NIKOLA TESLA'S LATER ENERGY GENERATION DESIGNS

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ABSTRACT

Ten years after patenting a successful method for producing alternating current, Nikola Tesla claimed the invention of an electrical generator that would not "consume any fuel." Such a generator would be its own prime mover. Two of Tesla's devices representing different stages in the development of such a generator are identified.

INTRODUCTION

While in college Nikola Tesla claimed it should be possible to operate an electrical motor without sparking brushes. He was told by the professor that such a motor would require perpetual motion and was therefore impossible. In the 1880's he patented the alternating current generator, motor, and transformer.

During the 1890's he intensively investigated other methods of power generation including a charged particle collector patented in 1901. When the *New York Times* in June of 1902 carried a story about an inventor who claimed an electrical generator not requiring a prime mover in the form of an external fuel supply, Tesla wrote a friend that he had already invented such a device.

Fuelless electrical generation raises the same objection of perpetual motion as did the generator in use today when it was first proposed. Research Nikola Tesla carried out during his second creative period and the resulting devices that were the basis for his assertion of fuelless electrical generation will be examined. Whether Tesla's fuelless generator was a "perpetual motion scheme" of the sort his teacher warned him against, or a creative application of recognized natural phenomena will be discussed.

TESLA'S STATEMENTS

In *The Brooklyn Eagle*, Tesla announced, on July 10th, 1931, that "I have harnessed the cosmic rays and caused them to operate a motive device." Later on in the same article he said that "More than 25 years ago I began my efforts to harness the cosmic rays and I can now state that I have succeeded." In 1933, he made the same assertion in an article for the *New York American*, November 1st, under the lead in "Device to Harness Cosmic Energy Claimed by Tesla." Here he said:

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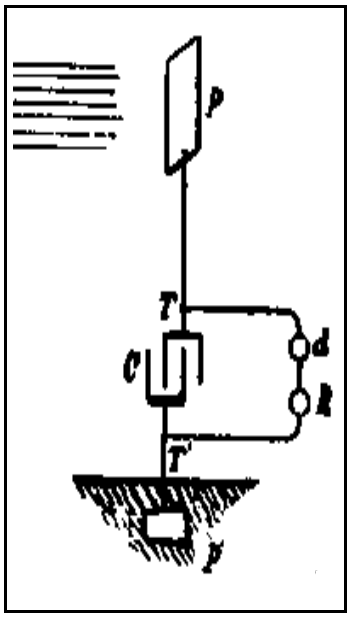
> This new power for the driving of the world's machinery will be derived from the energy which operates the universe, the cosmic energy, whose central source for the earth is the sun and which is everywhere present in unlimited quantities.

Dating back "more than 25 years ago" from 1933 would mean that the device Tesla was speaking about must have been built before 1908. More precise information is available through his correspondence in the Columbia University Library's collection. Writing on June 10th, 1902 to his friend Robert U. Johnson, editor of *Century* Magazine, Tesla included a clipping from the previous day's *New York Herald* about a Clemente Figueras, a "woods and forest engineer" in Las Palmas, capital of the Canary Islands, who had invented a device for generating electricity without burning fuel. What became of Figueras and his fuelless generator is not known, but this announcement in the paper prompted Tesla, in his letter to Johnson, to claim he had already developed such a device and had revealed the underlying physical laws.

IDENTIFYING THE INVENTION

The device that, at first, seems to best fit this description is found in Tesla's patent for an "Apparatus for the Utilization of Radiant Energy," number 685,957, that was filed for on March 21, 1901 and granted on November 5, 1901. The concept behind the older technical language is a simple one. An insulated metal plate is put as high as possible into the air. Another metal plate is put into the ground. A wire is run from the metal plate to one side of a capacitor and a second wire goes from the ground plate to the other side of the capacitor. Then:

> 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 [1].



