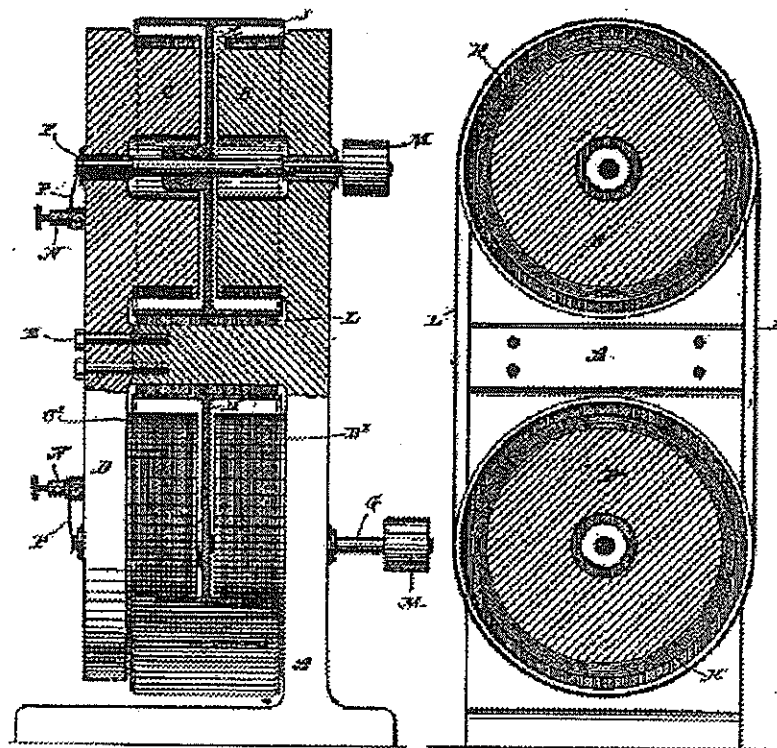


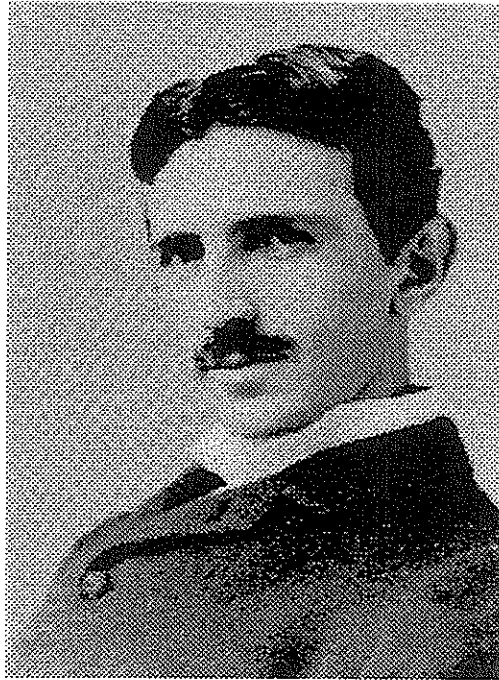
Tesla's Fuelless Generator and Wireless Power Transmission



Analytical papers on Tesla's plan for a new electrical generator,
his wireless power transmission system and its possible connection
to the Tunguska explosion of 1908.

Oliver Nichelson

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*For Claude Thibault
A dedicated researcher
and kind Paris host
Best wishes -
Oliver Nicholson 10/24/07*

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Preface

Nikola Tesla's life (1856 - 1943) spanned two scientific periods - that of the 19th century which saw the universe as filled with an invisible matter, the aether, and that of the 20th century which saw the universe as an empty vacuum with bits of matter in random motion. As an example of the difference between these two world views when the idea of the electron was proposed at the end of the 1800s it was then pictured as a spinning vortex of this aether that condensed into solid matter.

However, Tesla's engineering accomplishments, particularly the alternating current generator, transformer and motor, translated easily from the older science to the newer science. Motors invented in the 1880s ran just as well in the 1920s even though the old science upon which they were based was considered wrong by that time.

The shift in scientific paradigms was, and still is, an obstacle to understanding Tesla's later work. His discoveries were based on a broader understanding of electrical science than that of his day or even than that of today. This is particularly true in relation to his work in the 1890s on a new type of electrical generator that would, he claimed, extract energy directly from the "ambient medium." It also applies to his wireless power transmission method which rested on the concept of the earth being filled with an incompressible material that allowed the transfer of force to any place on the globe.

The following papers are an effort to translate Tesla's accomplishments in power generation and transmission from the language and concepts of 19th century science into today's scientific language.

Nikola Tesla's "Free Energy" Documents reproduces the inventor's 1902 letter to Robert U. Johnson about Tesla's new energy generator that would not consume fuel. This letter was found in the Tesla Collection at Columbia University Library when attending the IEEE Tesla Symposium in New York in January 1976. This letter will come to be considered as important in the history of electrical science as the papers of Franklin, Faraday and Maxwell.

Nikola Tesla's Later Energy Generation Designs was prepared for the 26th Intersociety Energy Conversion Engineering Conference in August 1991. The paper documents that Nikola Tesla claimed to have built an electrical power generator that would not consume fuel, where in his writings the description of such a device is found, the theory of how a fuelless generator could be possible, and a suggestion as to how Tesla's new device might have operated. The paper moves from historical fact, the claims for such a generator in a letter hand written by Tesla, to speculation about the operating principles of the inventions. At the time of writing the paper, the historical material was certain, but the engineering explanation of how the new type of generator work was not convincing.

The Second Law of Thermodynamics and Tesla's Fuelless Generator was prepared, for the 28th (1993) IECEC conference. It takes up Tesla's argument for a fuelless electric power generator that does not violate the Second Law of Thermodynamics. Though the device appears to supply power without fuel, it is not a perpetual motion machine. Tesla's explanation and a modern analysis is given of the device's operation. This paper presents a more satisfactory theory about the engineering aspects of the new generator than the 1991 IECEC paper.

Since the papers on Tesla's new type of electrical generator were published there have been a number of inquiries about his *Notes on a Unipolar Dynamo* article and the Carl Linde device for air liquefaction. The Tesla article and a book chapter on Linde's device have been reproduced here.

A Special Case of Voltage Gain is a technical note showing that the equation for voltage gain will have to be modified for a special coil that may be related to Tesla's fuelless energy generator design. A regular coil and one of Tesla's design are measured and compared. Measurements show that the Tesla design is over 900% better in voltage gain than predicted by calculation.

Underwater Communication System of Nikola Tesla was written originally in 1992 as part of an investigation into his method of submarine communication. Its starting point is an acceptance of Tesla's assertion that his wireless system worked without electromagnetic radiation and transmitted through the earth. Modern analysis of his wireless method, on the other hand, starts with the incorrect assumption that he was using the radio broadcast methods of today and, then, goes on to either disprove Tesla's claims, or tries to find some way of making Tesla's description of his transmission method fit today's technology. Variations on the earth/ionospheric cavity oscillation theory have been popular in both of these efforts. This paper shows, however, that Tesla's work with electrostatics points to his use of displacement currents for through-the-earth transmission. Such a method is shown to be consistent with Tesla's claims and scientifically possible.

Tesla's Wireless Power Transmitter and the Tunguska Explosion of 1908 first appeared in a different form as a magazine article in 1990. Many references to the use of his wireless power transmission technology as a directed energy weapon system appear in Tesla's writings. The more the claims were investigated, the more his statements about a weapons application were discovered to correspond to both his personal circumstances and to public events. They pointed to the likelihood of his having made a test firing of his power transmitter as a directed energy weapon.

Tesla: Forgotten Genius, with Christopher Bird, is an overview of Tesla's work and that of "free energy" device inventors Alfred Hubbard, Lester Hendershot and T. Henry Moray. It appeared in *New Age* magazine in February 1977.

Thanks go to the many people who shared their resources and time to make Tesla material available: Chris Bird, John Ratzlaff, Leland Anderson, Andrew Michrowski, Andrija Puharich, David Faust and Moray King.

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Nikola Tesla's "Free Energy" Documents

Oliver Nicholson

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 we use today.

Ten years after virtually inventing modern electrical technology, Tesla claimed he developed a generator that would not "consume any fuel." Such a generator would not have a conventional source of energy such as oil, coal or falling water. This new generator would get energy from what he called the "ambient medium." He described this source in 1933:

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.

For nearly 100 years researchers have sought the design for Tesla's "free energy" generator. Clues, in Tesla's own handwriting, to the nature of the device and how it operated have been uncovered.

On June 9th, 1902, both the *New York Times* and the *New York Herald* carried a story of a Clemente Figueras, a "woods and forest engineer," in the Canary Islands who invented a device for generating electricity without burning any fuel. What became of Figueras and his fuelless generator is not known, but this announcement in the paper prompted Tesla to send a clipping of the *Herald* story in a letter to his friend Robert Underwood Johnson, editor of *Century Magazine*.

In this letter, a part of the Nikola Tesla Collection, at Columbia University Library, Tesla claimed he had already developed such a generator and to have revealed the underlying physical laws.¹

USES ELECTRICITY WITHOUT A MEDIUM

Scientist Declares He Can Apply
Atmospheric Current
Without Motive Force.

WAS SIMPLE DISCOVERY

Senor Clemente Figueras, Engineer,
of Canary Isles, Inventor
of the Method.

[SPECIAL CABLE TO THE HERALD.]
The Herald's European edition publishes the following from its correspondent:—
London, Monday. — A most remarkable claim, the genuineness of which it is as yet impossible to test, says a cable despatch published by the Daily Mail from its Las Palmas correspondent, has been made by Senor Clemente Figueras, Engineer of Woods and Forests in the Canary Islands, for many years professor of physics at St. Augustine's College at Las Palmas.

It seems that for many years he has been working silently at a method of directly utilizing atmospheric electricity—that is to say, without chemicals or dynamo—and making a practical application of it without the need of employing any motive force.

A true revelation might rob him of his reward, and even now, while he claims to have succeeded, he is silent concerning the exact principles of his discovery.

He asserts, however, he has invented a generator by which he can collect electricity and so as to be able to store it and apply it for infinite purposes—for instance, in connection with shops, railways and manufacturing.

He says he expects its effect will be a tremendous economic and industrial revolution. He will not give the key to the invention, but declares that the only extraordinary point about it is that it has taken so long to discover a simple scientific fact.

He intends shortly going to Madrid and Berlin to patent his invention.

In addition to the discovery, the Daily Mail says that, according to letters received in London from his friends in Tenerife, Senor Figueras has constructed a rough apparatus by which, in spite of its small size and defects, he obtains a current of 30 volts, which he utilizes in his own house for lighting purposes and driving a motor of twenty horse power.

His inventions comprise a generator, a motor and a sort of governor or regulator, the whole apparatus being so simple that a child could work it.

Figure 1 *N.Y. Herald*, June 9, 1902

In the three-page letter Tesla states that he suggested such a generator in his *Century* magazine article, and that he has worked on such a design for sometime.

The Waldorf-Astoria
New York.

June 10. 1902.

Dear Luka,

The invention seems to have been suggested by my article which has given great trouble to you and infinitely more to me. Look up page 200 of *Century* particularly where I refer to novel facts. The report is not likely

Figure 2 Tesla to Johnson, June 10, 1902, page 1.

The text of the letter reads:

June 10, 1902
Dear Luka,²

The invention seems to have been suggested by my article which has given great trouble to you and infinitely more to me. Look up page 200 of *Century* particularly where I refer to novel facts.
The report is not likely

To be true but it
 is singular that I
 have also found a solution
 which I have been following
 up since a long time
 and which promises very
 well. I was at the
 point of revealing my
 method in the article
 but you pressed me to
 find that I did not have
 enough energy left to
 do it. I am glad
 now.
 The conditions at the

Figure 3 Tesla to Johnson, page 2.

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 The conditions at the

Pic of Teneriffe are
 ideal for the success
 of such methods as
 I contemplate to employ
 for getting a steady
 supply of small amounts
 of energy.
 Sorry I was unable
 to call.
 Nikola

Figure 4 Tesla to Johnson, page 3.

Pic of Teneriffe are
 ideal for the success
 of such methods as
 I contemplate to employ
 for getting a steady
 supply of small³ amounts
 of energy.

Sorry I was unable
 to call.

Nikola

Tesla once called the June 1900 *Century* article the most important he had written. The "novel facts" citation mentioned in the letter is found on page 200 of the article in the first column, next to the last paragraph, first sentence.⁴ Discussion of the "novel facts" just precedes the article's subsection dealing with a "'Self-Acting' Machine...Capable...of Deriving Energy From the Medium."

A careful examination of the article reveals the inventor believed his design for an electrical generator which is its own prime mover, that is, does not "consume any fuel," would not violate the energy conservation principle. Tesla believed, rather, that his design transformed one form of energy into another⁵.

Notes

¹The Tesla-Johnson letter and *Herald* clipping are used with permission of the Nikola Tesla Collection, Rare Book and Manuscript Library, Columbia University, New York City.

² The nickname Tesla gave to Johnson refers to "Luka Filipov...a legendary Serbian hero he admired..." Margaret Cheney, *Tesla: Man Out of Time*, Dell, 1983, pg. 83.

³ Underlined in the manuscript. Tesla's attitude was that any amount of power less than that needed for a good sized city was "small."

⁴ The page numbering in the original article differs from the reproduction in the Belgrade *Lectures, Patent, Articles*. In the reproduction, page 200 of the magazine corresponds to pages A-138 and A-139.

⁵ An analysis of the inventions intended by Tesla in this letter is found in: Oliver Nicholson, "Nikola Tesla's Later Energy Designs," IECEC, 26th Proceedings, Am. Nuclear Society, Vol. 4, pp. 439-444, 1991.

NIKOLA TESLA'S LATER ENERGY GENERATION DESIGNS

Oliver Nichelson

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:

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.

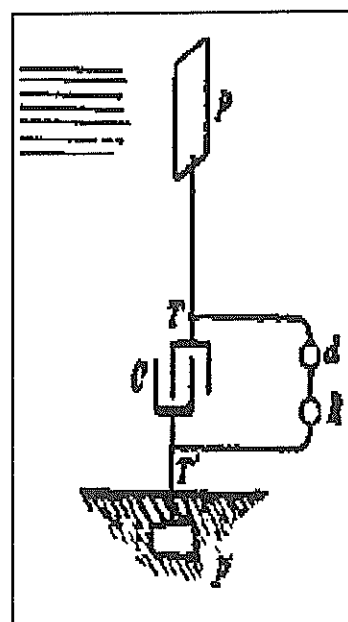
Dating back "more than 25 years ago" from 1933 would mean that the device Tesla was speaking about must have been built before 1908. More precise information is available through his correspondence in the Columbia University Library's collection. Writing on June 10th, 1902 to his friend Robert U. Johnson, 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].

