penetrate through substance almost without interactions [57], [62], [66].
4. They could achieve a speed far above of the speed of light [57], [58], [66]. This velocity is only limited by the mass to charge ration of the particles [66].
5. They are the cause of radioactivity because they're bombarding and destabilizing the nucleus of the atoms [54], [57].
6. They arrive the Earth form all directions [57], [66].
7. They are emitted form all the stars, therefore also form the sun. This is why this radiation during day is a little bit higher than during night [57], [60], [66].
8. A small fraction of this radiation is absorbed by celestial bodies which causes them to increase in masse and volume continuously [66].
9. They can be proved with vacuum tube experiments [57].

Later TESLA^[54] himself has mentioned 1897 as the year of discovery of the *radiations*. When exactly Tesla was convinced to measure this *radiations* is not precisely known, but should be between the years 1896-1897. What can be said for sure is that TESLA has filed two patents^{[41],[42]} where he describes the utilization of this *radiations* in a crude way.

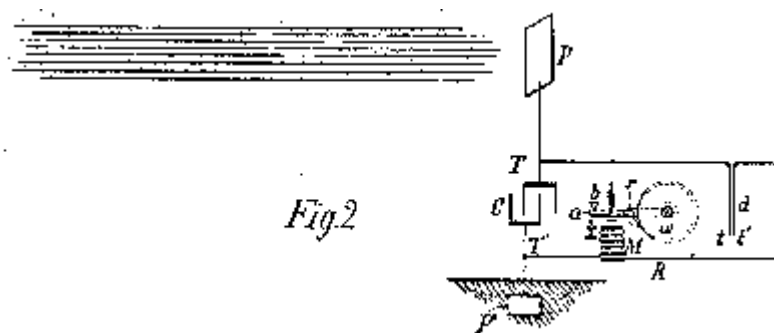


Figure 1: Nikola TESLA, „Apparatus for the Utilization of Radiant Energy“, US-Patent 685,957, issued on November 05,1901, Fig. 2

Also known is, that TESLA presented in his speech before the Institution of Electrical Engineers in London – where he explained many experiments he has done with some special kind of bulbs –an experiment where radiant matter is emitted form a single electrode within a partly evacuated glass bulb (Figure 2).

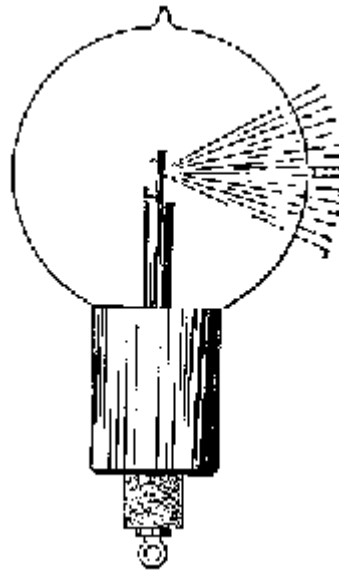


Figure 2: Nikola TESLA, „Experiments with Alternate Currents of High Potential and High Frequency“, February 03/04, 1982

Then Tesla mentioned not only the cosmic space as the source of this radiation but also a glass tube with one single electrode^{[41]-Fig.4}.

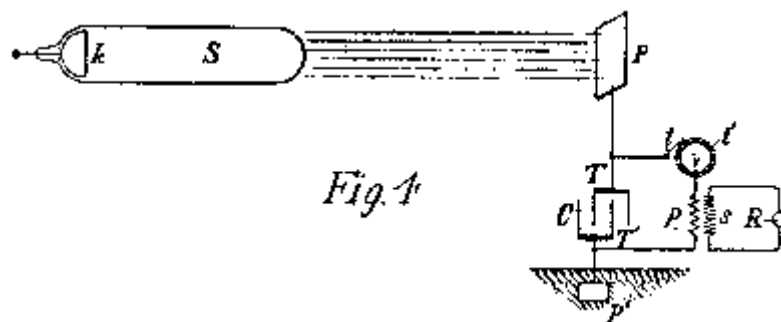


Figure 3: Nikola TESLA, „Apparatus for the Utilization of Radiant Energy“, US-Patent 685,957, issued on November 05, 1901, Fig. 4

Consequently TESLA experimented for decades with vacuum tubes. In his Colorado Springs Notes^{[36]- p.29} three drawings can be found about a simple connected tube with different surrounding constructions (reflectors). This note carries the title „Arrangements with single terminal tube for production of powerful rays.“ The purpose of this experiments can be found in the last sentence: „The capacity would be such as to bring about maximum rise of e.m.f. on the free terminal.“

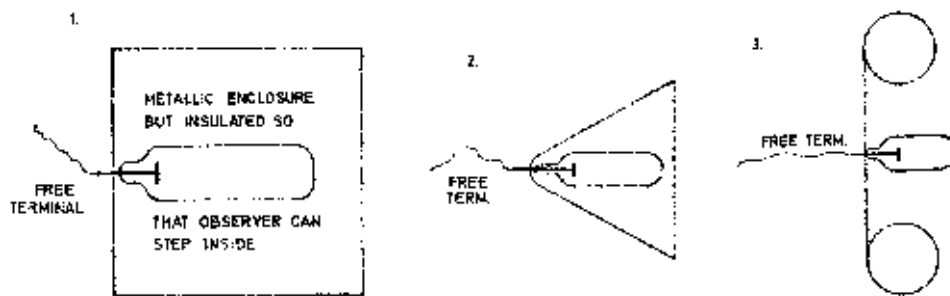


Figure 4: Nikola TESLA, „Colorado Springs Notes“; page 29, June 06, 1899.

37 years later (July 11th, 1937, *New York Times*, page 13) he still writes about the successful construction of a powerful tube with supplementary circuitry which can be operated with voltages far above 100'000'000 volts.

Obviously the key to TESLA's *radiations* lies in his earlier experiments with high frequency currents and voltages. Therefore this passages of his papers, which could probably bring more light on this enigma, should now be examined more closely.

In his first lecture^[18] before the American Institute of Electrical Engineers on May 20th 1891 TESLA describes merely his inventions and discoveries with partly evacuated glass bulbs. He describes the fascinating properties of Professor CROOKES's radiometer. He founds, that the bombardment of the residing charges within the glass bulbs cause the heat production at the spherical single electrode of his spherical bulbs. Until these days he has perfected the production of high frequency generation with high voltages to examine leading experiments with cathode rays.

One must remember this area at the beginning of the last century full of new discoveries. The atom was totally unknown except that it can not be decomposed into smaller parts. The constituents of an „electric flux“ (LENARD rays, named after Philip LENARD 1862-1947) in a vacuum tube was totally unknown. Then in August 1874 George Johnstone STONEY^[16] has postulated with his examinations of electrolytic liquids a certain small amount of electricity E_r , which he named in October 1894 with the name „electron“. William CROOKES^{[2],[4]} published 1878 and 1879 his experiments with cathode rays. Wilhelm Conrad ROENTGEN^[15] discovered new penetrating rays on November 08, 1895. And some months later Antoine Henri BECQUEREL^[1] speaks on February 24th, 1896 before the French Academy of Science about a new radiation emitted form phosphorescent materials. Then in October 1897 Joseph John THOMSON^[70] has first confirmed the existence of the electron.

Different experiments with vacuum tubes and photographic plates has characterized this time of discoveries. With his high frequency lighting system TESLA already has had a broad experimental experience with vacuum tubes and high voltage equipment. Obviously TESLA has forced his experiments to higher and higher frequencies and voltages. The original lamp more and more transformed into electron tubes which has later on be built by TESLA in hundreds of variants. With the use of his high voltage systems TESLA was able to accelerate electrons to extremely high velocities.

TESLA has produced many photographs with his powerful electron tubes but despite of some sharp shadows on his photo plates he did not recognize the new kind of X-rays, which later has been reported by ROENTGEN. Then with the announcement of ROENTGEN the main focus of TESLA was directed away from electron rays toward the discovery of new rays. Probably TESLA did not firstly report of this new kind of rays because of the fire in March 13 1896 in his New York laboratory which has destroyed almost all

apparatus and papers totally. So the official discovery of the X-rays has been done by ROENTGEN. This was TESLA's first missed Nobel price.

In the year 1896 TESLA published a remarkable series of articles in the *New York Electrical Review* about his work with ROENTGEN rays. Soon on March 11, 1896 he presented his first Roentgen pictures which he has produced with his high frequency coils and vacuum tubes. Obviously the peculiar construction of his vacuum tube with only one single electrode is very important. TESLA writes about it^[20]: »Clearly, if we put two electrodes in a bulb ..., we limit the potential, for the presence not only of the anode but to any conducting object has the effect of reducing the practicable potential on the cathode.«

A week later on March 18, 1896 TESLA^[21] describes that he can produce radiographs at a distance up to 40 feet. At that time this was an enormous distance for the transmission of Roentgen rays through air.