1. Particle Collector

This seems like a very straightforward design and would seem to fulfill his claim for having developed a fuelless generator powered by cosmic rays, but in 1900 Tesla wrote what he considered his most important article in which he describes a self-activating machine that would draw power from the ambient medium, a fuelless generator, that is different from his Radiant Energy Device. Entitled "The Problem of Increasing Human Energy - Through the Use of the Sun," it was published by his friend Robert Johnson in *The Century Illustrated Monthly Magazine* for June 1900 soon after Tesla returned from

Colorado Springs where he had carried out an intensive series of experiments from June 1899 until January of 1900.

The exact title of the chapter where he discusses this device is worth giving in its entirety:

A DEPARTURE FROM KNOWN METHODS - POSSIBILITY OF A "SELF ACTING" ENGINE OR MACHINE, INANIMATE, YET CAPABLE, LIKE AN LIVING BEING,OF DERIVING ENERGY FROM THE MEDIUM - THE IDEAL WAY OF OBTAINING MOTIVE POWER

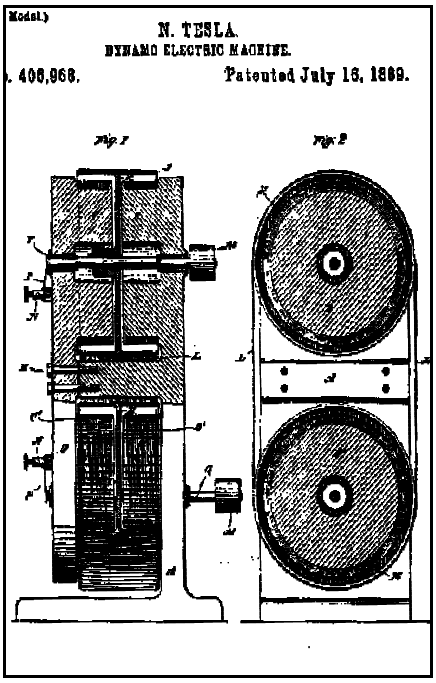
Tesla stated he first started thinking about the idea when he read a statement by Lord Kelvin who said it was impossible to build a mechanism capable of abstracting heat from the surrounding medium and to operate by that heat. As a thought experiment Tesla envisioned a very long bundle of metal rods, extending from the earth to outer space. The earth is warmer than outer space so heat would be conducted up the bars along with an electric current. Then, all that would be needed is a very long power cord to connect the two ends of the metal bars to a motor. The motor would continue running until the earth was cooled to the temperature of outer space. "This would be an inanimate engine which, to all evidence, would be cooling a portion of the medium below the temperature of the surrounding, and operating by the heat abstracted [2]," that is, it would produce energy directly from the environment without "the consumption of any material."

Tesla goes on in the article to describe how he worked on the development of such an energy device, and here it takes a bit of detective work to focus on which of his inventions he meant. He wrote that he first started thinking about deriving energy directly from the environment when he was in Paris during 1883, but that he was unable to do much with the idea for several years due to the commercial introduction of his alternating current generators and motors. It was not "until 1889 when I again took up the idea of the self-acting machine [3]."

THE TURBINE

He quickly came to realize that an ordinary electrical machine, like his generator, would not be able to directly extract energy from the cosmos and turned his efforts to what he called a "turbine" design.
The best known turbine, that is, water pump, associated with Tesla is his patent for such a device, #1,061,206, which was filed for in 1909 and granted in 1913. The unique point about this water pump is that instead of using some form of paddle wheels inside a box to move the water, he discovered that more water could be moved faster by using a set of flat metal disks. The turbine is, in itself, fascinating and may yet prove to be another important overlooked invention, but what is of concern regarding the electrical design is the general shape of the turbine - metal disks turning inside a supporting box.

This same shape turns up in another patent, this one for a "Dynamo-Electric Machine." This patent was filed and granted in the same year that Tesla said he returned to work on the "self-activating" machine, in 1889. The dynamo consists of metal disks that are rotated between magnets to produce an electric current.


(Model.)
N. TESLA.
DYNAMO ELECTRIC MACHINE.
No. 406,968. Patented July 16, 1889.