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



1. Particle Collector

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]."

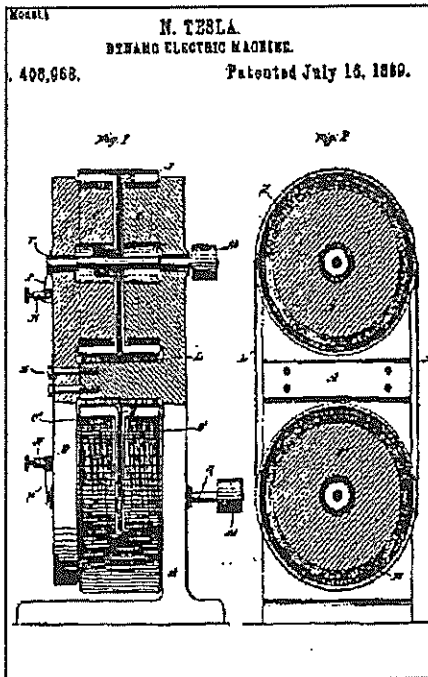
THE TURBINE

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.



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.

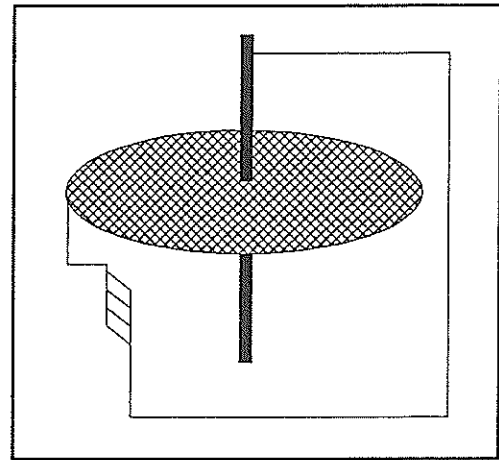
SELF-SUSTAINING CURRENT

Before going into the details of this invention it would be worthwhile 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."

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 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.



3. Faraday Generator with electromagnet

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].

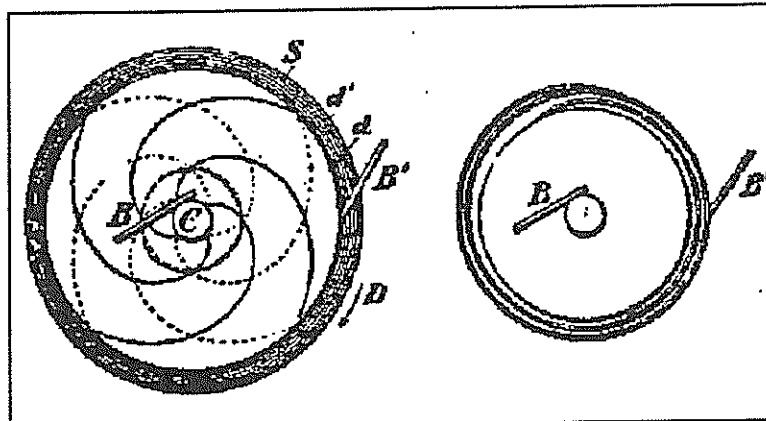
Tesla did not have a material a thousand times more conductive than copper, neither was he able to spin a disk at the ultra-high speeds needed to produce such a current, nor did he plan on using a piece of rotating metal several miles in diameter. What he did was to use energy that is usually wasted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

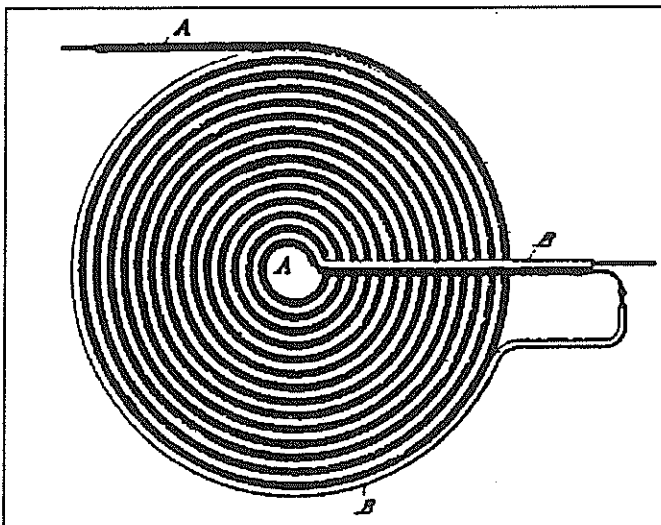
He continued, in the article, to elaborate on his energy pump but changed the image slightly. On the surface of the earth we are at a high energy level and can imagine ourselves at the bottom of a lake with the water surrounding us equal to the energy in the surrounding medium. If a "sink" for the energy 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]."



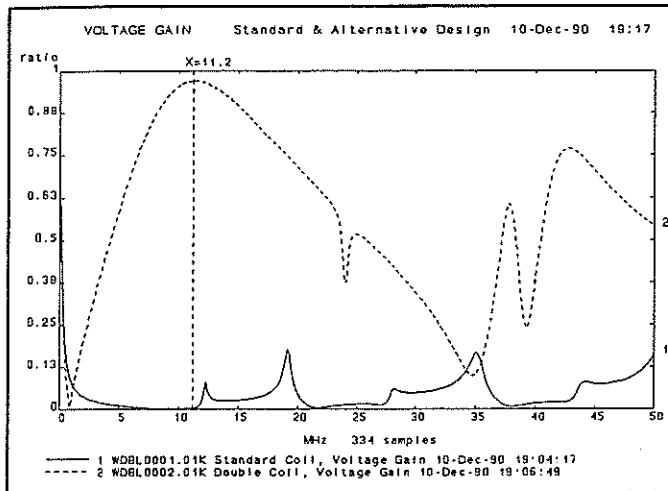
5. Coil for Electro-Magnets

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,

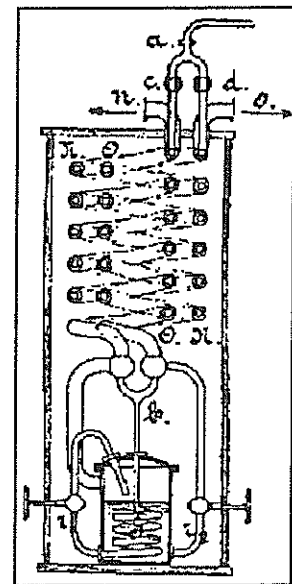
one with a single, the other with a bifilar winding, show differences in voltage gain [15]. In figure 6, the upper curve is from the Tesla design, the lower was produced by the single wound coil. The patent, however, gives no hint of what might have been its more unusual capability.



6. Voltage gain comparison

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.

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.



7. Linde's condenser

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.

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

Thanks to Mr. John Ratzlaff of Millbrae, California for generously sharing a variety of Tesla material that helped make this paper possible.

References

- [1] Nikola Tesla, U.S. Patent #685,957, "Apparatus for the Utilization of Radiant Energy," reproduced in *Nikola Tesla: Lectures * Patents * Articles* (hereafter *LPA*), Tesla Museum, Beograd, 1956, reprinted by Health Research, Mokelumne Hill, CA., p. P-344, 1973.
- [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. Nicholson at Eyring, Inc., with a HP 3577A network analyzer on 3 inch diameter coils with 43 turns each of number 20 wire.

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

[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 Nicholson, "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 Nicholson, "Nikola Tesla: Great Scientist, Forgotten Genius," *New Age*, p. 36 ff, Feb. 1977.

The Second Law Thermodynamics and Tesla's Fuelless Generator

Oliver Nichelson

During an address commemorating the installation of his electrical generators at Niagara Falls, Nikola Tesla told his listeners:

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. I now feel sure that the realization of that idea is not far off. ...the possibilities of the development I refer to, namely, that of the operation of engines on any point of the earth by the energy of the medium...(Tesla, 1897)

In 1902, Tesla wrote to his friend and publisher Robert Underwood Johnson that he had already developed a device for using the energy of the surrounding medium to generate electricity (Nichelson, 1993). In the letter he stated that the design principles for this new type of generator were discussed in his June 1900 *Century Magazine* article (Tesla, 1902) on page 200, "particularly where I refer to novel facts."

An Energy Sink

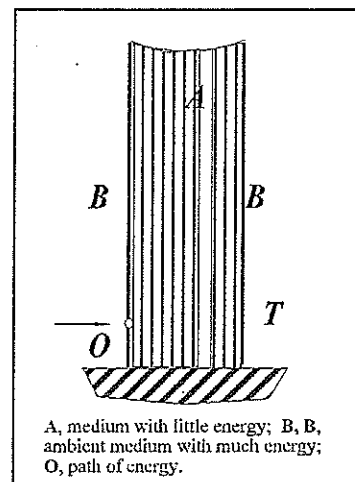
His reference is to the article "The Problem of Increasing Human Energy - Through the Use of the Sun's Energy" (Tesla, 1900). The "novel facts" are mentioned in a section entitled "Energy from the Medium." It is in this and in the following section where the theoretical and developmental discussions of this new generator take place. Tesla uses two versions of simple graphic image to explain how such an energy extracting generator would work.

In the first example he asks that we consider a closed cylinder

such that energy could not be transferred across it except through a channel or path *O*... and ... that, by some means or other, in this inclosure a medium were maintained which would have little energy, and that on the outer side of the same there would be the ordinary ambient medium with much energy.

Tesla continues:

Under these assumptions the energy would flow through the path *O*, as indicated by the arrow, and might then be converted on its passage into some other form of energy. Could we produce artificially such a "sink" for the energy of the ambient



1. Ambient Medium Energy

of the ambient medium to flow in [and]... be enabled to get at any point of the globe a continuous supply of energy, day and night (Tesla, 1900).

In the next paragraph Tesla gives another version of how this energy extraction process would take place. He asks if we can produce cold in a given portion of space and cause the heat to flow in continually. Creating such a "cold hole" in the medium would be like creating in a lake either an empty space or a space filled with something much lighter than water.

This we could do by placing in the lake a tank, and pumping all the water out of the latter. We know, then, that the water if allowed to flow back into the tank, would, theoretically, be able to perform exactly the same amount of work which was used in pumping it out, but not a bit more. (Tesla, 1900)

He notes that in such an operation, nothing would be gained by pumping the water out and letting it fall back down the tank. It would be impossible, in this case, to create a sink in the medium.

Tesla, then, asks that we "reflect a moment" and adds:

Heat, though following certain general laws of mechanics, like a fluid, is not such; it is energy which may be converted into other forms of energy as it passes from a high to low level...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 very little, power. For example, if heat [is represented] by the water of the lake, the oxygen and hydrogen composing the water may illustrate other forms of energy into which the heat is transformed in passing from hot to cold.

Corresponding to this ideal case, all the water flowing into the tank would be decomposed into oxygen and hydrogen before reaching the bottom (Tesla, 1900), and the result would be that 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 heat or, respectively, the water to flow into, a condition enabling us to get any amount of energy without further effort.

Second Law of Thermodynamics

Understanding the operation of Tesla's new generator is a two part task - picturing it as he did in terms of 19th century science and explaining it in terms of today's science. Fortunately, he framed his explanation within the context of the Second Law of Thermodynamics as it was being formulated by the leading physical theorists of the day.

Rudolph Clausius put it, in 1850: "It is impossible for a self-acting machine unaided by an external agency to convert heat from one body to another at higher temperature." As given by Kelvin, "It is impossible by means of inanimate material agency to derive mechanical effect

from any portion of matter by cooling it below the temperature of surrounding objects." If a machine was able, by itself, to take heat energy out of the surrounding environment and use that energy to run its cooling work, it would be a perpetual motion machine. Cooling the surrounding medium requires energy from an external source.

In his *Century Magazine* article, Tesla takes up the thermodynamics question in a section entitled "Possibility of a Self-Acting Engine...Inanimate, yet Capable of Deriving Energy from the Medium." He challenges the assertion about the impossibility of a cooling machine's ability to operate from the heat derived from the medium with a simple thought experiment.

If two metal rods ran from the earth to outer space, the temperature difference between the ends of the rods would create an electric current in the rods which could operate an electric motor. This would be a device that would cool the medium and do work from the heat of the medium.

With this example, Tesla does not refute the Second Law of Thermodynamics but shows the limits of its popular understanding. He does not deny the most basic tenant that energy flows from hot to cold, from a high energy state to a lower state. What he asserts is that good engineering can cause work to be done in the change from a higher to lower energy state without creating a perpetual motion machine.

Ambient Medium

How an energy sink can be created on earth requires two additional pieces of information presupposed by Tesla's thermodynamics discussion - the nature of the fluid that makes up the ambient medium and what constitutes a low temperature in this medium.

To understand the concept of the energy of the ambient medium, it is necessary to return to the historical roots of electrical science. From the time of Franklin until the beginning of this century, electricity was pictured as a fluid that flowed through conductors and, like steam that powered the engines of the day, could be condensed out the medium. The capacitors of today were once known as condensers due to this concept.

Before the last paradigm shift at which the universe came to be viewed as atomic particles moving randomly in a void, physics believed all matter was made from a primary substance. It was this primary material, the aether (Dunlap, 1934) of Maxwell and Kelvin, that filled the ambient medium.

As for temperature, Tesla wrote (Tesla, Feb. 1919) that "in light of present knowledge we may liken electric potential to temperature." Creating a low temperature region in the high energy ambient medium meant creating a sustained low electrical potential. Relative to the medium, the device creating this low pressure region could be seen as a self-cooling apparatus.

In principle, the electrical fluid would enter the device, transform into a lower form of energy and perform work as the fluid continued to flow into the device. The nature of this transformation is conjecture at this point, but it seems that the electrical fluid was seen to be transformed into positive and negative potential.

Thermodynamic Work

In accordance with the Second Law of Thermodynamics, Tesla's device would make use of energy moving from a higher temperature to a lower temperature, but would be self-sustaining, or self-cooling by converting the energy coming from the environment into a different form in a process that consumed only a small amount of the incoming energy.