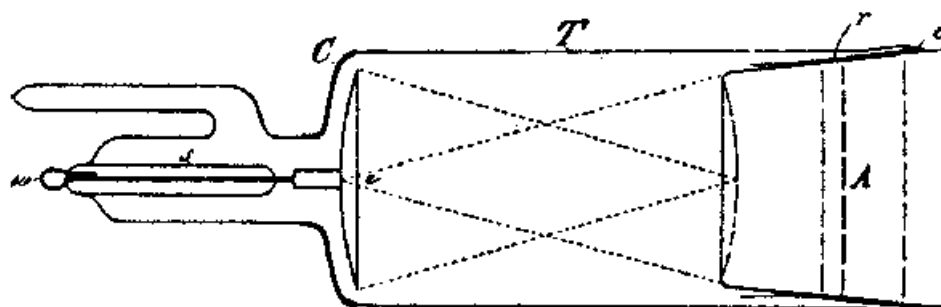


Figure 5: One of Tesla's Roentgen tubes with one single electrode (from [30]).

On the 1st of April TESLA^[23] shows that ROENTGEN rays can be reflected. He made his experiments not only with conducting reflectors. According to TESLA the insulator Ebonite has the same reflection index as copper. This shows, that besides the ordinary reflection of ROENTGEN radiation TESLA has produced a secondary effect today known as Back Scattering Electrons (BSE). This BSE effects depends solely of the reflector's density and not on its conductivity. And this was also mentioned by TESLA. Then TESLA reports that he did not succeed with the deflection of ROENTGEN rays despite the fact he has used many different kinds of glass lenses.

On April 8th he reports more on the impossibility of the deflection of ROENTGEN rays and also writes about experiments^[24] with multi-layered metal reflectors. But despite of a great effort it was not possible to reflect more that a few percent of the incoming rays.

On April 22nd TESLA^[25] believes that the LENARD and ROENTGEN rays are almost identical, except that the ROENTGEN rays do have a much higher velocity. In addition he postulated that the order of the reflecting metals due to their reflection capabilities are equal to the series of voltage elements according to Alessandro VOLTA. From this TESLA concluded that the ROENTGEN rays are made of the same agent as that, what is responsible for the different voltages between two metals. With this he was partly correct and partly not, as we know today. Obviously he mixed the ROENTGEN radiation (electromagnetic waves or high energy photons) with the electrons, but he recognized correctly, that the reflected particles (BSE electrons) are identical to the particles (valence electrons) which cause the voltage between different metals.

This publication^[25] of TESLA is also of a particularly interest in connection with his later statements^{[61],[65]} about the sun.

On June 08th TESLA describes the source of the ROENTGEN rays as this place, where the LENARD rays impact the first time on an obstacle. This obstacle could be the glass wall of the vacuum tube or a metal plate placed within the tube. Today this radiation is well known as bremsstrahlung, but at the time of TESLA's experiments and years later this was not known in theoretical science.

On August 12th 1896 TESLA^[27] is absolutely sure about the corpuscular nature of the ROENTGEN rays and presents eleven reasons for this. The ROENTGEN rays consists of the same but much faster particles than the LENARD rays. Also TESLA reports the exposure of photo plates up to a distance of 30 meters.

On December 02nd 1896 TESLA^[28] describes the particle nature of the ROENTGEN rays in more details. Now he distinguished the ROENTGEN rays clearly between the LENARD rays and he compares the ROENTGEN rays similar to the disassociation process of Lord KELVIN's aether atoms^[71]. This particles of a „primordial form“ are created after the impact of Lenard rays on an obstacle and then they have different intensities and velocities.

On April 06th 1897 TESLA gave a lecture before the New York Academy of Sciences entitled with *The Streams of Lenard and Roentgen and Novel Apparatus for Their Production*, which has never been published by him in a written form. A reconstruction of this lecture has been done by Leland ANDERSON^[30]. In this lecture TESLA has made a very astonishing claim, then he said, that he has succeeded to deflect the LENARD rays as well as the X-rays with a magnet. This has been published by the *Electrical Engineer*^[31] in a short notice on April 14th 1897 as well as by the *Electrical Review* with the same date^[32] and again on August 09th 1897^[34].

On May 05th 1897 TESLA^[33] assigned a small electric charge to the particles of the ROENTGEN rays and states, that this rays are able to transmit a huge amount of electricity.

Then on August 11th 1897 TESLA^[34] confirms again his statements in the lecture of April 06th about the deflection of ROENTGEN rays with magnetic fields and promises to publish this experiments to a later time. But unfortunately a publication about this very important experiments has never been done, as far as the author knows. In opposite, from this time on TESLA's publications has been dried up for decades. One reason for this was certainly the protection for further patent applications for the utilization of this rays, then a mayor part of TESLA's financial income was derived from (sometime only hoped) patent license fees.

Analysis

Many things points to the fact, that TESLA has observed the classical ROENTGEN rays as an effect of the Bremsstrahlung. His particle theory was as correct as the wave theory, then today we know of the quatisized nature of the electromagnetic radiation and it is common to describe light with photons. It seems as TESLA has recognized the particle character of electromagnetic radiation correctly. TESLA has used the following causal chain for the description of the production and effects of ROENTGEN rays:

1. The LENARD rays consists of sub-atomic particles analogue to the KELVIN's aether vortexes, which travel with a velocity between hundred and several thousands kilometers per second.
2. If this particles of the LENARD rays impact on an obstacle then this particles are disassociated and the result of the impact are much smaller particles, which now travels with higher speed than the particles of the LENARD rays.

3. Not all particles of the LENARD rays are disassociated on the first obstacle. The thicker the obstacle the intense are the resulting ROENTGEN rays.
4. This smaller particles correspond to the ROENTGEN radiation. It is not possible to deflect ROENTGEN radiations with glass lenses but they can be reflected on conducting surfaces.
5. This granular ROENTGEN rays are capable to charge distant ball capacitors positively. Therefore the particles of the ROENTGEN rays are charged positively. Thus the rays of LENARD and ROENTGEN are very similar in nature.
6. If the ROENTGEN rays are composed of electric positive and fast particles, it must be possible to deflect this rays with magnets. According to TESLA this can be proved with a sensitive measuring device.

Now we try to translate TESLA's causal chain into the terminology of today's physics:

1. The LENARD rays consists of electrons, which can travel close to the speed of light if the accelerating voltage is high enough.
2. If this electrons impact on an obstacle they are highly accelerated. The result of the impact are emitted high energy photons (bremsstrahlung) which now travels wit the speed of light.
3. Not all electrons are absorbed in the first obstacle. The thicker the obstacle is made the longer is the (negative) acceleration of the electrons and the intense is the resulting ROENTGEN radiation.
4. This high energy photons correspond to the ROENTGEN rays. The frequency range of this photons is far above visible light. Therefore ROENTGEN radiation can be deflected with optimized crystal lenses (1912 discovered by Max von LAUE) but not by ordinary glass lenses. They also can be reflected on metallic surfaces.
5. This high energy photons are able to knock out electrons form distant conductors so that this conductor is charged positively.
6. Electromagnetic waves, and therefore also the photons, can not be deflected with magnetic fields. But a rotation of the light's polarity can be done (known as FARADAY effect).

Except the last point all of TESLA's statements are well known today and can be explained by known physical models. The decisive question lies in the deflection of such rays which TESLA called ROENTGEN rays with magnetic fields.

Only once TESLA^[25] gives probably a hint about a possible experimental device. There he references to a ball-shaped vacuum tube developed by him without a metallic anode or cathode, which he has presented^[20] in 1892 on the first time (figure 6).

If the tube is exited with his high frequency coils for a certain time between some hours and a few weeks, a thin sensible light can be observed in this tube which can be compared best with a brush. This week light stream is never in rest but is always moving. The positions of this light reacts very sensitive on external magnetic fields. If, for example, the bulb hangs down straight to the Earth's center, the Earth's magnetic field forces the light brush to rotate clockwise.

If TESLA really has used such sensitive devices for the measurement of the deflection is not known for certain. Also a text passage of his lecture held on April 06th 1897 which was reprinted in the *Electrical Engineer*^[31] does not gives more help. Then it is also possible that TESLA has deflected electrons or ions with a magnetic field, which then has charged a distant capacitor.