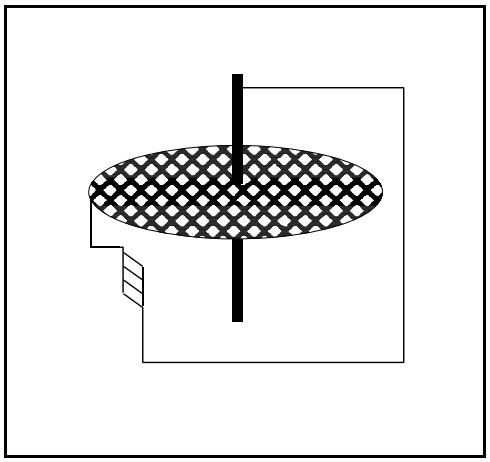
2. Dynamo Electric Machine

Compared to his alternating current generator, this "dynamo" represents something of a curious throwback to the days of Faraday's early experiments with a copper disk and a magnet. Tesla makes some improvement over the Faraday setup by using magnets that completely cover the spinning metal disks and he also adds a flange to the outside of the disks so current can be taken off more easily - all of which makes for a better generator than Faraday's. On the surface, though, it is hard to see why Tesla patented such an anachronistic machine at this point in his work.

The next piece of the puzzle is found in an article Tesla wrote for *The Electrical Engineer* in 1891 entitled "Notes on a Unipolar Dynamo." Here Tesla presents an in-depth analysis of the Faraday disk generator, explains why it was an inefficient generator, describes his improved variations on the Faraday machine, and, at the bottom of the third page of the article, states that he has devised a generator in which "the current, once started, may then be sufficient to maintain itself and even increase in strength [4]." Then, at the close of the article, he states that "several machines ... were constructed by the writer two years ago ...[5]." Two years before the writing of that article was 1889. All the evidence points to the turbine-shaped Unipolar Dynamo as being Tesla's first design for a machine that can continue to produce electricity after being disconnected from an outside source of power.

SELF-SUSTAINING CURRENT

Before going into the details of this invention it would be wor thwhile to have an idea of how any generator, even in theory, could be capable of producing a self-sustaining current. This has been clearly explained by Walter M. Elsasser in a *Scientific American* article (May 1958) titled "The Earth as a Dynamo."



3. Faraday Generator with electromagnet

Elsasser models the earth-dynamo, conveniently for this explanation, on the Faraday generator of a metal disk spinning over a bar magnet placed at the edge of the disk. He notes, also, that the bar magnet could be replaced by an electromagnet which could get its power from the spinning disk by attaching one end of the electromagnet's wire to the outside of the disk and the other end of the wire to the metal rod running through the center of the disk.

Elsasser then points out that an ordinary disk generator "could not maintain a current for very long because the

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current induced in the disk is so weak that it would soon be dissipated by the resistance of the conductor [the disk]." This conventional arrangement would not be an answer to "how currents could be built up and perpetuated to maintain the earth's magnetic field." He does, though, propose three options in the dynamo model that would explain the earth's persistent magnetism.

> If we had a material that could conduct electricity a thousand times better than copper, the system would indeed yield a self-sustaining current. We could also make it work by spinning the disk very fast... a third way we could make such a dynamo self-sustaining ... is to increase the size of the system: theory says that the bigger we make such a dynamo, the better it will function. If we could build a coil-and-disk apparatus of this kind of scale of many miles, we would have no difficulty in making the currents self-sustaining [6].