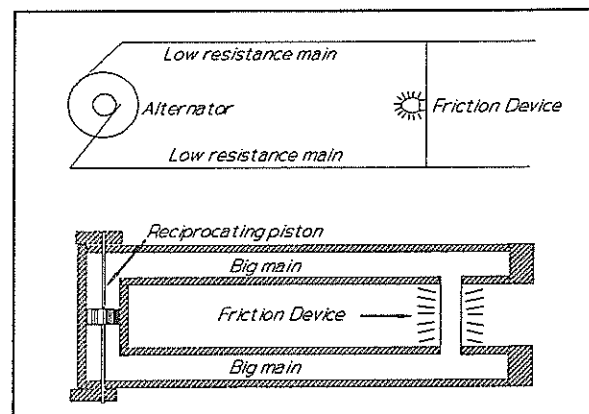
This last element in the operation of the device - that it consume very little of the working energy - is mentioned (Tesla, Feb. 1919) in connection with his wireless receiver. He wrote that "energy will be economically transmitted and very little power consumed as long as **no work is done** in the receiver." Here "work" is meant in the technical sense - power expended over time.

The Tesla device for extracting energy from the ambient medium, then, operated by transforming the input energy into potential and doing no or little work in the device itself. Electrical energy, the units of work, is measured in watt-secs or amperes x volts x secs. Volts and amperes are the quantities of the electrical fluid and because potential is enhanced, the conclusion is that work, or energy, is conserved by reducing conduction current in the device. The new generator appears to have operated by potential variations and with no or very little current. It seems to have been an electrostatic device.

Because the receiver in the Tesla wireless system and new energy generator share the characteristic of using no, "or very little, power," it is useful to examine how the receiver was pictured to have operated. In 1919, Tesla detailed his wireless method in the *Electrical Experimenter*, using hydraulic analogies.

A conventional electrical transmission system requiring two wires is equated to a hydraulic system with a reciprocating piston, Fig. 2. The working fluid is pushed and pulled "with high velocity thru the small channel" so "that virtually all the energy of movement would be transformed into heat by friction, similarly to that of the electric current in the lamp filament."

On the other hand, the wireless method is like the one-wire transmission system Tesla demonstrated several times, Fig. 3. A reciprocating cylinder pushes the working fluid through the



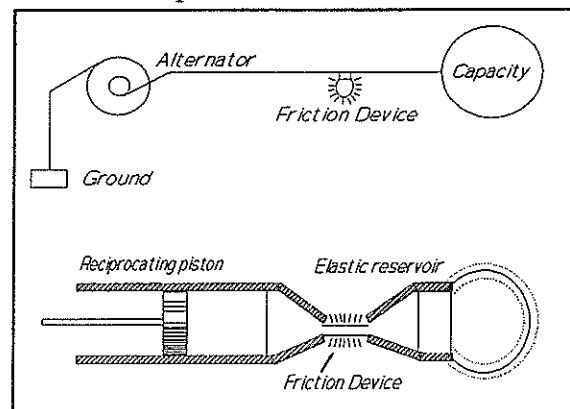
2. Electric Transmission Thru Two Wires and Hydraulic Analog

friction device and into a large elastic reservoir. When the piston has reached the end of its stroke, the elastic reservoir is filled with the working fluid and sends it back through the friction device...

the fluid is made to surge thru the restricted passage with great speed, this resulting in the generation of heat as in the incandescent lamp. Theoretically considered, the efficiency of conversion of energy should be the same in both cases.

Tesla seems to be saying that for a light bulb of a given wattage, it can be powered either by a commercial power source of a certain voltage and amperage, or by a single wire of much smaller amperage but much greater voltage. For example, a 100 watt light bulb could be powered by 100 volts and 1 ampere or by 1000 volts and .1 ampere.

For an electrical device to do no work, this arrangement has to be taken another step. Work consists of a force moving something over a period of time. In the case of electricity this is a voltage pushing a charge carrier through a cross sectional area of a conductor. The number of coulombs of charge passing a certain point in a conductor in a second constitutes a current, $q/s = i$. Doing no electrical work means the number of charge carriers passing a point in the conductor has to approach zero.



3. Electric Transmission Thru a Single Wire Hydraulic Analog

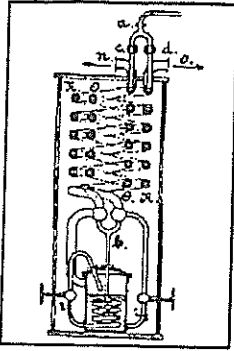
Displacement Current

The condition in which an alternating current can be maintained with no translational movement of charge carriers is found in a capacitor. A displacement current consists of the back and forth movement of bound charges within the lattice structure of a non-conducting dielectric material.

No work would be done if the device operated with a displacement current. If a large voltage displaced a small amount of bound charge, the power requirements of a load, like a light bulb, would be met with no conduction current, therefore, with no expenditure of energy.

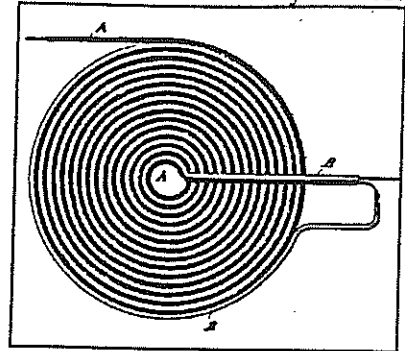
Tesla's thermodynamic argument with the rods-reaching-into-space thought experiment is that energy differences in the environment can be used to power a device that extracts that energy without being a perpetual motion machine. With his new energy extraction device, his argument is that energy can be taken from the environment, and, if converted to pure potential, can power a load while doing no work within the device. In the first example the long rods will allow a motor to operate until the earth has the same temperature as outer space. In the second instance, he describes a device that incorporates an energy difference within itself and expends no, or very

little of that energy in powering a load. Though the second device may appear outwardly to be a perpetual motion machine, it does, as he shows, follow the Second Law of Thermodynamics.



4. Linde device

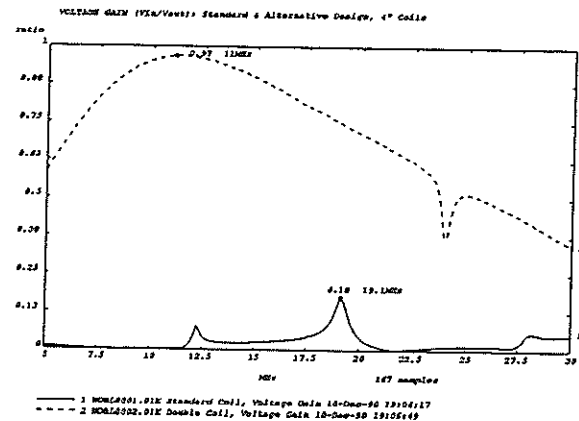
Tesla's comparison (Tesla, 1900) of his self-cooling energy extractor with Carl Linde's double coiled apparatus for liquefying air, Figure 4, points to his double wound coil (Tesla, 1894) design, Fig. 5, as one likely embodiment (Nichelson, 1991) of his energy extraction device.



5. Coil for Electro-Magnets

Measurements (Nichelson, 1991) of the same size single and double wound coils, both with approximately the same inductance have shown that, at resonance, both the voltage response and voltage gain to be several orders of magnitude greater for the double wound design. Figure 6 shows the voltage gain of two 4 inch diameter helix wound coils with the same number of turns. The lower curve is that of the single wound coil and the upper curve is that of the double wound coil.

Assuming this bifilar coil is related to Tesla's design for a new energy device, it can be theorized that it would be driven at a voltage as great as could be tolerated by the wire's insulation and that the amount of stored charge would be at least as great as required by the load at the operating voltage and frequency. To take a purely hypothetical example, if the load is a 100 watt light bulb and the potential in the coil is 5000 volts and the coil is oscillating at a frequency of 1000 Hz, then in a period of a quarter cycle a charge of 5×10^{-6} coulombs would have to be displaced.



6. Voltage Gains

$$100 \text{ watts} / 5000 \text{ volts} = .02 \text{ amperes}$$

$$\text{and } 1/4 \times 1000 \text{ Hz} = 2.5 \times 10^{-4} \text{ s}$$

$$\therefore q = i \times s = .02 \times 2.5 \times 10^{-4} \\ = 5 \times 10^{-6} \text{ coulombs}$$

This would give a system capacitance of

$$C = q/v = 5 \times 10^{-6} / 5000 = .001 \mu f$$

Like the equations of Maxwell and the AC motor of Tesla, both conceived within the context of 19th century aether based physics and are still used after the physics has been discarded, the new energy device does not require belief in an energetic ambient medium. The concept served

only to explain the source of electricity to earlier researchers who naively sought an answer to this fundamental question. Modern engineering practice does not require a primary source of electricity be given, but only a description of how it operates or makes a device operate.

Tesla's new "generator" can be explained solely on the basis of its electrical activity. A bifilar coil is capable of holding more charge than a single wound coil. When operated at resonance, the distributed capacitance of the bifilar coil is able to overcome the counter force normal to coils, inductive reactance. It does not allow what Tesla described (Tesla, 1894) as the formation of "false currents."

Because the electrical activity in the coil does not work against itself in the form of a counter-emf, the potential across the coil quickly builds to a high value. The difference between the turns becomes great enough that (Tesla, 1892) "the energy would be practically all potential." At this point, the system becomes an electrostatic oscillator.

Minimal work is done in the system due to absence of translational movement in the displacement current. As small heat losses occur, oscillations are maintained by the surplus charge stored in the coil. Very low energy expenditure allows power delivery to a load over an extended time period without an external fuel supply. After an initial input of energy from an outside source, Tesla's new electrical generator would operate as a fuelless device.

References

Dunlap, Orrin E., Jr., "Tesla Sees Evidence That Radio and Light Are Sound," *N.Y. Times*, X, p. 9, April 8, 1934.

Linde, Carl, "Process and Apparatus for Attaining Lowest Temperatures, for Liquefying Gases, and for Mechanically Separating Gas Mixtures," *The Engineer*, p. 509, Nov. 20, 1896.

Nichelson, Oliver, "Nikola Tesla's Later Energy Designs," IECEC, 26th Proceedings, Am. Nuclear Society, Vol. 4, pp. 439-444, 1991.

Nichelson, Oliver, "Nikola Tesla's 'Free Energy' Documents," American Fork, Utah, 1993.

Tesla, Nikola, "Experiments with Alternate Currents of High Potential and High Frequency," IEE, London, Feb. 1892, reproduced in *Nikola Tesla: Lectures * Patents * Articles (hereafter, LPA)*, published by the Nikola Tesla Museum, Nolit, Beograd, 1956, p. L-105.

Tesla, Nikola, "Coil for Electro-Magnets," U.S. Patent #512,340, Jan. 9, 1894.

Tesla, Nikola, "On Electricity," *Electrical Review*, Jan 27, 1897, in *LPA*, p. A-107.

Tesla, Nikola, Letter to R.U. Johnson, **1902**, in the Nikola Tesla Collection, Rare Book and Manuscript Library, Columbia University, New York City. Page 200 of the magazine corresponds to pages A-138 and 139 in *LPA*.

Tesla, Nikola, "The Problem of Increasing Human Energy, *Century Magazine*, June **1900**, in *LPA*, pp. A-109 to A-152.

Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, Gernsback Publications, Feb. **1919**, pp. 692-694 ff.

Tesla, Nikola, "The True Wireless," *Electrical Experimenter*, Gernsback Publications, May **1919**, pp. 28-30 ff.

NOTES ON A UNIPOLAR DYNAMO* 1

It is characteristic of fundamental discoveries, of great achievements of intellect, that they retain an undiminished power upon the imagination of the thinker. The memorable experiment of Faraday with a disc rotating between the two poles of a magnet, which has borne such magnificent fruit, has long passed into every-day experience; yet there are certain features about this embryo of the present dynamos and motors which even to-day appear to us striking, and are worthy of the most careful study.

Consider, for instance, the case of a disc of iron or other metal revolving between the two opposite poles of a magnet, and the polar surfaces completely covering both sides of the disc, and assume the current to be taken off or conveyed to the same by contacts uniformly from all points of the periphery of the disc. Take first the case of a motor. In all ordinary motors the operation is dependent upon some shifting or change of the resultant of the magnetic attraction exerted upon the armature, this process being effected either by some mechanical contrivance on the motor or by the action of currents of the proper character. We may explain the operation of such a motor just as we can that of a water-wheel. But in the above example of the disc surrounded completely by the polar surfaces, there is no shifting of the magnetic action, no change whatever, as far as we know, and yet rotation ensues. Here, then, ordinary considerations do not apply; we cannot even give a superficial explanation, as in ordinary motors, and the operation will be clear to us only when we shall have recognized the very nature of the forces concerned, and fathomed the mystery of the invisible connecting mechanism.

Considered as a dynamo machine, the disc is an equally interesting object of study. In addition to its peculiarity of giving currents of one direction without the employment of commutating devices, such a machine differs from ordinary dynamos in that there is no reaction between armature and field. The armature current tends to set up a magnetization at right angles to that of the field current, but since the current is taken off uniformly from all points of the periphery, and since, to be exact, the external circuit may also be arranged perfectly symmetrical to the field magnet, no reaction can occur. This, however, is true only as long as the magnets are weakly energized, for when the magnets are more or less saturated, both magnetizations at right angles seemingly interfere with each other.

For the above reason alone it would appear that the output of such a machine should, for the same weight, be much greater than that of any other machine in which the armature current tends to demagnetize the field. The extraordinary output of the Forbes unipolar dynamo and the experience of the writer confirm this view.

Again, the facility with which such a machine may be made to excite itself is striking, but this may be due — besides to the absence of armature reaction — to the perfect smoothness of the current and non-existence of self-induction.

* The Electrical Engineer, N.Y., Sept. 2, 1891.

If the poles do not cover the disc completely on both sides, then, of course, unless the disc be properly subdivided, the machine will be very inefficient. Again, in this case there are points worthy of notice. If the disc be rotated and the field current interrupted, the current through the armature will continue to flow and the field magnets will lose their strength comparatively slowly. The reason for this will at once appear when we consider the direction of the currents set up in the disc.