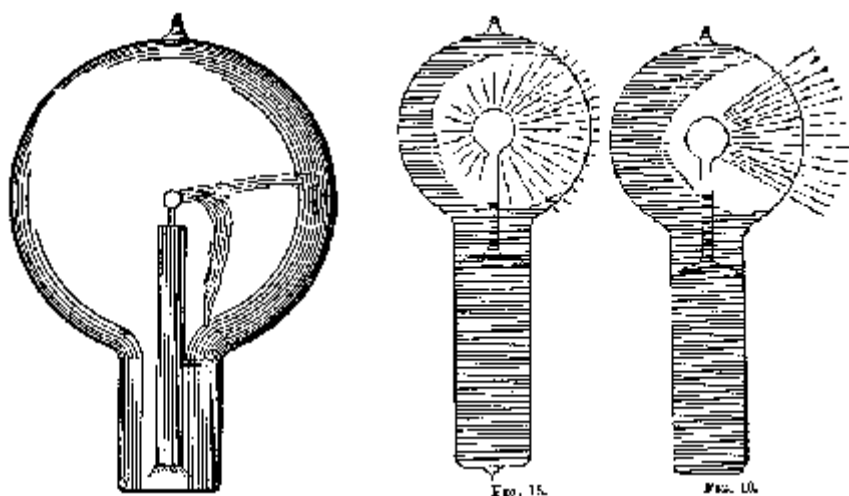


Figure 6: Nikola Tesla, „Experiments with Alternate Currents of High Potential and High Frequency“, February ¾, 1882; the rotating brush bulbs

If TESLA's observations are correct, then he has produced at least two different effects outside his vacuum tube under high voltage pressure. One effect was the high frequency ROENTGEN radiation and the other effect was of a corpuscular nature. Then the corpuscular effects are only detectable for very high accelerating voltages for the electrons in the vacuum tubes, if this electrons impact at the end of the tube with high energy and not release the whole energy into the ROENTGEN radiation due to bremsstrahlung. The simultaneous appearing of two different effects could explain many inconsistencies of TESLA's statements. Once the fresh discovered Roentgen rays can be deflected by a magnet, an other time not. Once a photographic plate can be exposed at a distance of over 30 meter through air without problems^[27], an other time this is only possible for close plates. Later TESLA recognized this parallel effects and has decided to proceed further with the particle ray model only which does not diminish with the $1/r$ law as known from electromagnetic radiations. This particle rays can be focused so that they are able to transmit large amounts of energy without losses^[63]. We can suppose that TESLA^[75] was able to make such transmissions with voltages of 4 million volts at his New York laboratory already in the year 1898.

Some phenomena of this TESLA experiments can be explained with today's knowledge. The main difficulty for a further analysis is the mixing in his original papers of the effects of electromagnetic waves and of the effects of particle beams. As long as not more information is available we only can speculate now which particles represent TESLA's *radiations*.

Which particles TESLA has generated and transmitted from one point to an other? When looking at his enormous voltages it is clear that TESLA has worked with some kind of a linear accelerator for electrical charges which was able to accelerate electrons up to energies of 2.4MeV. Later TESLA has worked with voltages of 10MV, what makes even higher electron energies possible. And if the particles are electrically charged, there is the next problem, then TESLA claimed, that the charge of such a particle is only a fraction of the elementary charge (of an electron). Beneath the quarks no elementary particles with a smaller charge than the elementary charges are known.

There has been the suggestions^{[72], [11]} that TESLA's *radiations* can be interpreted as neutrinos but also other particles are possible candidates for this *radiations*. Then neutrinos doesn't have an electrical charge and only a small rest mass (energy). Despite to the

fact that neutrinos do fit well to most characteristics of the radiations listed in the first section of this chapter it is not very likely that they constitute the main part of TESLA's *radiations*.

It is still not possible to say exactly how TESLA has found his statements about the corpuscular nature of the radiations. If, for example, we compare a statement TESLA's^[68] about the conservation of electrical charge, then it is also possible to interpret this statement in an other way. There TESLA has claimed that the electric charge is growing with increasing velocity and that the velocity of such charges easily can exceed the speed of light. The author^[73] has shown, that this view of TESLA can be interpreted from a conventional standpoint and that therefore this statement TESLA's should not be weighed to much.

And finally on one occasion TESLA^[62] describes the *radiations* similar to small ball lightning or, in modern words, as *high-density charge clusters* known from Kenneth SHOULDERS^[16].

It can be concluded from the above analysis the TESLA's *radiations* are particle rays consisting of minute charges and do not have many in common with an electromagnetic wave or photons. But this is all what can definitively be said about the nature of the *radiations*. Probably an other discipline of physics about the *cosmic rays*, which are very close connected to Tesla's radiations, can provide more information.

The Cosmic Rays

These *radiations* – which reach the Earth from all directions from outer space – are the fundament on which TESLA has founded his ideas for the utilization of a new and ecological energy source since the year 1900. Again TESLA was ahead of his time then only in 1912 Viktor Franz HESS^[7] has succeeded to prove to existence of cosmic rays with balloon experiments by rising balloons carrying electrometers in board on an altitude of about 17'500 feet and later up to 28'000 feet. For this investigations HESS has been nominated for Nobel price of physics in 1936. This is the third missed Nobel price for TESLA.

The source of this cosmic rays, as this rays are called today in science, are at least for its high energy constituents still in discussion^[5], the measuring methods too. The cosmic rays close to Earth are measured with balloons or satellites and with a more indirect method by the measurement of its secondary radiations in the atmosphere.

The composition of this cosmic rays is complex. In terms of numbers there predominate the photons and neutrinos as well as the lighter particles as electrons or positrons but also protons and alpha particles. But also much heavier nucleus as for example iron can be found. Outside of the Earth's atmosphere the particles of the cosmic rays travel close to the speed of light and therefore some of them have a very high kinetic energy. But still today it is not known in detail what is the cause for the propelling force which drives the cosmic rays.

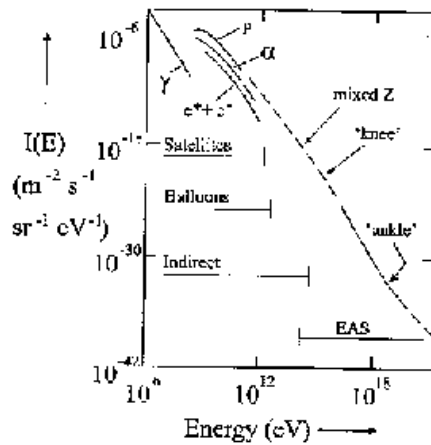


Figure 7: Energy spectra (intensity) of cosmic rays on measured Earth surface; from ERLYKIN A. D and A. W. WOLFENDALE, „The origin of cosmic rays“, *European Journal of Physics* **20** (1999) p410

The very high particles with much more kinetic energy than the main part of the cosmic rays can be seen clearly (please note the logarithmic scales in figure 7). The distribution of the different particles relative to the numbers of Silicon is shown in figure 8.

Now, due to the Earth's magnetic field the electrons are deflected far away from the Earth and do either pass the Earth or do come in more in the polar regions (aurora borealis). If the cosmic rays in outer space may be electrically neutral in average, as it is commonly suggested, then it is even possible that the heavier particles really reaching wide areas of the Earth (i.e. not polar areas) and there a net positive electrical charge can be measured in atmosphere.

This has been observed by TESLA^[66]. Therefore he suggested the sun and other stars are charged positively and they continuously emit positive charges into space. This charges are then absorbed by the relatively negative charged planets. According to TESLA^[65] the sun would have an electrical charge of $5.0 \cdot 10^{19}$ COULOMBS whereas the relative charge of the sun against the Earth is „only“ $216 \cdot 10^9$ COULOMB's. The question how he has determined this values he has never answered.

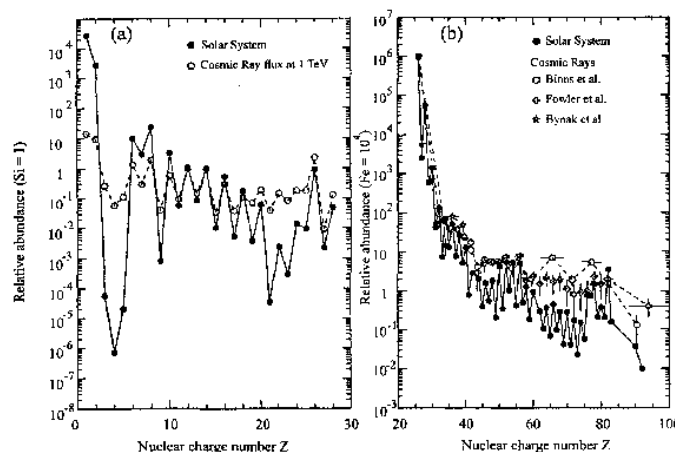


Figure 8: Relative distribution of the positive ions of cosmic rays on Earth's surface; from ERLYKIN A. D and A. W. WOLFENDALE, „The origin of cosmic rays“, *European Journal of Physics* **20** (1999) p411

Probably TESLA^[39] has determined this values with an experiment he reported in January 1901. Here he writes about a remarkable property of elevated ball capacitors. According to his publication the capacity increases with its height about ground with ~0.5% per feet. But this is not all. In addition it is possible to measure a seasonal and a daily variation of the capacity. The seasonal variation shows a maximum in summer and a minimum in winter and the daily variation has its maximum during night. With this experiments TESLA didn't measure the capacity C of the elevated sphere directly. He has always measured the resonance frequency of the sphere capacity together with his coil arrangement^{[36]-14.09.1899}. If he rised the sphere he has in turn needed to remove some windings of one of his coils to establish the same resonant frequency as before. The dependency of the capacity from the relative position to the sun is interesting. Because there are no more data available the author can only assume that TESLA has determined the charge of Earth and sun with this measurings.