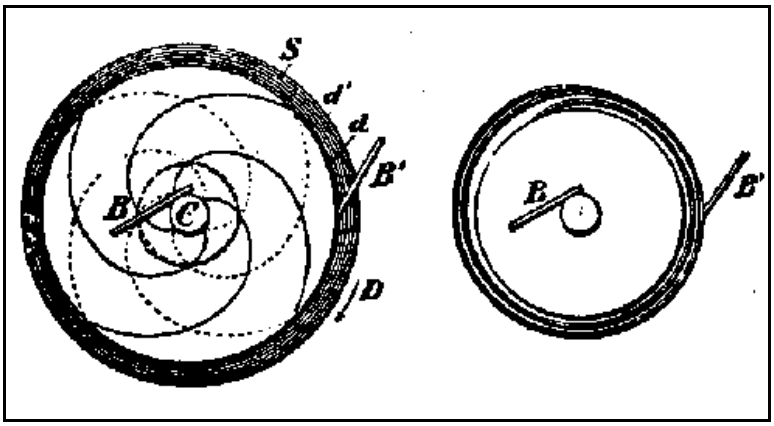
Tesla did not have a material a thousand times more conductive than copper, neither was he able to spin a disk at the ultra-high speeds needed to produce such a current, nor did he plan on using a piece of rotating metal several miles in diameter. What he did was to use energy that is usually wasted in a generator and turn it into a source of power.

UNIPOLAR DYNAMO

Tesla's design varied from that of Faraday in two major ways. First, he used a magnet that was bigger in diameter than the disk so that the magnet completely covered the disk. Second, he divided the disk into sections with spiral curves radiating out from the center to the outside edge.

In the Faraday unipolar generator "the current," as Tesla noted, "set up will therefore not wholly pass through the external circuit ... and ... by far the greater portion of the current generated will not appear externally...[7]." By having the magnet completely cover the disk, Tesla made use of the whole disk surface in current generation instead of only a small section directly adjacent to the bar magnet, as happened in the Faraday device. This not only increases the amount of current generated, but, by making the current travel from the center to the outside edge, makes all of that current accessible to the external circuit.

More importantly, these modifications on the Faraday design eliminated one of the biggest problems in any physical system - the reaction to every action. It is this reaction that works to cancel out whatever effort goes into causing the original action. In an electrical system if there are two turns of wire wound next to each other and a current



4. Tesla's Unipolar Generator

is sent through the wire, the current passing through the first loop will set up a magnetic field that will work against the current passing through the second loop.

The spiral divisions in the disk cause the current to travel the full radius of the disk or, as in his alternative version of the generator, to make a full trip around the outside edge of the disk. Because the current is flowing in a large circle at the rim of the disk, the magnetic field created by the current not only does not work against the field magnet above the circular plate, as in conventional generators, but it actually reinforces the magnet. So as the disk cuts the magnetic lines to produce a current, the current coming off of the disk strengthens the magnet, allowing it to produce even more current.

Like conventional direct current generators, the unipolar dynamo also functions as a motor if current is put into the disk while under the magnet, and this seems to be the last element that could make the device self-sustaining, that is, capable of generating a current after being disconnected from an outside source of movement like falling water or steam.

Rotation is started by, say, a motor powered by line current. Both a generator and a motor disk are mounted in the magnetic enclosure. As the disks gain speed, current is produced which, in turn, reinforces the magnets, which cause more current to be generated. That current is, likely, first directed to the motor disk which increases the speed of the system. At a certain point the speed of the two disks is great enough that the magnetic field created by the current has the strength to keep the dynamo/motor going by itself.

What process might have kept the unipolar dynamo operating after the powered start-up is speculation at this point, however two features of the generator are significant. First, when a resistive load, like a light bulb is added to the circuit, it lowers the voltage at the center of the disk. This lower voltage at the center means that there is a greater difference in voltage between the center and the outside edge of the disk than there was before the light bulb was added. As the difference between the center and the outside increases, the dynamo works harder and makes more current. Second, yet more important, the dynamo takes either very little, or no energy to keep going because the current coming off the generator is doing double duty. The current makes the bulb glow, but on its way from the generator to the filament in the bulb, it travels a path that adds to the momentum of the dynamo and, therefore, consumes energy at a very low rate. The process

continues , it would seem, until heat losses in the filament equal the rotational energy of the generator's flywheel.

In terms of Elsasser's criteria for a self-sustaining generator, the Tesla unipolar dynamo comes closest to satisfying the condition of a better electrical conductor. It is not that a new material is used, but a new geometry is applied so that the current does not create its own opposing forces. This is similar, but not equivalent, to having a better conductor.