Referring to the diagram Fig. 1, d represents the disc with the sliding contacts $B B'$ on the shaft and periphery. N and S represent the two poles of a magnet. If the

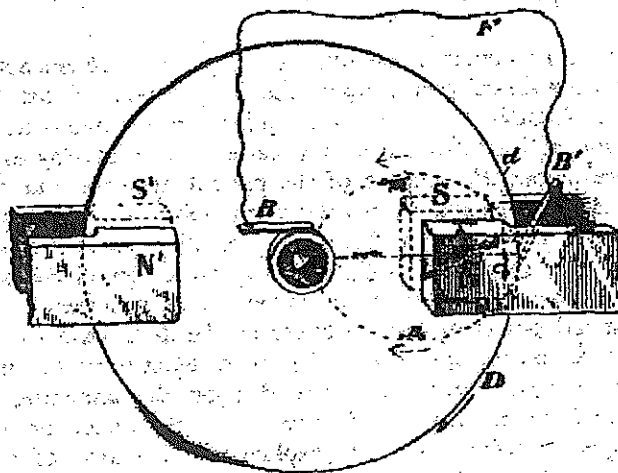


Fig. 1.

pole N be above, as indicated in the diagram, the disc being supposed to be in the plane of the paper, and rotating in the direction of the arrow D , the current set up in the disc will flow from the centre to the periphery, as indicated by the arrow A . Since the magnetic action is more or less confined to the space between the poles $N S$, the other portions of the disc may be considered inactive. The current set up will therefore not wholly pass through the external circuit F , but will close through the disc itself, and generally, if the disposition be in any way similar to the one illustrated, by far the greater portion of the current generated will not appear externally, as the circuit F is practically short-circuited by the inactive portions of the disc. The direction of the circulating currents in the latter may be assumed to be as indicated by the dotted lines and arrows m and n , and the direction of the energizing field current being indicated by the arrows a, b, c, d , an inspection of the figure shows that one of the two branches of the eddy current, that is, $A B' m B$, will tend to demagnetize the field, while the other branch, that is, $A B' n B$, will have the opposite effect. Therefore, the branch $A B' m B$, that is, the one which is approaching the field, will repel the lines of the same, while branch $A B' n B$, that is, the one leaving the field, will gather the lines of force upon itself.

In consequence of this there will be a constant tendency to reduce the current flow in the path $A B' m B$, while on the other hand no such opposition will exist in path $A B' n B$, and the effect of the latter branch or path will be more or less preponderating over that of the former. The joint effect of both the assumed currents might be represented by that of one single current of the same direction as that energizing the field. In other words, the eddy currents circulating in the disc will energize the field magnet. This is a result quite contrary to what we might be led to

suppose at first, for we would naturally expect that the resulting effect of the armature currents would be such as to oppose the field current, as generally occurs when a primary and secondary conductor are placed in inductive relations to each other. But it must be remembered that this result from the peculiar disposition in this case, namely, two paths being afforded to the current, and the latter selecting that path which offers the least opposition to its flow. From this we see that the eddy currents flowing in the disc partly energize the field, and for this reason, when the field current is interrupted, the currents in the disc will continue to flow, and the field magnet will lose its strength with comparative slowness, and may even retain a certain strength as long as the rotation of the disc is continued.

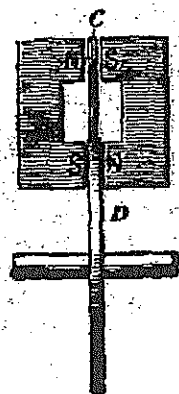


Fig. 2.

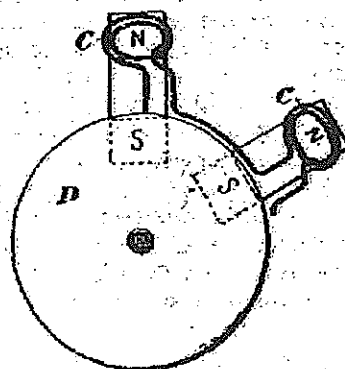


Fig. 3.

The result will, of course, largely depend on the resistance and geometrical dimensions of the path of the resulting eddy current and on the speed of rotation. These elements, namely, determine the retardation of this current and its position relative to the field. For a certain speed there would be a maximum energizing action; then at higher speeds, it would gradually fall off to zero and finally reverse, that is, the resultant eddy current effect would be to weaken the field. The reaction would be best demonstrated experimentally by arranging the fields N S, N' S', freely movable on an axis concentric with the shaft of the disc. If the latter were rotated as before in the direction of the arrow D, the field would be dragged in the same direction with a torque, which, up to a certain point, would go on increasing with the speed of rotation, then fall off, and, passing through zero, finally become negative; that is, this field would begin to rotate in opposite direction to the disc. In experiments with alternate current motors in which the field was shifted by currents of differing phase, this interesting result was observed. For very low speeds of rotation of the field the motor would show a torque of 900 lbs. or more, measured on a pulley 12 inches in diameter. When the speed of rotation of the poles was increased, the torque would diminish, would finally go down to zero, become negative, and then the armature would begin to rotate in opposite direction to the field.

To return to the principal subject; assume the conditions to be such that the eddy currents generated by the rotation of the disc strengthen the field and suppose the latter gradually removed while the disc is kept rotating at an increased rate. The current, once started may then be sufficient to maintain itself and even increase in strength, and then we have the case of Sir William Thomson's "current accumulator."

But from the above considerations it would seem that for the success of the experiment the employment of a disc *not subdivided* would be essential, for if there should be a radial subdivision, the eddy currents could not form and the self-exciting action would cease. If such a radially subdivided disc were used it would be necessary to connect the spokes by a conducting rim or in any proper manner so as to form a symmetrical system of closed circuits.

The action of the eddy currents may be utilized to excite a machine of any construction. For instance, in Figs. 2 and 3 an arrangement is shown by which a machine with a disc armature might be excited. Here a number of magnets, N S, N S, are placed radially on each side of a metal disc D carrying on its rim a set of insulated coils, C C. The magnets form two separate fields, an internal and an external one, the solid disc rotating in the field nearest the axis, and the coils in the field further from it. Assume the magnets slightly energized at the start; they could be strengthened by the action of the eddy currents in the solid disc so as to afford a stronger field for the peripheral coils. Although there is no doubt that under proper conditions a machine might be excited in this or a similar manner, there being sufficient experimental evidence to warrant such an assertion, such a mode of excitation would be wasteful.

But a unipolar dynamo or motor, such as shown in Fig. 1 may be excited in an efficient manner by simply properly subdividing the disc or cylinder in which the currents are set up, and it is practicable to do away with the field coils which are usually employed. Such a plan is illustrated in Fig. 4. The disc or cylinder D is supposed to be arranged to rotate between the two poles N and S of a magnet, which completely cover it on both sides, the contours of the disc and poles being represented by the

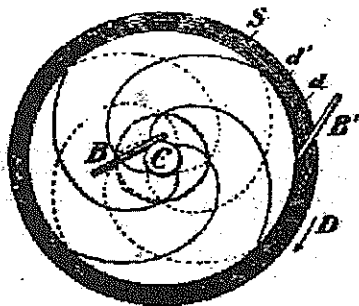


Fig. 4.

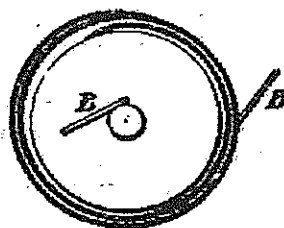


Fig. 5.

circles d and d' respectively, the upper pole being omitted for the sake of clearness. The cores of the magnet are supposed to be hollow, the shaft C of the disc passing through them. If the unmarked pole be below, and the disc be rotated screw fashion, the current will be, as before, from the centre to the periphery, and may be taken off by suitable sliding contacts, B B', on the shaft and periphery respectively. In this arrangement the current flowing through the disc and external circuit will have no appreciable effect on the field magnet.

But let us now suppose the disc to be subdivided, spirally, as indicated by the full or dotted lines, Fig. 4. The difference of potential between a point on the shaft and a point on the periphery will remain unchanged, in sign as well as in amount. The only difference will be that the resistance of the disc will be augmented and that there will be a greater fall of potential from a point on the shaft to a point on the periphery when the same current is traversing the external circuit. But since the current is forced to follow the lines of subdivision, we see that it will tend either to energize or de-energize

the field, and this will depend, other things being equal, upon the direction of the lines of subdivision. If the subdivision be as indicated by the full lines in Fig. 4, it is evident that if the current is of the same direction as before, that is, from centre to periphery, its effect will be to strengthen the field magnet; whereas, if the subdivision be as indicated by the dotted lines, the current generated will tend to weaken the magnet. In the former case the machine will be capable of exciting itself when the disc is rotated in the direction of arrow D; in the latter case the direction of rotation must be reversed. Two such discs may be combined, however, as indicated, the two discs rotating in opposite fields, and in the same or opposite direction.

Similar disposition may, of course, be made in a type of machine in which, instead of a disc, a cylinder is rotated. In such unipolar machines, in the manner indicated, the usual field coils and poles may be omitted and the machine may be made to consist only of a cylinder or of two discs enveloped by a metal casting.

Instead of subdividing the disc or cylinder spirally, as indicated in Fig. 4, it is more convenient to interpose one or more turns between the disc and the contact ring on the periphery, as illustrated in Fig. 5.

A Forbes dynamo may, for instance, be excited in such a manner. In the experience of the writer it has been found that instead of taking the current from two such discs by sliding contacts, as usual, a flexible conducting belt may be employed to advantage. The discs are in such case provided with large flanges, affording a very great contact surface. The belt should be made to bear on the flanges with spring pressure to take up the expansion. Several machines with belt contact were constructed by the writer two years ago, and worked satisfactorily; but for want of time the work in that direction has been temporarily suspended. A number of features pointed out above have also been used by the writer in connection with some types of alternating current motors.

1. Nikola Tesla, "Notes on a Unipolar Dynamo", reproduced in *Nikola Tesla: Lectures * Patents * Articles*, Tesla Museum, Beograd, 1956, reprinted by Health Research, Mokelumne Hill, CA., p. A-22 - A-26, 1973.

Carl Linde's Air Liquefaction Device

When writing about his device for extracting energy from the ambient medium Tesla compares his theoretical machine for creating an energy sink with the Carl Linde's double coiled apparatus for condensing and liquefying air. The Linde device used two coiled tubes, one inside the other, so that the atmospheric gases that were cooled first would work to cool the incoming gases. The effect was to increase the efficiency of condensing gas into a liquid.

It was pointed out in the previous papers that this double coil design of Linde's resembled the configuration in Tesla's "Coil for Electro-Magnets," U.S. Patent #512,340 which has double windings of wire. It was reasoned that the double wound coil might have been related to Tesla's design for a new type of energy generator capable of "self-cooling" and condensing energy out of the ambient medium.

Since the publication of the papers on Tesla's design for a new type of electrical generator there have been a number of requests for more information on the Linde device, information on which is not readily available. Linde's original paper on his air liquefaction device was published in Linde, Carl, "Process and Apparatus for Attaining Lowest Temperatures, for Liquefying Gases, and for Mechanically Separating Gas Mixtures," *The Engineer*, p. 509, Nov. 20, 1896. That paper, however, was printed in a very small type, on non-standard size paper, with small illustrations and has proven difficult to reproduce.

In place of the original Linde article is a chapter from T. O'Connor Sloane's *Liquid Air and the Liquefaction of Gases*, "The Linde Apparatus," 1920. This chapter analyzes the operation of Linde's process and provides large, clear illustrations of the device.

Hopefully, this will add to the understanding of Tesla's double wound coil for electro-magnets and his explanation of how an electrical device can extract energy from the ambient medium.

LIQUID AIR

AND THE

LIQUEFACTION OF GASES

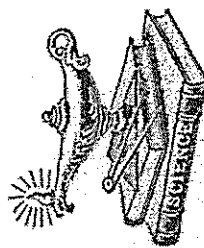
A PRACTICAL WORK GIVING

The entire history of the liquefaction of gases from the earliest times of achievement to the present day—the biography of the great investigators—the manipulation of liquid air and liquefied gases—experiments with the same—the modern uses of liquefaction processes and of their products—the utilization of the nitrogen and oxygen of the air, the rare gases, helium, argon, and neon, and their utilization, and the latest developments in this field of industrial science, are also treated.

BY

T. O'CONNOR SLOANE, Ph.D.

Author of "Arithmetic of Electricity," "Electricity Simplified," Etc.



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LIQUEFACTION OF GASES.

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CHAPTER XIV.

THE LINDE APPARATUS.

Linde's apparatus—The simplest form of apparatus—Its operation—Its storing of air at atmospheric pressure—Avoidance of atomization and waste—Subdivision of pressure-drop—Laboratory apparatus—A feature of inefficiency in it—Its power of liquefaction—Continuous oxygen-producing apparatus—Date of Linde's first successful use of his apparatus.

Linde's apparatus, which is described as utilizing this small increment of cold, if the expression may be allowed, and by constant summation of such increments bringing about a high degree of refrigeration, caused much interest when its supposed principles were first stated and its operations were first disclosed. The term self-intensive has been aptly coined to describe machines of this type.

What the apparatus of the original Linde type does is this: Air is pumped through a circuit of pipes; the pipe from the outlet of the pump, after going through the given circuit, returns to the inlet, so that the air under treatment goes constantly around the same circuit. When a gas is pumped against resistance, it is compressed or diminished in volume and heated. The outlet pipe from the pump is kept at a uniform temperature by cold-water circulating in contact with the outside of the pipe, like a surface condenser.

The air thus cooled is forced through a small aperture, and the passage from high to low pressure, with consequent expansion, causes cooling. Between the water cooling apparatus and the aperture a long length of pipe intervenes. The cooled air is carried back to the pump so as to circulate around this pipe on its way back, and it abstracts heat from the air already cooled by the water. Hence the air reaches the aperture constantly at a lower temperature, but leaves the water condenser always at a uniform temperature. The real cold production is done after the air leaves the water condenser. The degree of cold keeps increasing until liquid air drops from the aperture and lies in the bottom of the apparatus. By a cock it can be drawn therefrom like water.

It seems at first sight impossible that the small decrease of temperature, due to the imperfection of the gaseous state as it exists in air, should be able to produce such refrigeration. What Hampson calls thermal advantages are to be aimed at. The surface on which the cooled air acts on its return must be large, the material of the pipes thin. These elements provide for a rapid cooling by the returning air of the counter-stream on its way to the aperture. The entire mass to be cooled must be as light as possible. The action of the pump is constantly heating the gas by compression, and this heat is removed by the water. The atmosphere surrounding the apparatus constantly heats the portions colder than itself by contact. The colder portions, therefore, must be protected from this action by thick jacketing or other means. Concentric air spaces produce a good effect, and doubtless if it were practicable Dewar's vacuum

heat insulation might be applied with excellent effect.

Linde made quite a sensation by his description of his apparatus, which, by purely mechanical means, liquefied air, although his first results were far from encouraging.