TESLA's assumed the potential difference between sun and Earth (and also between the sun and other planets) is the cause for an electric current of positive particles. TESLA^[68] has then taken an analogy of this electric current through space to Earth with one of his patents^[19] about a lighting system with only one supplying wire. And according to his thoughts this energy should not fall on Earth without a technical use. Merely this cosmic particle rays should somehow be collected – for example with apparatus described in a patent^[41] – and infused to Earth through a transformer to obtain electrical energy to drive machinery.

Because of the ionizing characteristic of the incoming high energy proton radiation many decay by-products are built when the protons collide with gas molecules of the upper atmosphere. From this incoming rays the atmosphere is finally charged slightly positive whereas the Earth has a slightly (relative) negative charge. Because of this on the Earth surface there always are some free electrons available which play an important role in nature.

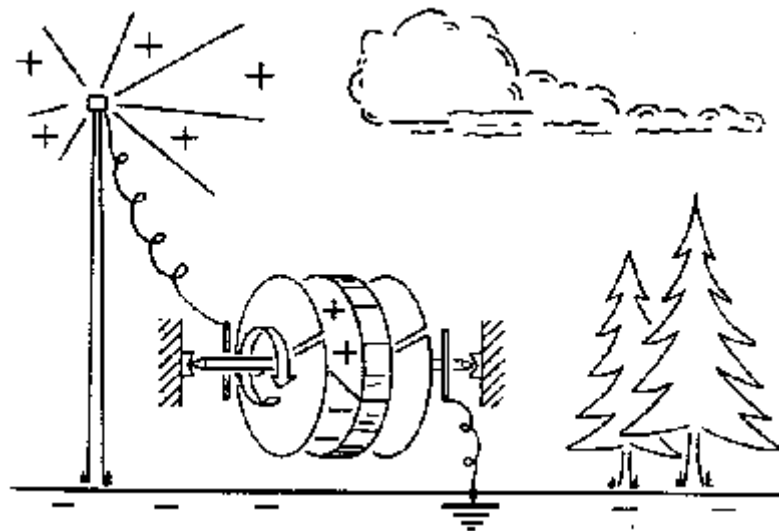


Figure 9: Driving an electrostatic motor wit the positive electric field of the atmosphere; from JEFIMENKO Oleg D., *American Journal of Physics* **39** (July 1971) p.777

With an abstract formulation the solar wind can be regarded as a superimposition of positive and negative direct currents from which a small fraction is available on Earth's surface. If we check this model with the method described in TESLA's patent^[42] to receive the radiations, it is clear, that with this solar wind alone not energy is available. Oleg

JEFIMENKO^[9] (figure 9) has shown with a particular rotating device that the simple collection of electrons in the near-Earth atmosphere can be done by using electretes (the electric analogy to the permanent magnet). With this rotating machine it was possible to draw the atmosphere's electrical energy directly into mechanical motion with a maximum power output of about 100 watts.

But a real analogy to TESLA's lighting patent^[19] is only given, when not the direct current feature of the solar wind is used, but instead a novel, not recognized and from TESLA^[68] postulated alternating current capability of the cosmic rays would be imagined. Then not the transport of charges to Earth itself is important but merely their longitudinal oscillations between sun and Earth. Then in analogy to TESLA's patent^[19] the solar wind is considered as the required oscillating medium (air). This now would be a real longitudinal wave consisting of oscillating charges.

Then the primary force does not act with a constant push but as an alternating source. About the frequency of this oscillation TESLA didn't not give further information. Shortly before his death he has made the following statement^[68]: *»The effects at great elevations are due to waves of extremely small lengths produced by the sun in a certain region of the atmosphere. This is the discovery I wish to make known.«* Today we know that the atmosphere has two 'windows' which can be passed well by electromagnetic radiation. The best known window lies in the range of the visible light and encloses a side window which covers a part of the infrared spectra. The second window lies in the short wave and ultra-short wave frequency range of 3MHz up to 3GHz. According to the patent^[38] TESLA's experiments in Colorado Springs has also been executed with frequencies of about 5MHz. This is just in the second window. But this is only a weak declaration then the searched longitudinal waves could also use other windows not suitable for electromagnetic radiation. For the search of the frequency one statement may be of interest, then TESLA^[61] mentioned that in the year 1900 – this is during the experiments in Colorado Springs – he has worked with wave lengths of one or two millimeters which corresponds to an average frequency of about 300GHz.

If such longitudinal waves between the celestial bodies really exists then every planet would be in contact with other planets and with other stars with this waves. Such a model is compliant with some older models of natural science – for example with astrology – but is not known in today's science. On the other hand the author does not know any measurements on the cosmic rays where superimposed high frequency oscillations have been searched.

Primary and Secondary Cosmic Rays

TESLA^[61] explains his model about the cosmic rays in two steps. If the primary rays collide with particles and atoms in space in-between sun and Earth a secondary radiation is created. According to Tesla this unknown primary rays are the cause of the ordinary cosmic rays for example reported by BOTHE and KOHLHÖRSTER^[2]. In addition TESLA^[61] says that this primary rays are the cause of radioactivity.

Accordingly the candidates for this arriving cosmic rays are high energy positively charged ions and atom nucleus which then causes the secondary radiation observed close to Earth's surface. The cause for this high energy cosmic rays is not known exactly still today. FRIEDLANDER^[6] for example describes the wide uncertainty as follows: *»No model yet satisfactorily encompasses all of our knowledge. The changing views of partisans in this long-running debate provide a fascinating insight into the swings of fashion and consensus. What I outline here is the model that now has wide support; it provides a framework within which to plan further observations and to judge the significance of each piece of evidence. ... Supernovas are now generally considered to be the best candidates for Cosmic Ray sources, either directly or indirectly. The evidence is circumstantial but persuasive, comprehensive but not yet compelling.«*

And still today in the year 2000 the source of this high energy rays is not known better. Some time ago there has been popped up the idea^{[72],[111]} that TESLA's described characteristics of the radiations could be covered completely with the neutrino. The propelling force of the cosmic particle rays can at least partly be explained with interactions with also emitted neutrinos. This could help to explain the cause of the cosmic particle acceleration. Then in terms of TESLA the neutrinos could be the energy source (primary rays) of the steady accelerated particles (secondary rays). According to actual models^[10] the energy radiated away by the sun consists of about 97% of photons and particles. The remaining three percent are radiated with the kinetic energy of neutrinos. But actually only 50..70% of the expected neutrinos seems to reach the Earth^[10], the others get somehow "lost" during their journey through space.

With a world-wide great effort the neutrino flux through Earth is measured with different detectors since over thirty years. If we now imagine that they interact with other matter in space during their flight and gives off more and of their kinetic energy away to this matter, it can probably be explained why on Earth less neutrinos are detected than expected by physical models. At least in a qualitative way the problem of missing solar neutrinos can be explained with the absorption of cosmic particles.

In this way the neutrinos may deliver a part of the propelling energy to the high energy cosmic rays, which has traveled a long way until they reach the Earth. A direct coupling to this neutrino flux seems to be a theoretical possibility to tap a new source of energy^{[72],[111]}, but this is extremely difficult to do with the technology available today. And because it is expected that the neutrino flux represents only about 3% of the total solar energy output, they stand not in first line as candidates for tapping the cosmic rays.

Longitudinal Wave Coupling to the Cosmic Rays

A coupling on the herein postulated longitudinal oscillations of the cosmic rays could rather be done than a coupling to the neutrino flux. And probably it was this what TESLA^[50] intended to do with his project "*Magnifying Transmitter*" in Wardencliffe.