Whether or not the dynamo is in fact a "fuelless" generator it appears to be an ingenious feat of engineering that takes one of the basic principles of nature, an equal and opposite action for every action, and turns it, by the use of a novel circuit geometry, into a reaction that is additive to the original action. Instead of the opposite reaction slowing down the system that created it, the reaction adds energy to the system.

Tesla, however, was not satisfied with his mechanical self-sustaining generator. The dynamo would provide the energy to run a single machine, but his vision was to light cities and in the 1900 *Century* magazine article he elaborated on the theory of such a machine.

Imagine, he suggested, an enclosed cylinder with a small hole in it near the bottom. Let us say that this cylinder, he added, contains very little energy but that it is placed in an environment that has a lot of energy. In this case, energy would flow from the outside environment, the high energy source, through the small opening at the bottom of the cylinder, and into the cylinder where there is less energy. Also suppose that as the energy passing into the cylinder is converted into another form of energy as, for example, heat is converted into mechanical energy in a steam engine. If it were possible to artificially produce such a "sink" for the energy of the ambient medium then "we should be enabled to get at any point of the globe a continuous supply of energy, day and night [8]."

He continued, in the article, to elaborate on his energy pump but changed the image slightly. On the surface of the earth we are at a high energy level and can imagine ourselves at the bottom of a lake with the water surrounding us equal to the energy in the surrounding medium. If a "sink" for the energy is to be created in the cylinder, it is necessary to replace the water that would flow into the tank with something much lighter than water. This could be done by pumping the water out of the cylinder, but when the water flowed back in, we would only be able to perform the same amount of work with the inflowing water as we did when it was first pumped out. "Consequently nothing would be gained in this double operation of first raising the water and then letting it fall down."

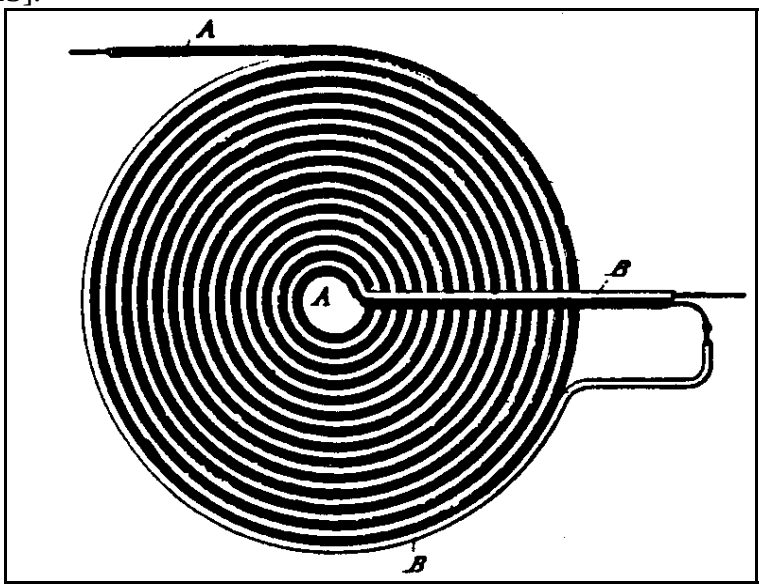
Energy, though, can be converted into different forms as it passes from a higher to a lower state. He said, "assume that the water, in its passage into the tank, is converted into something else, which may be taken out of it without using any, or by using very little power [9]." For example, if the energy of the ambient medium is taken to be the water, oxygen and hydrogen making up the water are the other forms of energy into which it could change as it entered the cylinder.

> Corresponding to this ideal case, all the water flowing into the tank would be decomposed into oxygen and hydrogen ...and the result would be that the water

> would continually flow in, and yet the tank would remain entirely empty, the gases formed escaping.We would thus produce, by expending initially a certain amount of work to create a sink for...the water to flow in, a condition enabling us to get any amount of energy without further effort [10].