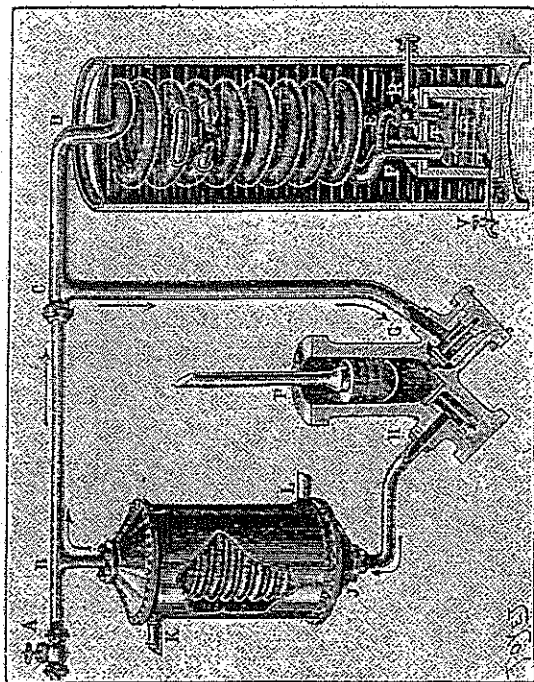
What is called Linde's simplest form of apparatus is illustrated in the cut, and will be readily understood, especially if the reader has grasped the very simple general theory on which its operation depends. It will be understood that the drawing is not a reproduction of the exact apparatus, but is diagrammatic, being purposely made as clear as possible without permitting detail to interfere with intelligibility.

P represents a pump which aspirates air from the pipe, G , and forces it out, under pressure, through H . The air forced out through H goes through a complete circuit of pipes and returns through G , thus constantly and repeatedly going around the circuit.

J is a water condenser or more properly a cooling apparatus. It is a cylindrical vessel, and the air pipe goes through it in a coil. Water enters at K and emerges at L , so that as the gas leaves the vessel it is always at the temperature of the inflowing water. The arrows show the direction of the current of gas, and all is perfectly clear to the point, C . The arrows might be taken to indicate that the gas, on reaching C , goes down directly to G , but they do not indicate this. The pipe, B , is of small diameter, and, without any opening or break, runs straight on to D , is bent into a coil, and descends to F and T . But from C to F it is surrounded by a second pipe concentric with

it, and it is this outer pipe which is connected to the pump suction by the vertical pipe extending downward from C and ending in G.

The cylindrical vessel on the right is simply a non-conducting casing or jacket to protect the pipes from the heating effect of the outer air. In the illustration



Linde's Apparatus for Liquefying Air.

the interior of the coil is shown, a part of the pipe being supposed to be broken away to show this.

In the course of the air in the pipes to the right of the point, C, lies the soul of the apparatus. The small pipe running down through the protecting vessel terminates in the chamber, Z. A valve, R, is provided which may be opened or shut so as to regulate the pressure drop, and this valve constitutes

the aperture through which the gas passes and expands with attendant cooling.

The end of the pipe, E, enters the small airtight box or chamber, Z. From the chamber rises a larger pipe, F, which, just above the top of the chamber, receives within it the smaller inlet pipe, E, and winds up through the protecting vessel concentric with the smaller pipe. On the second and third turns from the top the interior arrangement of the pipes is shown very clearly.

The operation is now clear. The air enters the pump at G, is forced through H and compressed, thereby being heated. The heat is removed in the cooling apparatus, J, and the compressed air, at the temperature of the water, goes on to D. There it descends in the inner pipe of the double coil, expands through R and is cooled thereby, passes through T and up through F, the outer pipe of the coil. There it cools the air in the inner pipe of the double coil. The air, therefore, reaches the valve, R, at a lower temperature than before, so that it is constantly falling in temperature, reaches R at lower and lower temperatures, and eventually the critical temperature of liquid air is reached and passed, and liquid air begins to collect in the chamber, Z, as shown in the cut. By the faucet, V, it can be drawn therefrom as required.

If air is liquefied in the apparatus, every cubic inch of liquid represents about one-half a cubic foot of air withdrawn from circulation in the apparatus. Once the apparatus begins to liquefy air, it has to have new material supplied it, just as a grist mill needs a supply of grain to keep the stones in operation. A pipe

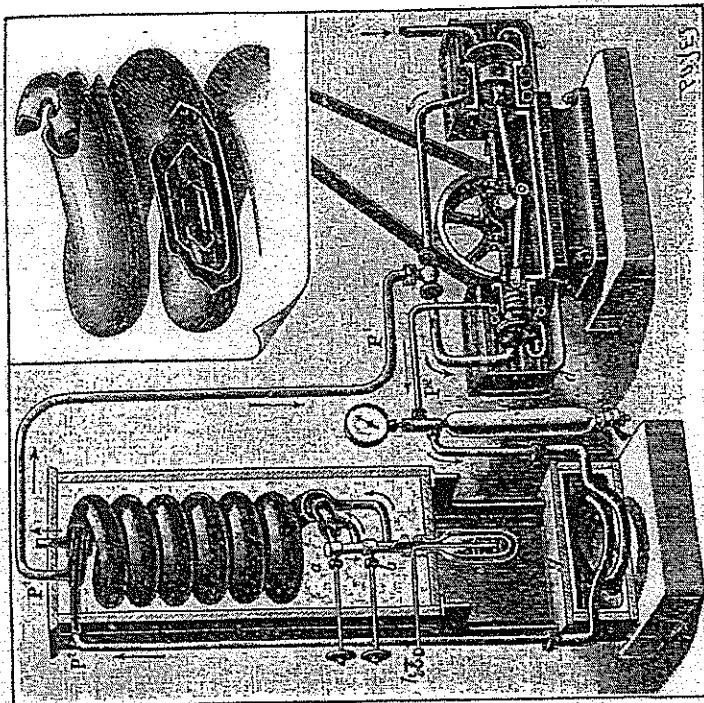
at *A* connects with a second pump which pumps in new air as required, so as to maintain an advantageous pressure in the system—one which will give an economical relation between the pressures on the opposite sides of the aperture.

A minor yet important feature of this apparatus is that the liquid air collects at atmospheric temperature, or thereabout. The effect is twofold. It can be withdrawn much more easily than when it has to be taken from a receiver in which it is subjected to 50 or 100 atmospheres pressure. In the latter case it rushes out, only controllable by the faucet, and the mechanically atomizing effect plays a part in wasting it and facilitating its loss by gasification. But, stored under atmospheric pressure, it not only is quietly withdrawn, as required, but, by volatilization, it keeps its own temperature down. The maintaining it in a quiet state and in bulk operates to make it evaporate more slowly, the battle of the squares and the cubes, as it has aptly been termed, being involved.

It is evident that to make the difference of pressure $p^2 - p^1$ (page 302) large, recourse may be had to the expedient adopted in steam engineering for expansion engines of high initial pressure. These are constructed with two cylinders (compound engines) or with three or more cylinders working in series, the steam passing seriatim from one cylinder into the next (triple, quadruple, etc., expansion engines). Just as in these engines the expansion is divided between several cylinders, so it is practicable in self-intensive refrigerating machines to force the air or gas through several apertures, letting each one take

care of its fraction of the total difference of pressures, $p^2 - p^1$.

Linde has done this in a partial way in his laboratory apparatus, and the cut shows the modification



Laboratory Apparatus.

in question. If the description of the simple apparatus has been understood, the drawing alone will be almost self-explanatory. There are, however, various refinements introduced in this machine which need explanation.

A double-barreled pump is used which takes in air from the open room, the pipe on the right, with the arrow pointing down it, being the intake. The right hand pump cylinder pumps the air through the coil in the water jacket, *c*, and thence it passes into the cylinder on the other end of the pump. On its way to the other or left hand end of the double pump, it is joined by a stream of air from the inter-changer or refrigerator, which air enters by the pipe, *P₁*. From the left hand pump barrel the air, now twice compressed, goes through a second water jacket, *d*, and by the pipe, *P₂*, passes to the left. These water jackets cool the air but partially. In order to more thoroughly cool it water is injected, and at *f* is a trap which removes most of the water. The air then goes through a coil in the small tank, *g*, which is surrounded by ice and salt. This cools the air thoroughly and removes the last of the water.

It will be remembered that in the first described apparatus an auxiliary pump was used to supply the deficiency of air, due to liquefaction of a portion thereof. In the laboratory apparatus the right hand pump barrel performs this function, compressing the air to 16 atmospheres only; the second or left hand pump barrel, taking in the air from the right hand barrel, and also the air from the pipe, *P₁*, compresses it all to 200 atmospheres.

The air thus compressed we have followed to its exit from the coil in *g*. Cold and dry, it rises to the top of the refrigerating case, entering it at *P₂* and going down a spiral pipe. This spiral pipe is the inner one of a triple concentric coil, whose construction is shown in the small sectional cut in the upper

right hand corner of the illustration. It descends through the interior coil to *a*, where it passes through an aperture regulated by a valve. Just below *a* is another valve, *b*. This valve is slightly opened, so that, of the air which passes *a*, one-fifth as near as may be passes *b*. The four-fifths of the air which does not pass through *b* rises through the annular space between the interior tube and the intermediate tube. This four-fifths of the air rises to the top of the refrigerating chamber and goes back to the pump by the pipe, *P₁*. This circuit is comparable to that in the first described machine.

The one-fifth of the air which passes through *b* has undergone a double expansion. It has expanded through two apertures, *a* and *b*. A portion of it when the liquefaction has begun passes on to the annular space between the intermediate pipe and the outside pipe of the coil, and, after passing through it, escapes into the open air at the top of the chamber. The outlet pipe is there shown leading from the outside tube up into the air. Three-quarters of it thus escape, one-quarter is liquefied and collects in the double-walled vessel, *c*. Thus, the air from the pump, entering the inner pipe at *P₂*, is cooled on its descent by the expanded air in the intermediate pipe. But this air is still further cooled by the constant uprising stream of still colder air rising in the outer pipe.

There is one peculiarity to be noted in the accumulative cooling action. The air from the pump entering at *P₂* is working in the opposite direction to the colder air in the intermediate annular space or pipe. This is the correct method. But the cool-

ing effect of the air in the outer tube is differently applied. This air rises, and cools in its rising the air in the intermediate tube, which is also rising. This is the wrong way of working, but its inefficiency is lessened by the fact that the entire quantity of air does not pass through the outer tube. It is only a question of one-fifth multiplied by three-quarters, which is three-twentieths of the original air. This is the quantity which passes up the outer tube. It operates, perhaps, more as a jacket than as a cooler.

The air, after it collects in the liquid state in the vessel, *c*, can be withdrawn by opening the cock, *h*. Enough back pressure is maintained in the vessel, *c*, to force the liquid air out at *h*, exactly like water from a soda water siphon.

It will be seen that the right hand pump barrel has to supply not only the deficiency in air caused by liquefaction of a portion of it, but has also to pump in air to supply the loss of that which escapes into the air after passing through the valve, *b*.

Another peculiar feature will be noticed. All of the air is not twice expanded. The majority is only once expanded, and all the liquid air which is produced is derived from the one-fifth of the total which is twice expanded through *a* and through *b*.

A pressure gauge is mounted on top of the trap, *f*, to enable the operator to maintain the proper pressure.

This apparatus, with the expenditure of three horse power, is credited with the production of nearly one quart of liquid air per hour.

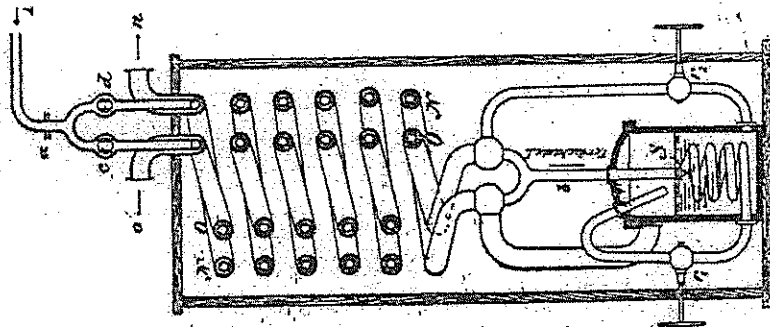
The makers of liquid air, confronted with their great success, as yet scarcely know what to do with

their wonderful product. One of their projects is to utilize it for the production of a highly oxygenated air, as it may be termed, for the production of a mixture of nitrogen and oxygen which will be very rich in oxygen.

The next illustration shows in diagram how Linde proposes to effect this by a continuous process. In the cut are shown a double set of annular or concentric pipes, forming two coils such as used in the first described apparatus.

These coils are in parallel with each other. The air from the pump enters both coils by the small branched tube seen at the top of the apparatus and designated by *a*. It goes down the two interior tubes of the coils through the valves, *c* and *d*, and, leaving the outer concentric pipes, the tubes unite to a single pipe, *b*. Thence the single tube

passes through the liquid air vessel, *S*, and emerges at the bottom. The air expands through the valve, *r*¹, and part of it liquefies and collects in *S*.



Linde's Oxygen-producing Apparatus.

When air is liquefied and allowed to stand, it gives off nitrogen much more rapidly and in larger quantities than it does oxygen. Hence, a gas rich in nitrogen is given off by the liquid air in *S*, and this gas rises through the annular space between inner and outer pipe in the coil, which starts from the left of the liquid air vessel.

The liquid air, constantly growing richer in oxygen, passes out of a pipe leading to the right out of the bottom of the liquid air vessel and, controlled by the valve, *r*², evaporates into the annular space of the other coil. The nitrogenous gas in the one annular space and the gas rich in oxygen in the other annular space cool off the gas from the pump so as to form the true self-intensive heat interchanging system.

The two outer pipes are kept separate as they emerge from the interchanger. One, marked *n*, delivers a product poor in oxygen. This may be allowed to escape. The other, marked *o*, delivers a product rich in oxygen, which may be utilized for many technical purposes.

If the gases from the outer pipes of both coils are allowed to escape, one into the air, the other into an oxygen receiver, the pump will have to work upon new air constantly. There will no longer be a question of supplying a loss of a fraction of the air—all will have to be pumped in during the operation.

Linde's first successful experiments were performed in May, 1895. Fifteen hours' pumping was required to liquefy air, and then he collected some three quarts of liquid air per hour, containing about 70 per cent. of oxygen. He used in his interchanger

iron tubes over 300 feet long, 1½ and 2¼ inches in internal diameter respectively. His pump was a carbon dioxide or carbonic acid gas compressor, and he got from it a compression varying from 22 to 65 atmospheres. The liquid was crystal clear and bluish in color.

The inventor's own words describe his apparatus as eliminating heat from gas "exclusively by expenditure of internal work." This internal work he holds to be the work of separating the gas's own sluggish molecules from each others' vicinity.