To sum it up it can be said the following assumption: If TESLA speaks of electric longitudinal waves similar to sound waves then he really means a longitudinal oscillation of charged particles, which are the transport medium for energy transmission. At least this is the case with his experiments about a conductor-less (wireless) transmission of energy^[37] or of the system of electric lighting^[19] using only a one-wire supply. In all these cases the involved charges of the Earth, the atmosphere or even in his partly evacuated tubes oscillate in a longitudinal direction. Therefore not a new longitudinal electric field with a high range must be searched but merely longitudinal forces with a short range, namely to reach the next charge. So each receiving charge in turn becomes to a transmitting charge (similar to HUYGEN's principle^[8] of wave propagation in a medium). In opposite to the models of radio wave technology over large distances a TESLA wave needs matter (i.e. charges) for an optimal expansion. Therefore in an absolute vacuum no longitudinal waves are possible, or the range of this wave becomes very short. And this oscillating matter for TESLA's longitudinal waves are the cosmic rays itself.

The formula of a longitudinal effect of a moving and accelerating charge on an other free charge are known^{[73],[74]}. This effect diminishes with a spherical radiation if there are no more charges in-between. But if it is somehow arranged that the longitudinal oscillations are aligned and focussed in a certain direction the whole energy of the transmitter oscillations is transported to a receiver without mayor losses and without diminishing with the distance. If TESLA^{[62],[63]} intended to drive his death rays^[69] with such longitudinal waves is not known for certain.

On this point a new consideration of figure 2 and 3 can be done. It can be imagined that TESLA didn't only collect the static available charges of the atmosphere and draws them through a linear load as for example done by JEFIMENKO. He has operated his

radiations receiver as an oscillator with interrupter circuitry. And if one is only interested to collect free charges one does not continuously break the (direct) current flow. This alternating oscillation induction in the receiver does only make sense if one is interested in resonance coupling!

A coupling to a new and clean cosmic energy source, as TESLA^{[18],[20]} has mentioned over decades, means a coupling to the hypothetical longitudinal oscillations of the cosmic rays which reach the Earth day and night from all directions. If this oscillations really exists is not known. But if they exist, then the author is convinced, that they can be used to tap a new energy source on Earth as well as in outer space. Only with detailed and strongly focussed measurement on Earth (or in space) more information can be obtained about the feasibility of TESLA's visions.

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Appendix: Chronological Selection of important Statements of Nikola TESLA about *Radiations* and *Cosmic Rays*

It may be helpful for the reader, if he does not have to search all the referenced publications and quotations of TESLA with troublesome work. For this a condensed selection of important original passages of his publications are reprinted here. They are not complete but the author hopes they may animate the reader to read more original papers of TESLA. Then, the reader will soon recognize that some texts do correspond, some not. This is the reason why an exact interpretation and translation into today's knowledge is very difficult.

§1 20. Mai 1891^[18]: » *We are whirling through endless space, with an inconceivable speed, all around us everything is spinning, everything is moving, everywhere there is energy. There must be some way of availing ourselves of this energy more directly. Then, with the light obtained from the medium, with the power derived from it, with every form of energy obtained without effort, from the store forever inexhaustible, humanity will advance with giant strides. The mere contemplation of these magnificent possibilities expands our minds, strengthens our hopes and fills our hearts with supreme delight.*«

§2 03/04 February 1892^[20]: » *Ere many generations pass, our machinery will be driven by a power obtainable at any point of the universe. This idea is not novel. Men have been led to it long ago by instinct or reason. It has been expressed in many ways, and in many places, in the history of old and new. We find it in the delightful myth of Antheus, who derives power from the earth; we find it among the subtle speculations of one of your splendid mathematicians, and in many hints and statements of thinkers of the present time. Throughout space there is energy. Is this energy static or kinetic? If static our hopes are in vain; if kinetic – and this we know it is, for certain – then it is a mere question of time when men will succeed in attaching their machinery to the very wheelwork of nature.*«

§3 18 March 1896^[22]: » *“I state this merely for the sake of correctness of my communication, but, as far as the general truth of the fact of taking such a shadow at the distance given is concerned, your caption might as well stand, for I am producing strong shadows at distances of 40 feet. I repeat, 40 feet and even more. Nor is this all. So strong are the actions on the film that provisions must be made to guard the plates in my photographic department, located on the floor above, a distance of fully 60 feet, from being spoiled by long exposure to the stray rays.” ... »We have to deal here, evidently, with a radiation of astonishing power, and the inquiry into its nature becomes more and more interesting and important.« ... »In my attempts to contribute my humble share to the knowledge of the Roentgen phenomena, I am finding more and more evidence in support of the theory of moving material particles. It is not my intention, however, to advance at present any view as to the bearing of such a fact upon the present theory of light, but I merely seek to establish the fact of the existence of such material streams in so far as these isolated effects are concerned. I have already a great many indications of a bombardment occurring outside of the bulb, and I am arranging some crucial test which, I hope, will be successful. The calculated velocities fully account for actions at distances of as much as 100 feet from the bulb, and that the projection through the glass takes place seems evident from the process of exhaustion, which I have described in my previous communication. An experiment which is illustrative in this respect, and which I intended to mention, is the following: If we attach a fairly exhausted bulb containing an electrode to the terminal of a disruptive coil, we observe small streamers breaking through the side of the glass. Usually such a streamer will break*

through the seal and crack the bulb, whereupon the vacuum is impaired; but, if the seal is placed above the terminal, or if some other provision is made to prevent the streamer from passing through the glass at that point, it often occurs that the stream breaks out through the side of the bulb, producing a fine hole. Now, the extraordinary thing is that, in spite of the connection to the outer atmosphere, the air can not rush into the bulb as long as the hole is very small. The glass at the place where the rupture has occurred may grow very hot – so such a degree to soften; but it will not collapse, but rather bulge out, showing that a pressure from the inside greater than that of the atmosphere exists. On frequent occasions I have observed that the glass bulges out and the hole, through which the streamer rushes out, becomes so large as to be perfectly discernible to the eye. As the matter is expelled from the bulb the rarefaction increases and the streamer becomes less and less intense, whereupon the glass closes again, hermetically sealing the opening. The process of rarefaction, nevertheless, continues, streamers being still visible on the heated place until the highest degree of exhaustion is reached, whereupon they may disappear. Here, then, we have a positive evidence that matter is being expelled through the walls of the glass.«

§4 22 April 1896^[25]: »...we shall be justified to draw the following conclusions: first, the highly exhausted bulb emits material streams which, impinging on a metallic surface, are reflected; second, these streams are formed of matter in some primary or elementary condition; third, these material stream are probably the same agent which is the cause of the electromotive tension between metals in close proximity or actual contact, and they may possibly, to some extent, determine the energy of combination of the metals with oxygen; fourth, every metal or conductor is more or less a source of such streams; fifth, these streams or radiations must be produced by some radiations which exist in the medium; and sixth, streams resembling the cathodic must be emitted by the sun and probably also by other sources of radiant energy, such as an arc light or Bunsen burner.«

§5 March 1897^[29]: »But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts for a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all-dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered.«

§6 14 April 1897^[31]: Mr. Tesla stated, that he had also succeeded in deflecting the Roentgen rays by a magnet. He had proved this by deflecting the rays into a condenser placed a long distance from the source of the rays, and which in 5 seconds was charged sufficiently to throw a galvanometer needle off the scale.

§7 14 April 1897^[32]: Mr. Tesla announced two important discoveries relating to the Roentgen rays. First, he said he had discovered a new and powerful source of the rays in an electric arc formed under peculiar conditions. The second discovery was the deflection of the Roentgen rays by means of a magnet. This

discovery is particularly important in establishing the identity of the Roentgen rays, and those discovered by Lenard in 1891, and is, therefore, one of the most valuable contributions to our knowledge of these rays. ... To a few interested scientific men Mr. Tesla showed a great number of diagrams illustrating experiments he had performed which tended to prove the correctness of the views he holds in regard to the Roentgen phenomena being caused by material particles projected with great velocity.