Tesla recognized that no energy conversion system would be perfect, some water would always get into the tank, but "there will be less to pump out than flows in, or, in other words, less energy will be needed to maintain the initial condition than is developed [by the incoming water], and this is to say that some energy will be gained from the medium [11]."

He found that this pumping could be done with a piston "not connected to anything else, but was perfectly free to vibrate at an enormous rate [12]." This he was able to do with his "mechanical oscillator," a steam-driven engine used for producing high frequency currents. The faster the pump would work, the more efficient it would be at extracting energy from the cosmos. Research along this line culminated in the oscillator demonstrated at the Chicago World's Fair in 1893. It was not until much later, in the 1900 article, he revealed: "On that occasion I exposed the principles of the mechanical oscillator, but the original purpose of this machine is explained here for the first time [13]."

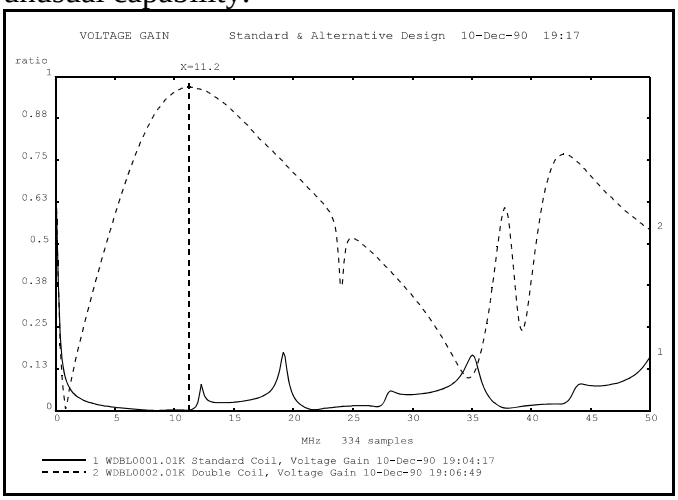


5. Coil for Electro-Magnets

It was also in 1893 that Tesla applied for a patent on an electrical coil that is the most likely candidate for a non-mechanical successor of his energy extractor. This is his "Coil for Electro-magnets," patent #512,340. It is another curious design because, unlike an ordinary coil made by turning wire on a tube form, this one uses two wires laid next to each other on a form but with the end of the first one connected to the beginning of the second one.

In the patent Tesla explains that this double coil will store many times the energy of a conventional coil [14]. Preliminary measurements of two helices of the same size and with the same number of turns, one with a single, the other with a bifilar winding, show differences in voltage gain [15]. In figure 6, the upper curve is from the Tesla design, the lower was produced

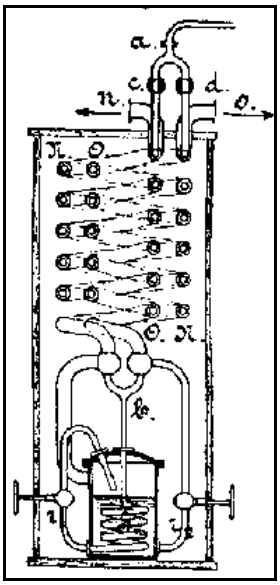
by the single wound coil. The patent, however, gives no hint of what might have been its more unusual capability.



6. Voltage gain comparison

In the *Century* article Tesla compares extracting energy from the environment to the work of other scientists who were, at that time, learning to condense atmospheric gases into liquids. In particular he cited the work of a Dr. Karl Linde who had discovered what Tesla described as a "self-cooling" method for liquefying air. As Tesla said, "This was the only experimental proof which I was still wanting that energy was obtainable from the medium in the manner contemplated by me [16]."

What ties the Linde work with Tesla's electromagnet coil is that both of them used a double path for the material they were working with. Linde had a compressor to pump the air to a high pressure, let the pressure fall as it traveled through a tube, and then used that cooled air to reduce the temperature of the incoming air by having it travel back up the first tube through a second tube enclosing the first [17]. The already cooled air added to the cooling process of the machine and quickly condensed the gases to a liquid.