A Special Case of Voltage Gain

Oliver Nicholson

A coil's inductive reactance and voltage gain are give by:

$$X_L = 2 \pi f L$$

and

$$V.G. = \frac{X_L}{R} = \frac{2 \pi f L}{R}$$

For two, 4 inch diameter, air core coils, each with 43 turns, one with a conventional single winding and the other with a series bifilar winding,¹ the measured inductance and resonant frequencies were²:

$$\text{Single coil: } L_s = 207.92 \mu H$$

$$f_s = 19 \text{ MHz}$$

$$\text{Bifilar coil: } L_b = 205.06 \mu H$$

$$f_b = 11 \text{ MHz}$$

The calculated voltage gain for each coil is:

$$V.G._s = \frac{2 \pi (19 \times 10^6) (208 \times 10^{-6})}{1} = 25 \times 10^3$$

$$V.G._b = \frac{2 \pi (11 \times 10^6) (205 \times 10^{-6})}{1} = 14 \times 10^3$$

The measured voltage gain, plotted on a scale of 0 - 1, is .18 for the single wound coil and .97 for the series bifilar wound coil.³ Expressed as a ratio of bifilar to single wound, the voltage gain of the series bifilar is greater than expected by theory.

$$\begin{aligned} & \text{Voltage Gain} \\ \frac{\text{Bifilar}}{\text{Single}} &= \frac{14}{25} = .57 \text{ Theory} \\ \frac{\text{Bifilar}}{\text{Single}} &= \frac{.97}{.18} = 5.39 \text{ Measured} \end{aligned}$$

The percentage of measured to calculated Voltage Gain is:

$$\frac{V.G._m}{V.G._c} = \frac{5.39}{.57} \times 100 = 929.3\%$$

1. Figure 1 is an illustration of the test configuration and Figure 2 reproduces a photograph of the measured coils. The measurements were made by inserting the coil leads into the inner conductors of ports 1 and 2 on an HP Network Analyzer. The ports' outer conductors were connected to ground.

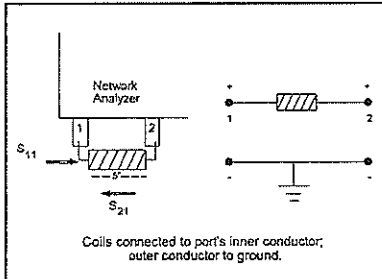


Fig. 1: Measurement configuration

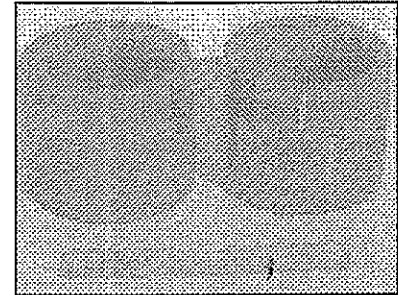


Fig. 2: Measured coils

Figure 3 is a schematic of the respective coil geometries and Figure 4 is a diagram showing the bifilar winding of the test coil. The darker and lighter lines represent the two windings, of the same size wire, in which the first winding is connected in series to the second winding.

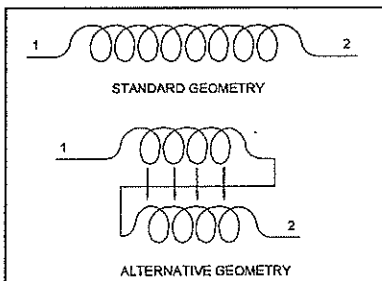


Fig. 3: Coil geometries

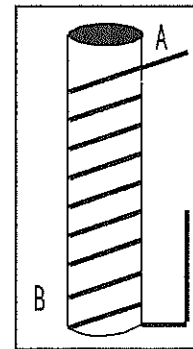
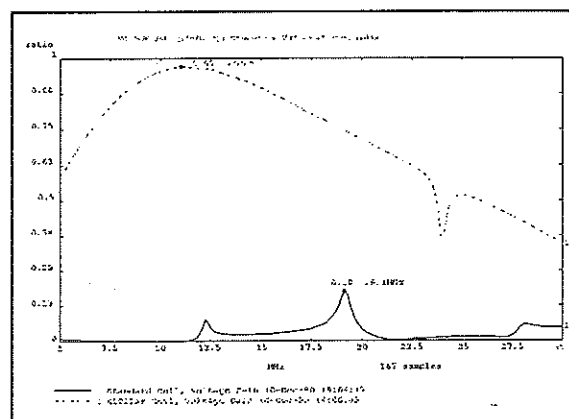


Fig. 4: Double coil

2. Inductance was measured with an HP 4263A LCR meter and resonant frequencies were derived from measurements with an HP 3577B Network Analyzer.

3. Voltage gain was measured by M. King and O. Nicholson at Eyring Corp. on an HP 3577 Network Analyzer.



The Underwater Communication System of Nikola Tesla

Oliver Nichelson

Historical Problems

Tesla described his wireless transmission method by three important characteristics:

- It did not use electromagnetic radiation.
- It operated through the earth or water.
- The mechanism of transmission is an electric current - not radiation.

Modern analysts, both those who believe Tesla had discovered something new and those who believe he was mistaken in his observations, see Tesla's transmission method the same as present day broadcast radio technology. The broadcast model assumes that there is an antenna propagating electromagnetic waves omnidirectionally into the air. The Tesla supporters propose many ingenious, but implausible, schemes that would account for Tesla's claims for his wireless system. The Tesla opponents simply point out that according to electromagnetic theory, Tesla's ideas are impossible. Both groups are incorrect in thinking that his wireless method is the same as the broadcast technology used today.

Anachronistic interpretation - applying the assumptions of today's electrical theories to Tesla's original turn of the century researches - is only half the problem of understanding the inventor's wireless method. The situation is further complicated by the similar sounding descriptions Tesla gave to his earlier and later transmission techniques.

In his early work, Tesla attempted electronic transmission by electrifying the atmosphere. This is the case in his patent entitled *Method of Intensifying and Utilizing Effects Transmitted Through Natural Media*, #685,953, applied for in June 1899. In this patent, he proposes a very powerful transmitter to ionize atmospheric gases and, by that, create a conductive path between the transmitter and receiver through which a current could be sent. Later, when Tesla disclosed his through-the-earth, and through water¹, transmission with essentially the same type of apparatus and operating at ELF frequencies, modern authorities have assumed that Tesla was mistaken about his method of propagation and was really witnessing earth-ionosphere cavity resonance at Schuman frequencies.² More recent scholarship, however, has shown that that Tesla was aware of the differences between conventional wireless transmission methods and the technology he was developing.³

Tesla was⁴ more than an engineer of conventional methods. He was an electrical researcher who investigated fundamental issues of the science. It will be shown that the three characteristics of Tesla's wireless transmission system describe an electrostatic wireless method that used the earth as a conductor and transmitted displacement currents. At moderate energy levels, the system could be used for communication. At greater levels, power could be sent by wireless.

Non-Hertzian Transmission

During-1899 - 1900, Tesla set up a laboratory in Colorado Springs to investigate wireless signal transmission. It was during this period he discovered that a properly configured receiver could detect waves, initiated by lightning strikes, propagating through the earth. Many details about the apparatus for generating and receiving electrical signals (such as tuned resonant circuits that were recognized in 1943 by the Supreme Court as the basis of commercial radio designs) are given in his writings, but he never directly reveals the physics behind the mode of propagation. Tesla does point toward his novel transmission technique when he notes that his transmission method is "the diametrical opposite of a transmitting circuit typical of telegraphy by Hertzian or electromagnetic radiations."⁴ This claim alone indicates a technology different from the transmission technology of today.

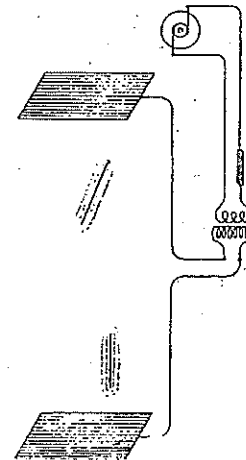
One of his early lectures on evacuated tube illumination provides a good example of physical effects he was using. Tesla describes a setup for illuminating bulbs. It consists of two plates on either side of the bulbs. The plates are connected to a transformer driven by an oscillator. The two plates are similar to a capacitor and the electrical activity between them is like the electrostatic field between two capacitor plates.

As he described it, an evacuated bulb was placed between the electrodes:

*... when we excite luminosity in exhausted tubes..., the effect is due to the rapidly alternating electrostatic potential; ... the medium is harmonically strained and released.*⁵

He also noted:

It might be thought that electrostatic effects are unsuited for such action at a distance. ... It is true that electrostatic effects diminish nearly with the cube of distance from the coil, whereas electromagnetic inductive effects diminish simply with distance. But when we establish an electrostatic field of force, the condition is very different, for then, instead of the differential effect of both the terminals, we get their conjoint effect.⁶



To make sure that the difference between the type of fields he intended and those of Hertz was understood he explained:

As the term electrostatic might imply a steady electric condition, it should be remarked, that in these experiments the force is not constant, but varies... When two conducting bodies are insulated and electrified, we say that an electrostatic force is acting between them.⁷

Tesla's emphasis on the non-Hertzian nature of his signaling process, particularly when taken within the context of his work with electrostatics, indicates the mode of propagation involves similar electrostatic effects between a transmitter and receiver. As he often insisted, this mode of transmission differs significantly from that of Hertzian waves in that this one is a form of conduction:

So far, I have considered principally effects produced by a varying electrostatic force in an insulating medium, such as air. When such a force is acting upon a conducting body of measurable dimensions, it causes within the same, or on its surface, *displacements of the electricity, and gives rise to electric currents*⁸

Also:

Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practicable to disturb by means of powerful machines *the electrostatic condition of the earth* and thus transmit intelligible signals and perhaps power.⁹

Tesla believed that the earth was not just a sink into which electrical energy can be poured, but that it is a reservoir of charge. The capacity of the earth is determined by the standard formula for the capacitance of an isolated sphere of radius R :

$$C = 4\pi\epsilon_0 R$$

For the earth, this works out to 708 microfarads.¹⁰

Tesla's idea was that his high power transmitter he could cause the earth's charge to oscillate and that these oscillations could be detected anywhere on the globe. He further noted that these oscillations were changes in pressure, "the energy will be economically transmitted and very little power consumed so long as no work was done in the receivers."¹¹

To differentiate Tesla's wireless method from contemporary understanding of the technique, and from the misunderstandings arising from the chronology of Tesla's research into the nature of electrical communication, his method can be contrasted with modern patents for electrostatic submarine communication and the inventor's earlier work in this field.

Contemporary Patents

L. Gilstrap's patent for an *Electrostatic Communication System*, #3,964,051, issued June 15, 1976, describes a device consisting of two concentric conducting spheres (#26 & #28) separated by a dielectric layer to form a monopole radiator for electrostatic waves.

The patent states that "longitudinal electrostatic or capacitive waves, also called scalar or polarization waves because of their relationship to the Maxwell wave equations" are the means of propagation but the patent does not explain how these waves differ from conventional forms of electromagnetic radiation. It

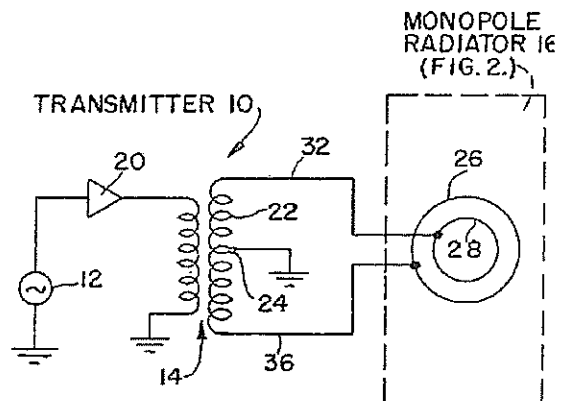
simply states that as the spheres are subject to voltages of opposite polarity the "outer sphere then appears as an ideal monopole radiator to the external dielectric medium, in this case water."¹²

In this configuration, electric field is confined to the region between the two conducting spheres of the transmitter. Little energy, if any, is available to stress the external dielectric medium, the water.

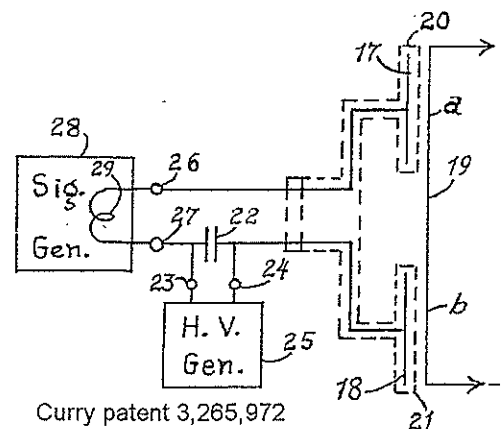
P. Curry's patent for an *Underwater Electric Field Communication System*, #3,265,972, issued August 9, 1966 proposes a radiator of a different configuration and presents a detailed discussion of communication by electrostatic induction.

Curry states:

The antenna system for an electromagnetic emission into space circulates energy in accordance with the laws governing



Gilstrap patent 3,964,051



electrical current in motion. Since the field strength produced by an antenna is proportional to the alternating currents circulating in it, its optimum structural relationships are directed to a reduction of the total antenna resistance, thus to increase the total current for a given power input to a radiator.¹³

He adds:

Being a current-actuated device, such an [electromagnetic] antenna will not operate in any physical conducting medium such as water or earth.¹⁴

While a radiator for electromagnetic emission produces its field strength by the effect of changing currents; the radiator for electrostatic emission of the type here to be described produces its field strength by the effect of changing potentials.¹⁵

Curry proposes "the electrical potentials of the signal to be transmitted to two equal metal plates (#17 & #18) each of which is hermetically sealed within insulating material (#20 & #21) ... immersed in a conducting fluid such as sea water."¹⁶ By applying a varying potential to the plates of the radiator, charge of opposite polarity accumulates on the two plates such that a charge gradient exists in the region between the radiators. The patent explains:

... a phase displacement of 90 degrees exists the wave of charge potentials induced by an alternating current signal upon the water ... and the resulting wave of charge displacements occurring in the water body between the segments.¹⁷

The method of propagation, then, is to periodically alternate electrical charges on the two plates that will launch sinusoidal carrier waves into the medium. When one plate is positive, the other will be negative; then the first will be negative and the second positive. This action, the patent states, will create the sinusoidal waves.