§8 05 May 1987^[33]: *»We have absolute experimental evidence that particles or rays, to express myself generally, convey an immense amount of electricity, and I have even found a way of how to estimate and measure that amount.«*

§9 11 August 1897^[34]: *“I did, however, on that occasion [6. April 1897 vor der New York Academy of Science, Anm. d. Autors] illustrate and describe experiments in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity of the rays named after these two discoverers.”*

§10 30 November 1898^[35]: *»As to the idea of rendering the energy of the sun available for industrial purposes, it fascinated me early but I must admit it was only long after I discovered the rotating magnetic field that it took a firm hold upon my mind. In assailing the problem I found two possible ways of solving it. Either power was to be developed on the spot by converting the energy of the sun’s radiations or the energy of vast reservoirs was to be transmitted economically to any distance. Though there were other possible sources of economical power, only the two solutions mentioned offer the ideal feature of power being obtained without any consumption of material. After long thought I finally arrived at two solutions, but on the first of these, namely, that referring to the development of power in any locality from the sun’s radiations, I can not dwell at present.« ... »I, namely, at once observed that the air, which is a perfect insulator for currents produced by ordinary apparatus, was easily traversed by currents furnished by my improved machine, giving a tension of something like 2,500,000 volts. A further investigation in this direction led to another valuable fact; namely, that the conductivity of the air for these currents increased very rapidly with its degree of rarefaction, and at once the transmission of energy through the upper strata of air, which, without such results as I have obtained, would be nothing more than a dream became easily realizable. This appears all the more certain, as I found it quite practicable to transmit, under conditions such as exist in highest well explored, electrical energy in large amounts.«*

§11 30 January 1901^[39]: *Ever since everything has been known about electricity, scientific men have taken for granted that the capacity of an electrical conductor is constant. When Tesla was experimenting in Colorado Springs he found out that this capacity is not constant – but variable. ... »The capacity is increased as the conducting surface was elevated, in open space, from one-half to three-quarters of 1 per cent per foot of elevation. In buildings, however, or near large structures, this increase often amounted to 50 per cent per foot of elevation. ... Far more interesting, however, for men of science is the fact I observed later, that the capacity undergoes an annual variation with a maximum in summer, and a minimum in Winter. ... Furthermore I observed that there was a diurnal variation with a maximum during the night. Further, I found that sunlight causes a slight increase in capacity. The moon also produces an effect, but I do not attribute it to its light. ... I find that this variation of the capacity and consequently of the vibration period is evidently dependent, first, on the absolute height above sea level, though in a smaller degree; second, on the relative height of the conducting surface or capacity with respect to*

the bodies surrounding it; third, on the distance of the earth from the sun, and fourth, on the relative change of the circuit with respect to the sun, caused by the diurnal rotation of the earth.«

§12 02 February 1901^[40]: *«The process of light production is, according to my views, as follows: The street current is passed through a machine which is an electrical oscillator of peculiar construction and transforms the supply current, be it direct or alternating, into electrical oscillations of very high frequency. These oscillations, coming to the metallic-coated ends of the glass tube, produce in the interior corresponding electrical oscillations, which set the molecules and atoms of the inclosed rarefied gases into violent commotion, causing them to vibrate at enormous rates and emit those radiations which we know as light. The gases are not rendered incandescent in the ordinary sense, for if it were so, they would be hot, like an incandescent filament. As a matter of fact, there is very little heat noticeable, which speaks well for the economy of the light, since all heat would be loss.» ... »It is a remarkable feature of the light that during the day it can scarcely be seen, whereas at night the whole room is brilliantly illuminated. When the eye becomes used to the light of these tubes, an ordinary incandescent lamp or gas burner produces a violent pain in the eye when it is turned on, showing in a striking manner to what a degree these concentrated sources of light which we now use are detrimental to the eye. I have found that in almost all its actions the light produces the same effects as sunlight, and this makes me hopeful that its introduction into dwellings will have the effect of improving, in a measure now impossible to estimate, the hygienic conditions. Since sunlight is a very powerful curative agent, and since this light makes it possible to have sunlight, so to speak, of any desired intensity, day and night in our homes, it stands to reason that the development of germs will be checked and many disease, as consumption, for instance, successfully combated by continually exposing the patients to the rays of these lamps.»*

§13 21 March 1901: *»The sun, as well as other sources of radiant energy throw off minute particles of matter positively electrified, which, impinging upon the upper plate, communicate continuously an electrical charge to the same. The opposite terminal of the condenser being connected to ground, which may be considered as a vast reservoir of negative electricity, a feeble current flows continuously into the condenser and inasmuch as the particles are charged to a very high potential, this charging of the condenser may continue, as I have actually observed, almost indefinitely, even to the point of rupturing the dielectric. «*

§14 07 January 1905^[43]: *»This invention, which I have described in technical publications, attempts to initiate, in a very crude way, the nervous system in the human body.» ... »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 it is practicable to distribute power from a central plant in unlimited amounts, with loss not exceeding a small fraction of one per cent in the transmission, even to the greatest distance, twelve thousands 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. « ... »But the fact, that stationary waves are producible in the earth is of special and, in many ways, still greater significance in the intellectual development of humanity. Popularly explained, such a wave is a phenomenon generically akin to an echo – a result of reflection. It affords a positive and uncontrollable experimental evidence that the electric current, after passing into the earth*

travels to the diametrically opposite region of the same and rebounding from there, returns to its point of departure with virtually undiminished force. The outgoing and returning currents clash and form nodes and loops similar to those observable on a vibrating chord.«

§15 19 May 1907^[44]: *»It would not be difficult to convey to one of our liners, say, 50'000 horsepower from a plant located at Niagara, Victoria or other waterfall, absolutely irrespective of location. In fact, there would not be a difference of more than a small fraction of one per cent, whether the source of energy be in the vicinity of the vessel or 12'000 miles away, at the antipodes.«*

§16 21 April 1908^[45]: *»According to an adopted theory, every ponderable atom is differentiated from a tenuous fluid, filling all space merely by spinning motion, as a whirl of water in a calm lake. By being set in movement this fluid, the ether, becomes gross matter. Its movement arrested, the primary substance reverts to its normal state. It appears, then, possible for man through harnessed energy of the medium and suitable agencies for starting and stopping ether whirls to cause matter to form and disappear.«*

§17 18 May 1917^[46]: *»Years ago I was in the position to transmit wireless power to any distance without limit other than that imposed by the physical dimensions of the globe. In my system it makes no difference what the distance is. The efficiency of the transmission can be as high as 96 or 97 per cent, and there are practically no losses except such as are inevitable in the running of the machinery. When there is no receiver there is no energy consumption anywhere. When the receiver is put on, it draws power. That is the exact opposite of the Hertz-wave system. In that case, if you have a plant of 1,000 horsepower, it is radiating all the time whether the energy is received or not; but in my system no power is lost.«*

§18 August 1917^[47]: *»At the time of those test I succeeded in producing the most powerful X-rays ever seen. I could stand at a distance of 100 feet from X-ray apparatus and see the bones of the hand clearly wit the aid of a fluoroscope screen; and I could have easily seen them at a distance several times this by utilizing suitable power. In fact, I could not then produce X-ray generators to handle even a small fraction of the power I had available. But I now have apparatus designed whereby this tremendous energy of hundreds of kilowatts can be successfully transformed into X-rays.«*

§19 February 1919^[48]: *»In the summer of 1897 Lord Kelvin happened to pass through New York and honored me by a visit to my laboratory where I entertained him with demonstrations in support of my wireless theory. He was fairly carried away with what he saw but, nevertheless, condemned my project in emphatic terms, qualifying it as something impossible, ' an illusion and a snare'. I had expected his approval and was pained and surprised. But the next day he returned and gave me a better opportunity for explanation of the advances I had made and of the true principles underlying the system I had evolved. Suddenly he remarked with evident astonishment: 'Then you are not making use of Hertz waves?' Certainly not, I replied, these are radiations. No energy could be economically transmitted to a distance by any such agencies. In my system the process is one of true conduction which, theoretically, can be effected at the greatest distance without appreciable loss.«*

§20 June 1919^[50]: *»In a more restricted meaning this wireless transmitter is one in which the Hertz-wave radiation is an entirely negligible quantity as compared with the whole energy, under which condition the damping factor is extremely small and an enormous charge is stored in the elevated capacity. Such a circuit may*

then be excited with impulses of any kind, even of low frequency and it will yield sinusoidal and continuous oscillations like those of an alternator. Taken in the narrowest significance of the term, however, it is a resonant transformer which, besides possessing these qualities, is accurately proportioned to fit the globe and its electrical constants and properties, by virtue of which design it becomes highly efficient and effective in the wireless transmission of energy. Distance is absolutely eliminated, there being no diminution in the intensity of the transmitted impulses. It is even possible to make the actions increase with the distance from the plant according to an exact mathematical law.« ... »On this occasion I would contradict the widely circulated report that the structure was demolished by the Government which owing to war conditions.« ... »I would add further, in view of various rumors which have reached me, that Mr. J. Pierpont Morgan did not interest himself with me in a business way but in the same large spirit in which he has assisted many other pioneers. He carried out his generous promise to the letter and it would have been most unreasonable to expect from him anything more.« ... »My project was retarded by laws of nature. The world was not prepared for it. It was too far ahead of time. But the same laws will prevail in the end and make it a triumphal success.«

§21 25 February 1923^[51]: *»I had perfected a wireless receiver of extraordinary sensitiveness, far beyond anything known, and I caught signals with I interpreted as meaning 1—2—3—4.«*

§22 16 October 1927^[52]: *»Notwithstanding my repeated explanations experts do not seem to realize that no concentration of energy such as I attain in my wireless power system can or will ever be achieved through the instrumentality of reflectors, for in transmitting energy in this manner the receiver can collect only an amount proportionate to the area exposed to the rays, while in my system it draws the energy from an immense reservoir in ever so much greater quantity.«*

§23 22 September 1929^[53]: *»Up to 1896, however, I did not succeed in obtaining a positive experimental proof of the existence of such a medium. But in that year I brought out a new form of vacuum tube capable of being charged to any desired potential, and operated it with effective pressures of about 4,000,000 volts. I produced cathodic and other rays of transcending intensity. The effects, according to my view, were due to minute particles of matter carrying enormous electrical charges, which, for want of a better name, I designated as matter not further decomposable. Subsequently those particles were called electrons.«*

§24 April 1930^[54]: He holds that radio-activity is due, not to forces in the substances themselves, but to a cosmic ray, the discovery of which he announced in 1897. In other words, an element like Radium emits radiations merely because the cosmic ray impinges upon it, producing these secondary effects. The element itself has no such energy, it all comes from the cosmic ray. Tesla says, that he has proved the existence of this rays by mathematical analysis and experiment, finding both in perfect agreement. It would seem to follow, from Tesla's theory, that the radiation from radium, or similar bodies, would change from place to place on the globe; and this has recently proved to be an actual fact, as determined by a Russian investigator. Tesla assured the writer in a recent interview, that through a new discovery he has perfected rays of tremendous power, penetrating through miles of solid substances, will become available shortly, by the use of his high potential cathode tube, without a target.