7. Linde's condenser

Tesla's intent was to condense the energy trapped between the earth and its upper atmosphere and to turn it into an electric current. He pictured the sun as an immense ball of electricity, positively charged with a potential of some 200 billion volts. The earth, on the other hand, is charged with negative electricity. The tremendous electrical force between these two bodies constituted, at least in part, what he called cosmic energy. It varied from night to day and from season to season but it is always present.

The positive particles are stopped at the ionosphere and between it and the negative charges in the ground, a distance of 60 miles, there is a large difference of voltage - something on the order of 360,000 volts. With the gases of the atmosphere acting as an insulator between these two opposite stores of electrical charges, the region between the ground and the edge of space traps a great deal of energy. Despite the large size of the planet, it is electrically like a capacitor which keeps positive and negative charges apart by using a non-conducting material as an insulator.

The earth has a charge of 90,000 coulombs. With a potential of 360,000 volts, the earth constitutes a capacitor of .25 farads (farads = coulombs/volts)[18]. If the formula for calculating the energy stored in a capacitor ($E = 1/2\ CV^2$) is applied to the earth, it turns out that the ambient medium contains 1.6×10^{11} joules or 4.5 megawatt-hours of electrical energy.

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In order to tap this energy storehouse Tesla had to accomplish two things - make a "cold sink" in the ambient energy and devise a way of making the "sink" self-pumping. Explaining how this process might have worked requires, again, speculation.

Such a "sink" would have to be at a lower energy state than the surrounding medium and, for the energy to continually flow into it, the "sink" would have to maintain the lower energy state while meeting the power requirements of the load attached to it. Electrical energy, watt-seconds, is a product of volts x amps x seconds. Because the period of oscillation does not change, either voltage or current has to be the variable in the coil's energy equation.

In that the double wound coil maximizes the voltage difference between its turns, it is probable that it is the current that is minimized to produce a low energy state in the coil. For the coil to be initially "empty" and at low energy would mean it operated at high voltage with a small amount of charge [19].

The coil, then, would be set into oscillation at its resonant frequency by an external power source. During a portion of its cycle the coil will appear to the earth's electric field as one plate of a capacitor. As the voltage across the coil increases, the amount of charge it can "sink" from the earth's higher energy field will increase.

The energy taken into the coil - through the "small opening" which appears to be the atomic structure of the conductor according to the physics of Tesla's time - is "condensed" into positive and negative components of current, a lower energy state relative to the originating field.

The current is equivalent to the water converted to gases in Tesla's description of the self-acting engine. The current would "escape" from the "sink" into whatever load was connected across the coil. The movement of current into the load would produce a strong magnetic field (the stated intention of the patent) which, when it collapsed, would, again, produce a high potential, low charge "sink" to couple with the earth's electric field.

Because the inflowing energy performs a double function similar to the unipolar generator, supplying current to the load and aiding the pumping function, the system's energy expenditure in moving charge is low, allowing the system to gain more energy from the medium than it expends in its operation. The coil needs no extra energy from an outside source to pump the energy it has extracted.

Energy would come directly from the sun.

A more modern view of such a device, should it prove to operate in this theoretical manner, would be to describe it as a self-oscillating capacitive system. Once the device is set into oscillation, very little power is expended in driving the load. Because it is an electrostatic oscillating system, only a small amount of charge moves through the load per cycle, that is, the coulomb per seconds = amps are low. If the charge is used at a low rate, the energy stored in the capacitive system will be turned into heat at a slow rate enabling the oscillations to continue for a long period of time.

With his prominent position in the world of science at the time, it is curious why Tesla's invention was not commercialized or at least publicized more. Economics, not science, appear to have been the main factor. The adoption of alternating current was opposed by powerful financiers of the period. Michael Pupin, another leading electrical researcher at the turn of the century, noted in his autobiography:

> ...captains of industry...were afraid that they would have to scrap some of their direct current apparatus and the plants for manufacturing it, if the alternating current system received any support ... ignorance and false notions prevailed in the early nineties, because the captains of industry paid small attention to highly trained scientists [20].