In a detailed analysis of forces involved in this type of transmission Curry shows that radiators with a capacitance of .0053 microfarads operating at 100 kHz with signal generator output of 200 volts coupled with a biasing potential of 1000 volts will produce a force from its charge displacement of 26,500 dynes.¹⁸

On the receiving side, Curry states that the charge gradient can be expected to attenuate substantially at even moderate distance from the point of transmission. As an example he notes that if a signal intensity of 10,600 dynes at the point of transmission is reduced one billion times the "standing wave of the signal energy will therefore be charged with a force differential of 1.06×10^{-5} dynes. Each dipole in his example has a capacitance of .0053 microfarads with a system capacitance of .00265 microfarads. The voltage developed in the receiving network is .02 volts. As noted "this is substantially above the minimum requirements of signal intensity for the detection of electrical signal energies."¹⁹

This detailed analysis, however, overlooks the important point that electrostatic waves do not propagate into the medium in the same way as electromagnetic waves. In an electromagnetic transmission system, charge is accelerated in an elevated conductor, an antenna, to launch waves omnidirectionally into the air. At a receiver, the electromagnetic waves induce a current in the antenna. The variations in the current are processed by the detection circuitry to replicate the transmitted information.

In electrostatics, it is not necessary for flux lines to detach from an antenna and close upon themselves to propagate a wave that is received at a distant point. The transmitter, in Tesla's plan, oscillates the earth's charge and the receiver is connected to that same charge reservoir. Signals are not launched, but exist as pressure variations in the earth's oscillating electric field. Because the field already exists at the point of transmission and at the point of reception, the propagation characteristics are different from electromagnetic waves.

In addition to the mode of propagation being different, what travels between the transmitter and receiver is different. In electromagnetic transmission waves are sent out that are picked up by the receiving antenna. These waves induce a current in the antenna. In an electrostatic system a current passes directly between the transmitter and receiver.

This current is the same as that which exists in a capacitor, that is, it is a displacement current. In a standard inductor-capacitor-resistance circuit, when it is energized and oscillating, it is understood that the current that passes through the conductors is completed through the non-conductor of the capacitor's dielectric through a displacement current. As charge is changed on one plate of the capacitor, an opposite but equal change in charge is seen on the other plate of the capacitor. In Tesla's system the transmitter and receiver act as the capacitor plates and what passes between them is a displacement current.

Displacement current, today, is seen as something of a virtual current, something different from a "real" or conduction current that flows through a wire. Tesla, however, understood what is meant by an electrical current in the same sense as Maxwell - that "all charge is the residual effect of the polarization of the dielectric"²⁰ and that "the variations of electric displacement evidently constitute electric currents."²¹ As a Maxwellian, Tesla was correct in describing his transmission system as one using true electric currents.

Tesla's wireless electrical energy transmission system differed in all three characteristics he claimed - it was not electromagnetic, it operated through the earth or water, and conveyed electrical energy by a current. Once Tesla's communication method is better understood as a new branch of electrical science that was started over 100 years ago, it will not only have an impact on terrestrial technology, but will have applications in the future for space communications.

NOTES

¹ Tesla states that his transmission system is an "apparatus for submarine signaling" in Tesla, Nikola, "The True Wireless," *Electrical Experimenter*, May 1919, pg. 30; in the same article he also states that "transmission thru sea-water is more efficient" with his wireless method, pg. 87.

² Wait, James R., "Propagation of ELF Electromagnetic Waves and Project Sanguine/Seafarer," *IEEE Journal of Oceanic Engineering*, vol. OE-2, no. 2, April 1977, pgs. 161-172.

³ Tesla, Nikola, "Nikola Tesla on his Work with Alternating Currents and their Application to Wireless Telegraphy, Telephony and Transmission of Power, An Extended Interview," transcripts with legal counsel given in 1916, Leland I. Anderson, Editor; Sun Publishing, Denver, 1992, pgs. 132-133.

⁴ Tesla, Nikola, "The Transmission of Electric Energy Without Wires," originally in *The Electrical World and Engineer*, March 5, 1904, reproduced in *Nikola Tesla: Lectures * Patents* Articles*, published by the Nikola Tesla Museum, Nolit, Beograd, (hereafter, *LPA*) 1956, A-156.

⁵ Tesla, Nikola, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination" (1891), *LPA*, pg. L-42. Emphasis added.

⁶ *LPA*, pg. L-43.

⁷ Tesla, Nikola, "On Light and Other High Frequency Phenomena" (1893), *LPA*, pg. L-121.

⁸ LPA, L-127, emphasis added.

⁹ LPA, pg. L-138, emphasis added.

¹⁰ See : "The Earth as a Condenser and Its Role in Wireless Telegraphy," *Scientific American Supplement*, No. 1451, October 24, 1903, pg. 23248.

¹¹ Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, February 1919, pg. 732.

¹² Gilstrap #3,964,051, Column 2, lines 34 - 48.

¹³ Curry #3,265,972, Column 1, lines 21 - 28.

¹⁴ Curry, Column 1, lines 29 - 31.

¹⁵ Curry, Column 1, lines 44 - 48.

¹⁶ Curry, Column 1, lines 49 -54.

¹⁷ Curry, Column 4, lines 8 - 38.

¹⁸ Curry, Columns 5 - 6.

¹⁹ Curry, Column 7, lines 35 - 75 to column 8 line 2.

²⁰ Maxwell, James Clerk, *A Treatise on Electricity and Magnetism*, Volume One, Part I, Electrostatics, pg.167.

²¹ Maxwell, pg. 65.

Tesla's Wireless Power Transmitter and the Tunguska Explosion of 1908

Oliver Nichelson

The French ship *Iena* blew up in 1907. Electrical experts were sought by the press for an explanation. Many thought the explosion was caused by an electrical spark and the discussion was about the origin of the ignition. Lee De Forest, inventor of the Audion vacuum tube adopted by many radio broadcasters, pointed out that Nikola Tesla had experimented with a "dirigible torpedo" capable of delivering such destructive power to a ship through remote control. He noted, though, Tesla also claimed that the same technology used for remotely controlling vehicles also could project an electrical wave of "sufficient intensity to cause a spark in a ship's magazine and explode it." ¹

In the summer of 1913, Signor Giulio Ulivi, blew up a gas meter with his "F-Ray" device and destroyed his laboratory. Then, in August of that year, exploded three mines in the port of Trouville for a number of high ranking French naval officers. The following November, he travelled to Splezzia, Italy to repeat the experiments on several old ships and torpedo boats for that country's navy.²

In the Spring of 1924 newspapers carried several stories about "death rays" inventions in different parts of the world. The work of Harry Grindell-Matthews, London, was the first reported. The *New York Times* of May 21st had this one:

Paris, May 20 - If confidence of Grindell Matthews, inventor of the so-called 'diabolical ray,' in his discovery is justified it may become possible to put the whole of an enemy army out of action, destroy any force of airplanes attacking a city or paralyze any fleet venturing within a certain distance of the coast by invisible rays. So much the inventor consented to tell The New York Times correspondent today while continuing to refuse to divulge the exact nature of the rays beyond that they are used to direct an electric current able to perform the program just mentioned.³

Grindell-Matthews stated that his destructive rays would operate over a distance of four miles and that the maximum distance for this type of weapon would be seven or eight miles. Asked if it would be possible to destroy an approaching enemy fleet, the inventor said it would not, because "Ships, like land, are in continual contact with the earth, but what I can do is to put the ships out of action by the destruction of vital parts of the machinery, and also by putting the crews temporarily out of action through shock."⁴ Airplanes, on the other hand, could be completely destroyed. As soon as his ray touched the plane it would burst into flames and fall to earth.

Grindell-Matthews asserted, "I am convinced the Germans possess the ray." He believed, though, they were carrying out their experiments with high frequencies and at high power, around 200 kilowatts, and could not control the weapon to hit a specific target. So far, said Grindell-Matthews, he had tried tests at 500 watts in his laboratory over a distance of sixty-four feet.

A French company, the Great Rhone Engineering Works of Lyon, had offered Grindell-Matthews extensive financial backing that would allow him to test his device at much higher power levels. He replied that would not undertake such tests "except under conditions of absolute safety on a wide tract of uninhabited land," such was the destructive power of his rays.

Details of the "diabolical rays" destructive power surfaced that August. "Tests have been reported where the ray has been used to stop the operation of automobiles by arresting the action of the magnetos, and an quantity of gunpowder is said to have been exploded by playing the beams on it from a distance of thirty-six feet."⁵ Grindell-Matthews was able, also, to electrocute mice, shrivel plants, and light the wick of an oil lamp from the same distance away.⁶

His own laboratory assistants were themselves became unintentional victims of the ray. When crossing its path during tests they were either knocked unconscious by violent electrical shocks or received intense burns. The inventor stated that though it would be possible to kill enemy infantry with the ray, "it would be quite easy to graduate the electric power used so that hostile troops would only be knocked out long enough to effect their capture."⁷

On May 25th, a second death ray was announced in England. Doctor T.F. Wall, a "lecturer in electrical research in Sheffield University, "applied for a patent for means of transmitting electrical energy in any direction without the use of wires. According to one report. even though he has not made tests on a large scale yet "Dr. Wall expressed the belief that his invention would be capable of destroying life, stopping airplanes in flight and bringing motor cars to a standstill." On a more positive note, he added that his invention would have beneficial applications in surgical and medical operations.⁸

Germany joined the technology race on May 25th when it announced its electrical weapon. As the *Chicago Tribune* reported:

Berlin - That the German Government has an invention of death rays that will bring down airplanes, halt tanks on the battlefields, ruin automobile motors, and spread a curtain of death like the gas clouds of the recent war was the information given to Reichstag members by Herr Wulle, chief of the militarists in that body. It is learned that three inventions have been perfected in Germany for the same purpose and have been patented.

Sensing something of importance the *New York Times* copyrighted its story of May 28th on a ray weapon developed by the Soviets. The story opened: "News has leaked out from the Communist circles in Moscow that behind Trotsky's recent war-like utterance lies an electromagnetic invention, by a Russian engineer named Grammachikoff for destroying airplanes."⁹

Tests of the destructive ray, the *Times* continued, had began the previous August with the aid of German technical experts. A large scale demonstration at Podosinsky Aerodome near Moscow was so successful that the revolutionary Military Council and the Political Bureau decided to fund enough electronic anti-aircraft stations to protect sensitive areas of Russia. Similar, but more powerful, stations were to be constructed to disable the electrical mechanisms of warships. The Commander of the Soviet Air Services, Rosenholtz, was so overwhelmed by the ray weapon demonstration that he proposed "to curtail the activity of the air fleet, because the invention rendered a large air fleet unnecessary for the purpose of defense."

An English engineer, J.H. Hamil, offered the American army plans for producing "an invisible ray capable of stopping airplanes and automobiles in midflight," invented by a German scientist. The ray device was said to have been used the previous summer to bring down French planes over Bavaria. Hamil noted, however, that "the fundamental work was done by Nikola Tesla in Colorado Springs about 30 years ago. He built a powerful electrical coil. It was found that the dynamos and other electrical apparatus of a Colorado fuel company within a 100 yards or so were all put out of business."¹⁰

Hamil believed the Tesla coil scattered rays which short-circuited electrical machinery at close range. Laboratories all over the world, he added, were testing methods of stepping up the Tesla coil to produce its effects at greater distances. "Working on an entirely different principle," Hamil said, "the German scientist has succeeded in projecting and directing electrical power."

Those Colorado Springs tests carried out by Tesla were well remembered by local residents. With a 200 foot pole topped by a large copper sphere rising above his laboratory he generated potentials that discharged lightning bolts up to 135 feet long. Thunder from the released energy could be heard 15 miles away in Cripple Creek. People walking along the streets were amazed to see sparks jumping between their feet and the ground, and flames of electricity would spring from a tap when anyone turned them on for a drink of water. Light bulbs within 100 feet of the experimental tower glowed when they were turned off. Horses at the livery stable received shocks through their metal shoes and bolted from the stalls. Even insects were affected: Butterflies became electrified and "helplessly swirled in circles - their wings spouting blue halos of 'St. Elmo's Fire.'"¹¹

The effect that captured the attention of foreign death ray inventors occurred at the Colorado Springs Electric Company powerhouse. One day while Tesla was conducting a high power test, the crackling from inside the laboratory suddenly stopped. Bursting into the lab Tesla demanded to know why his assistant had disconnected the coil. The assistant protested that had not done anything. The power from the city's generator, the assistant said, must have quit. When the angry Tesla telephoned the power company he received an equally angry reply that the power company had not cut the power, but that Tesla's experiment had destroyed the generator!

The inventor explained to *The Electrical Experimenter*, in August of 1917 what had happened.

As an example of what has been done with several hundred kilowatts of high frequency energy liberated, it was found that the dynamos in a power house six miles away were

repeatedly burned out, due to the powerful high frequency currents set up in them, and which caused heavy sparks to jump thru the windings and destroy the insulation! The lightning arresters in the power house showed a stream of blue-white sparks passing between the metal plates to the earth connection.¹²

When questioned about the Ulivi ray that created so much comment a few years earlier, Tesla asserted, in the same interview, that "it was transplanted from this country to Italy." He saw it as simply a modification of his ultra-powerful high frequency coil tested in Colorado. With thousands of horsepower¹ of energy "it would become readily possible to detonate powder and munition magazines by means of the high frequency currents induced in every bit of metal, even when located five to six miles away or more."

With others attributing an energy weapons technology to Tesla's wireless power transmission research, his comments on the destructive capabilities of his system take on a great deal of importance. Writing tersely for *Liberty* magazine of February 1935 he stated:

My invention requires a large plant, but once it is established it will be possible to destroy anything, men or machines, approaching within a radius of 200 miles. It will, so to speak, provide a wall of power offering an insuperable obstacle against any effective aggression.¹³

He went on to make a distinction between his invention and those brought forward by others. He claimed that his device did not use any so-called "death rays" because such radiation cannot be produced in large amounts and rapidly become weaker over distance. He likely was making reference to a Grindell-Matthews type of device that, according to contemporary reports, used a powerful ultra-violet beam to make the air conducting so that high energy current could be directed to the target. The range of an ultra-violet searchlight would be much less than what Tesla was claiming. As he put it: "all the energy of New York City (approximately two million horsepower [1.5 billion watts]) transformed into rays and projected twenty miles, would not kill a human being."