§25 July 1931: *Time*, pp27-28: *»I'm working to develop a new source of power. When I say a new source, I mean that I have turned for power to a source which no previous scientist has turned, to the best of my knowledge. The conception, the idea when it first burst upon me was a tremendous shock. It will throw light on*

many puzzling phenomena of the cosmos, and may prove also of great industrial value, particularly in creating a new and virtually unlimited market for steel.« Tesla said it will come from an entirely new and unsuspected source, and will be for all practical purposes constant day and night, and at all times of the year.

§26 07. November 1931^[55]: Tesla disagreed with the part of the Einstein Theory which states that the mass of an object increases with its speed. The mass of a body is unalterable, contended Dr. Tesla, according to the article, *»otherwise energy could be produced from nothing, since the kinetic energy acquired in the fall of a body would be greater than that necessary to lift it at a small velocity.*«

§27 December 1931^[56]: *»It was clear to me many years ago that a new and better source of power had to be discovered to meet the ever increasing demands of mankind. In a lecture delivered before the American Institute of Electrical Engineers at Columbia University May 20, 1891, I said: "We are whirling through endless space with inconceivable speed, all around us everything is spinning, everything is moving, everywhere is energy. There must be some way of availing ourselves of this energy more directly. Then, with the light obtained from the medium, with the power delivered from it, with every form of energy obtained without effort, from the store forever inexhaustible humanity will advance with giant strides." I have thought and worked with this object in view unremittingly and am glad to say that I have sufficient theoretical and experimental evidence, that my efforts of years will be rewarded and that we shall have at our disposal a new source of power, superior to the hydro-electric, which may be obtained by means of simple apparatus everywhere and in almost constant and unlimited amount.*«

§28 06 February 1932^[57]: *»When radioactivity was discovered, it was thought to be an entirely new manifestation of energy limited to a few substances. I obtained sufficient evidence to convince me that such actions were general and in nature the same as those exhibited by my tubes. In these, minute corpuscles, regarding which we are still in doubt, are shot from a highly electrified terminal against a target where they generate Roentgen or other rays by impact. Now, according to my theory, a radioactive body is simply a target which is continuously bombarded by infinitesimal bullets projected from all parts of the universe, and if this, then unknown, cosmic radiation could be wholly intercepted, radioactivity would cease. I made some progress in solving the mystery until in 1899 I obtained mathematical and experimental proofs that the sun and other heavenly bodies similarly conditioned emit rays of great energy which consist of inconceivably small particles animated by velocities vastly exceeding that of light. So great is the penetrative power of these rays that they can traverse thousands of miles of solid matter with but slight diminution of velocity. In passing through space, which is filled with cosmic dust, they generated a secondary radiation of constant intensity, day and night, and pouring upon the earth equally from all directions. As the primary rays projected from the suns and stars can pass through distances measured in light-years without great diminution of velocity, it follows that whether a secondary ray is generated near a sun or at any distance from it, however great, its intensity is the same. Consequently, if our sun, or any other, would be snuffed out of existence, it would have no appreciable effect on the secondary radiation. The latter is not very penetrative and is partly absorbed by the atmosphere. According to my determinations, its intensity beyond the atmosphere is about 50 per cent greater than at sea level. The whole atmosphere being equivalent to about 36 inches of lead, it is easy to determine the intensity of this radiation by making a measurement of the penetration at any known altitude. This theory is borne out strictly in experiments with my vacuum tubes, but even if I did not have such proofs I would consider it plausible.*«

§29 10 July 1932^[58]: *»I have harnessed the cosmic rays and caused them to operate a motive device«,* declared Nikola Tesla, famous scientist, in an interview last evening on the eve of his 76th birthday. *»Cosmic ray investigation is a subject that is very close to me. I was the first to discover these rays and I naturally feel toward them as I would toward my own flesh and blood.«,* said Dr. Tesla. ... Dr. Tesla stated that the amount of power he was able to develop in the device was insignificant. I asked him if its power output was of the same magnitude as that of Crookes' radiometer, the device with four vanes in a glass tube that are rotated by sunlight, and which is often seen in jewelers' windows. He stated that the power output was many thousand times that of a Crookes' radiometer. *»The attractive features of the Cosmic rays is their constancy. They shower down on us throughout the whole 24 hours, and if a plant is developed to use their power it will not require devices for storing energy as would be necessary with devices using wind, tide or sunlight. All of my investigations seem to point to the conclusion that they are small particles, each carrying so small a charge that we are justified in calling them neutrons. They move with great velocity, exceeding that of light. More than 25 years ago I began my efforts to harness the cosmic rays and I can now state that I have succeeded in operating a motive device by means of them.«* I was able to prevail upon Dr. Tesla to give me some idea of the principle upon which his cosmic ray motor works. *»I will tell you in the most general way«,* he said. *»The cosmic ray ionizes the air, setting free many charges – ions and electrons. These charges are captured in a condenser which is made to discharge through the circuit of the motor.«*

§30 10 September 1933^[59]: *»My first and most important discovery concerns the harnessing of a new source of power, hitherto unavailable, to be developed through fundamentally novel machines of my invention. ... My power generator will be of the simplest kind – just a big mass of steel, copper and aluminum, comprising a stationary and rotating part, peculiarly assembled. ... Such a source of power obtainable everywhere will solve many problems with which the human race is confronted.«*

§31 02 November 1933^[60]: A principle by which power for driving the machinery of the world may be derived from the cosmic energy which operates the universe, has been discovered by Nikola Tesla, noted physicist and inventor of scientific devices, he announced today. This principle, which taps a source of power described as „*everywhere present in unlimited quantities*“ and which may be transmitted by wire or wireless from central plants to any part of the globe, will eliminate the need of coal, oil, gas or any other of the common fuels, he said. ... The central source of cosmic energy for the earth is the sun, Dr. Tesla said, but *»night will not interrupt the flow of the new power supply«.*

§32 July 1934^[61]: *»Some years ago I urged the experts engaged in the commercial application of the wireless art to employ very short waves, but for a long time my suggestions were not heeded. Eventually, though, this was done, and gradually the wave lengths were reduced to but a few meters. Invariably it was found that these waves, just as those in the air, follow the curvature of the earth and bend around obstacles, a peculiarity exhibited to a much lesser degree by transverse vibrations in a solid. Recently, however, ultra-short waves have been experimented with and the fact that they also have the same property was hailed as a great discovery, offering the stupendous promise of making wireless transmission infinitely simpler and cheaper. It is of interest to know what wireless experts have expected, knowing that waves a few meters long are transmitted clear to antipodes. Is there any reason that they should behave radically different when their length is reduced to about half of one meter? As the knowledge of this subject seems very limited, I*

may state that even waves one or two millimeters long, which I produced thirty-four years ago, provided that they carry sufficient energy, can be transmitted around the globe. This is not so much due to refraction and reflection as to the properties of a gaseous medium and certain peculiar action.« ... »I have disintegrated atoms in my experiments with a high potential vacuum tube I brought out in 1896 which I consider one of my best inventions. I have operated it with pressures ranging from 4,000,000 to 18,000,000 volts. More recently I have designed an apparatus for 50,000,000 volts which should produce many results of general scientific importance.« ... »And as for the cosmic ray: I called attention to this radiation while investigating Roentgen rays and radioactivity. In 1899 I erected a broadcasting plant at Colorado Springs, the first and only wireless plant in existence at that time, and there confirmed my theory by actual observation.« ... »I have satisfied myself that the rays are not generated by the formation of new matter in space, a process which would be like water running up hill. According to my observations, they come from all the suns of the universe and in such abundance that the part contributed to our sun is very insignificant by percentage. Some of these rays are of such terrific power that they can traverse through thousands of miles of solid matter. They have, furthermore, other extraordinary properties. This ray, which I call the primary solar ray, gives rise to a secondary radiation by impact against the air and the cosmic dust scattered through space. It is now commonly called the cosmic ray, and comes, of course, equally from all directions in space. If radium could be screened effectively against this ray it would cease to be radioactive.«