Tesla's patents for electrical generators and motors were granted in the late 1880's. During the 1890's the large electric power industry, in the form of Westinghouse and General Electric, came into being. With tens of millions of dollars invested in plants and equipment, the industry was not about to abandon a very profitable ten year old technology for yet another new one.

Tesla saw that profits could be made from the self-acting generator, but somewhere along the line he had pointed out to him the negative impact the device would have. At the end of the section in *Century* where he described his new generator he wrote:

> I worked for a long time fully convinced that the practical realization of the method of obtaining energy from the sun would be of incalculable industrial value, but the continued study of the subject revealed the fact that while it will be commercially profitable if my expectations are well founded, it will not be so to an extraordinary degree [21, 22].

Years later, in 1933, he was more pointed in his remarks about the introduction of his fuelless generator. In the Philadelphia *Public Ledger* of November 2nd, is an interview with Tesla under the headline "Tesla 'Harnesses' Cosmic Energy." In it he was "Asked whether the sudden introduction of his principle would upset the present economic system, Dr. Tesla replied, 'It is badly upset already.' He added that now as never before was the time ripe for the development of new resources."

It has been nearly a century since Nikola Tesla claimed a radically new method for producing electricity. The need for the development of new resources is greater now than at the end of the last century. Perhaps these overlooked inventions will make his vision of "increasing human energy through the use of the sun's energy" become a reality.

ACKNOWLEDGEMENT

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[2] Nikola Tesla, "The Problem of Increasing Human Energy - Through Use of the Sun's Energy," *The Century Illustrated Magazine*, reprinted in *LPA*, p. A-140.

[3] Reference 2, p. A-142.

[4] Nikola Tesla, "Notes on a Unipolar Generator," *The Electrical Engineer*," N.Y., Sept. 2, 1891, reprinted in *LPA*, p. A-24.

[5] Reference 4, p. A-26.

[6] W.M. Elsasser, "The Earth as a Dynamo," *Scientific American*, p. 44-48, May 1958.

[7] Reference 4, p. A-23.

[8] Reference 2, p. A-140.

[9] Reference 2, p. A-141.

[10] Reference 2, p. A-141.

[11] Reference 2, p. A-141.

[12] Reference 2, p. A-142.

[13] Reference 2, p. A-142.

[14] Nikola Tesla, U.S. Patent #512,340, "Coil for Electro-Magnets," reprinted in *LPA*, pp. P-428-429. He explains that a standard coil of 1000 turns with a potential of 100 volts across it will have a difference of .1 volt between turns. A similar bifilar coil will have a potential of 50 volts between turns. In that the stored energy is a function of the square of the voltages the energy in the bifilar will be $50^2/.1^2 = 2500/.01 = 250{,}000$ times greater than the standard coil.

[15] Measurements were made by M. King and O. Nichelson at Eyring, Inc., with a HP 3577A network analyzer on 3 inch diameter coils with 43 turns each of number 20 wire.

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[17] Carl Linde, "Process and Apparatus for Attaining Lowest Temperatures for Liquefying Gases, and for Mechanically Separating Gas Mixtures," *The Engineer*, pp. 485-6, Nov. 13, 1896 and p. 509, Nov. 20, 1896.

[18] "The Amateur Scientist," *Scientific American*, p. 160, May 1957.

[19] This resembles the electrostatic oscillator in Tesla's wireless transmission system: Oliver Nichelson, "The Underwater Communication System of Nikola Tesla," 1991.

[20] Michael Pupin, *From Immigrant to Inventor*, Charles Scribner's Sons, N.Y., pp. 285-286, 1930.

[21] Reference 2, p. A-143.

[22] For others who followed Tesla with inventions to extract energy from the ambient medium see: Christopher Bird and Oliver Nichelson, "Nikola Tesla: Great Scientist, Forgotten Genius," *New Age*, p. 36 ff, Feb. 1977.

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