§33 11 July 1934^[62]: The beam of force itself, as Dr. Tesla described it, is a concentrated current – it need be no thicker than a pencil – of microscopic particles moving at several hundred times the speed of artillery projectiles. The machine into which Dr. Tesla combines his four devices is, in reality, a sort of electrical gun. He illustrated the sort of thing that the particles will be by recalling an incident that occurred often enough when he was experimenting with a cathode tube. Then, sometimes, a particle larger than an electron, but still very tiny, would break off from the cathode, pass out of the tube and hit him. He said he could feel a sharp, stinging pain where it entered his body, and again at the place where it passed out. The particles in the beam of force, ammunition which the operators of the generating machine will have to supply, will travel far faster than such particles as broke off from the cathode, and they will travel in concentrations, he said. ... Such beams or rays of particles now known to science are composed always of fragments of atoms, whereas, according to Dr. Tesla, his would be of microscopic dust of a suitable sort. The chief differentiation between his and the present rays would appear to be, however, that his are produced in free air instead of in a vacuum tube. The vacuum tube rays have been projected out into the air, but there they travel only a few inches, and they are capable only of causing burns or slight disintegration of objects which they strike. ... He had, he said, detected *»certain motions in the medium that fills space, and measured the effects of this motions«*. The results of the experiments had led his *»inescapably«* to the conclusion that such bodies as the sun are taking on mass more rapidly than they are dissipating it by the dissipation of energy in heat and light. He pointed out that his theory means a future for the earth as different from the general belief as the future of the sun. It is generally held that life on the earth will cease when the sun grows so cold that the earth temperature drops to a point where life can no longer be supported. Dr. Tesla prophesies that life on the earth will cease because the planet will grow too warm to support life, and he believes that life will then begin on outer planets now too cold.

§34 February 1935^[63]: *»I want to state explicitly that this invention of mine does not contemplate the use of any so-called ‘death rays’. Rays are not applicable because they cannot be produced in requisite quantities and diminish rapidly in*

intensity with distance. All the energy of New York City (approximately two million horsepower) transformed into rays and projected twenty miles, could not kill a human being, because, according to a well known law of physics, it would disperse to such an extent as to be ineffectual. My apparatus projects particles which may be relatively large or of microscopic dimensions, enabling us to convey to a small area at a great distance trillions of times more energy than is possible with rays of any kind. Many thousands of horsepower can thus be transmitted by a stream thinner than a hair, so that nothing can resist. This wonderful feature will make it possible, among other things, to achieve undreamed-of results in television, for there will be almost no limit to the intensity of illumination, the size of a picture, or distance projection.«

§35 03 March 1935^[64]: *»There exists, however, an element of incertitude which in itself is sufficient to invalidate completely the results obtained and of which Dr. Kolhoerster[†] does not seem to have thought. Light is a wave motion of definite velocity, determined by the elastic force and density of the medium. Cosmic rays are particles of matter, the speed of which depends on the propelling force and mass and may be much smaller or greater than that of light. Consequently, there can be no concordance in the phases of the two disturbances at the place of observation. The cosmic rays, generated during the maximum brightness of the star, may reach the place many centuries sooner or later than the light, according to their speed.«*

§36 11 July 1935^[65]: *Cosmic rays, he asserted, he found are produced by the force of »electrostatic repulsion«; they consist of powerfully charged positive particles which come to us from the sun and other suns in the universe. He determined, »after experimentation«, he added, that the sun is charged »with an electric potential of approximately 215,000,000,000 volts, while the electric charge stored in the sun amounted to approximately 50,000,000,000,000,000 electrostatic units.«*

§37 18 August 1935^[66]: *»Condensation of the primary substance is going on continuously, this being in a measure proved, for I have established by experiments which admit of no doubt that the sun and other celestial bodies steadily increase in mass and energy and ultimately must explode, reverting to the primary substance. ...I finally ascertained with a reasonable degree of certitude, and to my amazement, that the sun was at a constant positive potential of about 216,000,000,000 volts. Thus the secret of the cosmic rays was revealed. Owing to its immense charge, the sun imparts to minute positively electrified particles prodigious velocities which are governed only by the ratio between the quantity of free electricity carried by the particles and their mass, some attaining a speed exceeding fifty times that of light.« ... »The greatest mistake is made in the appraisal of the energy of cosmic rays. In most cases the ionizing action is used as a criterion, which is useless, for the most powerful cosmic rays virtually do not ionize at all and leave no trace of their passage through the instrument. I have resorted to different means and methods and have found that the energy of the cosmic radiations impinging upon the earth from all sides is stupendous, such that if all of it were converted into heat the globe quickly would be melted and volatilized. Since expressing, in 1896, my ideas on the origin and character of cosmic rays and of the cause of radioactivity, all my views have been confirmed by my own findings and those others, while numerous theories advanced have been proved false or inadequate.«*

[†] TESLA probably points to the references below:

KOLHÖRSTER W, *Physikalische Zeitschrift* **26** (1925) 654

BOTHE W. und KOLHÖRSTER W. „Das Wesen der Höhenstrahlung“, *Zeitschrift für Physik* **56** (1929) 751-777

§38 12 July 1937^[67]: »My most important invention from a practical point of view is a new form of tube with apparatus for its operation. In 1896 I brought out a high potential targetless tube which I operated successfully with potentials up to 4 million volts from '96 to '98.« ... »At a later period I managed to produce very much higher potentials up to 18 million volts, and then I encountered insurmountable difficulties which convinced me that it was necessary to invent an entirely different form of tube in order to carry out successfully certain ideas I had conceived. This task I found far more difficult than I had expected, not so much in the construction as in the operation of the tube. For many years I was baffled in my efforts, although I made a steady slow progress. Finally though, I was rewarded with complete success and I produced a tube which it will be hard to improve further. It is of ideal simplicity, not subject to wear and can be operated at any potential, however high, that can be produced. It will carry heavy currents, transform any amount of energy within practical limits, and it permits easy control and regulation of the same. I expect that this invention, when it becomes known, will be universally adopted in preference to other forms of tubes, and that it will enable the production of cheap radium substitutes in any desired quantity and will be, in general, immensely more effective in the smashing of atoms and the transmutation of matter. However, this tube will not open up a way to utilize atomic or subatomic energy for power purposes. It will cheapen radium so, that it will be just a cheap – well, it will get down to \$1 a pound, in any quantity.« Expressing annoyance that some newspapers had indicated he would 'give a full description' of his atom-smashing tube at yesterday's luncheon, Dr. Tesla said he was bound by financial obligations 'involving vast sums of money' against releasing this information. »But it is not an experiment. I have built, demonstrated and used it. Only a little time will pass before I can give it to the world.«

§39 22 August 1937^[68]: »While the origin and character of the rays observed near the earth's surface had thus been sufficiently well ascertained, the so-called cosmic rays observed at great altitudes presented a riddle for more than twenty-six years, chiefly because it was found they increased with the height at a rapid rate. My investigations brought out the astonishing fact that the effects at high altitude are of an entirely different nature, having no relation whatever to cosmic rays. These are particles from celestial bodies at very high temperatures and charged to enormous electrical potentials.« It might be remarked parenthetically that Dr. Tesla does not accept the concept of the electron presented by physicists as an elementary unit and carrying a unit charge of electricity. He holds that the electron in a well-exhausted tube operated at high potential carries many multiples of this unit charge. The ignorance of this fact is responsible for many errors and fallacies in various scientific investigations. »The effects at great elevations«, Dr. Tesla continued, »are due to waves of extremely small lengths produced by the sun in a certain region of the atmosphere. This is the discovery I wish to make known. The process involved in the generation of the waves is the following: The sun projects charged particles constituting an electric current which passes through a conducting stratum of the atmosphere approximately ten kilometers (six miles) thick enveloping the earth. This is a transmission of electrical energy exactly as I illustrated in my experimental lecture in which one end of a wire is connected to an electric generator of high potential, its other end being free. In this case the generator is represented by the sun and the wire by the conducting air. The passage of the solar current involves the transference of electrical charges from particle to particle with the speed of light, resulting in the production of extremely short and penetrating waves. As the air stratum mentioned is the source of the waves it follows that the so-called cosmic rays observed at great altitude must increase as this stratum is approached.«