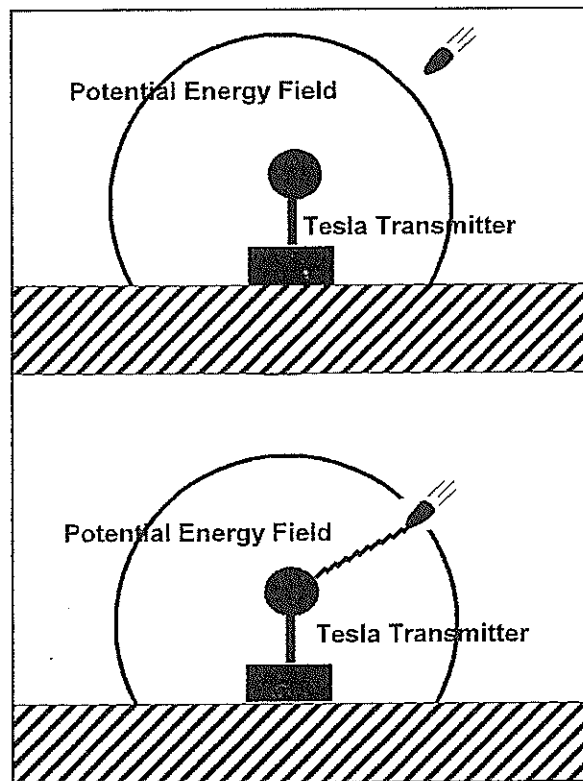
Not wanting to give away a potentially valuable creation in an interview, he was intentionally opaque concerning the details of his design. He did clarify how his design differed from the ray type of devices.

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 be thus transmitted by a stream thinner than a hair, so that nothing can resist.

¹One horsepower equals 745.7 watts.

If Tesla's energy a "ray" device, but as one particles, it would seem the other designs in one was making the beam of radiant energy, flashlight that has carrying photons, and his concentrated into a wide, or he was making a of the beam and the the target.

In a Grindell-Matthews flashlight model, a huge particles or photons from the system so that a target would be covered What Tesla seems to his energy transmitter force around itself would release its energy The effect would be like particles through a wire directly to the target. A large area on the target would not have to be "painted" by a beam, so the current reaching the intruder could be very thin and deliver a great deal of energy to a small area.



Tesla particle beam system - possible configuration

weapon cannot be called projecting microscopic that it had to differ from of two ways. Either he distinction between a like a beam from a billions of energy own with all of its energy stream a single particle distinction about the size method it is used to reach

type of beam, the number of high energy would have to be sent out large enough area on the in order to disable it. have intended was that would set up a field of which, when penetrated, directly to the target. sending a current of

The Colorado tests that gave rise to the variety of "death ray" inventions in the U.S. and Europe may have lead to the development of a much more powerful weapon.

When Tesla realized that economic forces would not allow the development of a new type of electrical generator that would supply power without burning fuel he "was led to recognize [that] the transmission of electrical energy to any distance through the media as by far the best solution of the great problem of harnessing the sun's energy for the use of man."^{14,15} His idea was that a relatively few generating plants located near waterfalls would supply his very high energy transmitters which, in turn, would send power through the earth to be picked up wherever it was needed.

Receiving energy from this high pressure reservoir only would require a person to put a rod into the ground and connect it to a receiver operating in resonance with the electrical motion in the earth. As Tesla described in 1911, "The entire apparatus for lighting the average country dwelling will contain no moving parts whatever, and could be readily carried about in a small valise."¹⁶

The difference between a current used to "light the average country dwelling" and a current used as a method of destruction, however, is a matter of timing. If the amount of electricity used to run a television for an hour is released in a millionth of a second, it would have a very different, and negative, effect on the television.

Tesla said his transmitter could produce 100 million volts of pressure and currents up to 1000 amperes, with experimental power levels of billion or tens of billions of watts.¹⁷ If that amount of power were released in "an incomparably small interval of time,"¹⁸ the energy would be equal to the explosion of millions of tons of TNT, that is, a multi-megaton explosion. Such a transmitter would be capable of projecting the force of a nuclear warhead by radio. Any location in the world could be vaporized at the speed of light.

Not unexpectedly, many scientists doubted the technical feasibility of Tesla's wireless power transmission scheme whether for commercial or military purposes. Modern authorities in electronics, even those who express admiration for the Tesla's genius, believe he was mistaken in the interpretation of his experiments when it came to electrical transmission through the earth.^{19,20,21}

On the other hand, statements from authoritative witnesses who saw Tesla's equipment in operation support his claim about transmission with something other than the radio waves known today. During the Chicago World's Fair of 1893, the Westinghouse exhibit set up by Tesla was visited by the Herman von Helmholtz, the first director of the Physico-Technical Institute of Berlin and one of the leading scientists of his time. When Tesla "asked the celebrated physicist for an expression of opinion on the feasibility of the [transmission] scheme. He stated unhesitatingly that it was practicable."²² In 1897, Lord Kelvin visited New York and stopped at the Tesla laboratory where Tesla "entertained him with demonstrations in support of my wireless theory."

Suddenly [Kelvin] remarked with evident astonishment: 'Then you are not making use of Hertz waves?' 'Certainly not', I replied, '*these are radiations.*' ... I can never forget the magic change that came over the illustrious philosopher the moment he freed himself from that erroneous impression. The skeptic who would not believe was suddenly transformed into the warmest of supporters. He parted from me not only thoroly convinced of the scientific soundness of the idea but strongly exprest his confidence in its success.²³

A recent analysis of Tesla's wireless transmission method shows that he used an electrostatic transmission technique that did not radiate radio waves as we know them and could sent waves through the earth with little loss of power.²⁴ The question remains of whether Tesla demonstrated the weapons application of his power transmission system. Circumstantial evidence found in the chronology of Tesla's work and financial fortunes between 1900 and 1908 points to there having been a test of this weapon.

1900: Tesla returned to New York from Colorado Springs after completing the tests of wireless power transmission that destroyed the power company's generator. He received \$150,000 from J.P. Morgan to build a transmitter to signal Europe. With the first portion of the money he obtained 200 acres of land at

Shoreham, Long Island and built an 187 foot tall tower with a steel shaft running 120 feet into the ground. This tower was topped with a 55 ton, 68 foot diameter metal dome. He called the research site "Wardenclyffe" and envisioned 2000 people eventually working at his global communications center.

A stock offering is made by the Marconi company. Supporters of the Marconi Company include his old adversary Edison and one-time associate Michael Pupin. Investors rushed to buy the Marconi shares. On December 12th, Marconi sent the first transatlantic signal, the letter "S," from Cornwall, England to Newfoundland, Canada. He did this with, as the financiers noted, equipment much less costly than that being built by Tesla.

1902: The Wardenclyffe transmitter nears completion. Marconi is hailed as a hero around the world while Tesla is seen as a shirker by the public for ignoring a call to jury duty in a murder case (he was excused from duty because of his opposition to the death penalty).

1903: When Morgan sent the balance of the \$150,000, it would not cover the outstanding balance Tesla owed on the Wardenclyffe construction. To encourage a larger investment in the face of Marconi's success, Tesla revealed to Morgan his real purpose was not to just send radio signals but the wireless transmission of power to any point on the planet. Morgan was uninterested and declined to provide further funding.

A financial panic that Fall put an end to Tesla's hopes for financing by Morgan or other wealthy industrialists. This left Tesla without money even to buy the coal to fire the transmitter's electrical generators.

1904 - 1906: Tesla writes for the *Electrical World*, "The Transmission of Electrical Energy Without Wires," noting that the globe, even with its great size, responds to electrical currents like a small metal ball.

Tesla declares to the press the completion of Wardenclyffe. Marconi is hailed as a world hero.

Tesla subject to multiple law suits over unpaid Colorado Springs expenses. George Westinghouse, who bought Tesla's patents for alternating current motors and generators in the 1880's, turns down the inventor's power transmission business proposal. Workers gradually stop coming to the Wardenclyffe laboratory when there are no funds to pay them. In an article, Tesla comments on Peary's expedition to the North Pole and tells of his, Tesla's, plans for energy transmission to any central point on the ground.

1907: When commenting on the destruction of the French ship *Iena*, Tesla noted in a letter to the *New York Times* that he has built and tested dirigible torpedoes (remotely controlled torpedoes), but that electrical waves would be more destructive. "As to projecting wave energy to any particular region of the globe ... this can be done by my devices," he wrote. Further, he claimed that "the spot at which the desired effect is to be produced can be calculated very closely, assuming the accepted terrestrial measurements to be correct."²⁵

1908: Tesla repeated the idea of destruction by electrical waves to the newspaper on April 21st. His letter to the editor stated, "When I spoke of future warfare I meant that it should be conducted by direct application of electrical waves without the use of aerial engines or other implements of destruction." He added: "This is not a dream. Even now wireless power plants could be constructed by which any region of the globe might be rendered uninhabitable without subjecting the population of other parts to serious danger or inconvenience."²⁶

In the period from 1900 to 1910 Tesla's creative thrust was to establish his plan for wireless transmission of energy. Undercut by Marconi's accomplishment, beset by financial problems, and spurned by the scientific establishment, Tesla was in a desperate situation by mid-decade. The strain became too great by 1906-1907 and, according to Tesla biographers, he suffered an emotional collapse.^{27,28} In order to make a final effort to have his grand scheme recognized, he may have tried one high power test of his transmitter to show off its destructive potential. This would have been in 1908.

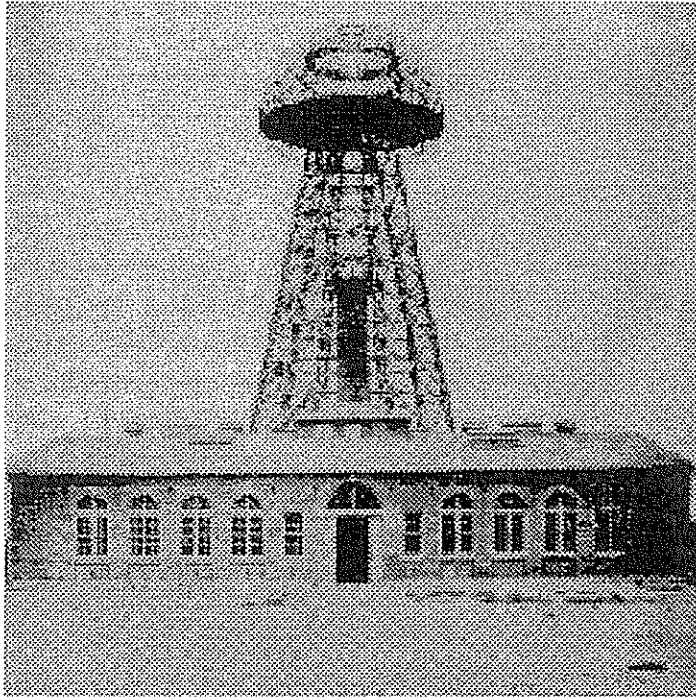
The Tunguska event took place on the morning of June 30th, 1908. An explosion estimated to be equivalent to 10-15 megatons of TNT flattened 500,000 acres of pine forest near the Stony Tunguska River in central Siberia. Whole herds of reindeer were destroyed. Several nomadic villages were reported to have vanished. The explosion was heard over a radius of 620 miles. When an expedition was made to the area in 1927 to find evidence of the meteorite presumed to have caused the blast, no impact crater was found. When the ground was drilled for pieces of nickel, iron, or stone, the main constituents of meteorites, none were found down to a depth of 118 feet.

Several explanations have been given for the Tunguska event. The officially accepted version is that a 100,000 ton fragment of Encke's Comet, composed mainly of dust and ice, entered the atmosphere at 62,000 mph, heated up, and exploded over the earth's surface creating a fireball and shock wave but no crater. Alternative explanations of the disaster include a renegade mini-black hole or an alien space ship crashing into the earth with the resulting release of energy.

Associating Tesla with the Tunguska event comes close to putting the inventor's power transmission idea in the same speculative category as ancient astronauts. However, historical facts point to the possibility that this event was caused by a test firing of Tesla's energy weapon.

In 1907 and 1908, Tesla wrote about the destructive effects of his energy transmitter. His Wardenclyffe facility was much larger than the Colorado Springs device that destroyed the power station's generator. Then, in 1915, he stated bluntly:

It is perfectly practical to transmit electrical energy without wires and produce destructive effects at a distance. I have already constructed a wireless transmitter which makes this possible. ... But when unavoidable [it] may be used to destroy property and life. The art is already so far developed that the great destructive effects can be produced at any point on the globe, defined beforehand with great accuracy (emphasis added).²⁹



Wardencliff

He seems to confess to such a test having taken place before 1915, and, though the evidence is circumstantial, Tesla had the motive and the means to cause the Tunguska event. His transmitter could generate energy levels and frequencies capable of releasing the destructive force of 10 megatons, or more, of TNT. And the overlooked genius was desperate.

The nature of the Tunguska event, also, is consistent with what would happen during the sudden release of wireless power. No fiery object was reported in the skies at that time by professional or amateur astronomers as would be expected when a 200,000,000 pound object enters the atmosphere at tens of thousands miles an hour. Also, the first reporters, from the town of Tomsk, to reach the area judged the stories about a body falling from the sky was the result of the imagination of an impressionable people. He noted there was considerable noise coming from the explosion, but no stones fell. The absence of an impact crater can be explained by there having been no material body to impact. An explosion caused by broadcast power would not leave a crater.

In contrast to the ice comet collision theory, reports of upper atmosphere and magnetic disturbances coming from other parts of the world at the time of and just after the Tunguska event point to massive changes in earth's electrical condition. Baxter and Atkins cite in their study of the explosion, *The Fire*

Came By, that the *Times* of London editorialized about "slight, but plainly marked, disturbances of ... magnets," which the writer, not knowing then of the explosion, associated with solar prominences.³⁰

In Berlin, the New York *Times* of July 3rd reported unusual colors in the evening skies thought to be Northern Lights: "Remarkable lights were observed in the northern heavens ... bright diffused white and yellow illumination continuing through the night until it disappears at dawn."³¹ Massive glowing "silvery clouds" covered Siberia and northern Europe. A scientist in Holland told of an "undulating mass" moving across the northwest horizon. It seemed to him not to be a cloud, but the "sky itself seemed to undulate." A woman north of London wrote the London *Times* that on midnight of July 1st the sky glowed so brightly it was possible to read large print inside her house. A meteorological observer in England recounted on the nights of June 30th and July 1st:

A strong orange yellow light became visible in the north and northeast... causing an undue prolongation of twilight lasting to daybreak on July 1st... There was a complete absence of scintillation or flickering, and no tendency for the formation of streamers, or a luminous arch, characteristic of auroral phenomena... Twilight on both of these night was prolonged to daybreak, and there was no real darkness.³²

The report that most closely ties these strange cosmic happenings with Tesla's power transmission scheme is that while the sky was aglow with this eerie light it was possible to clearly see ships at sea for miles in the middle of the night.³³ Tesla specifically claimed this as one of the effects he could achieve with his high power transmitter. Of particular importance is that none of his claims for lighting the ocean appeared before 1908.³⁴

A typical statement about the light induced by his transmitter is this from the New York *American* of December 7th, 1914:

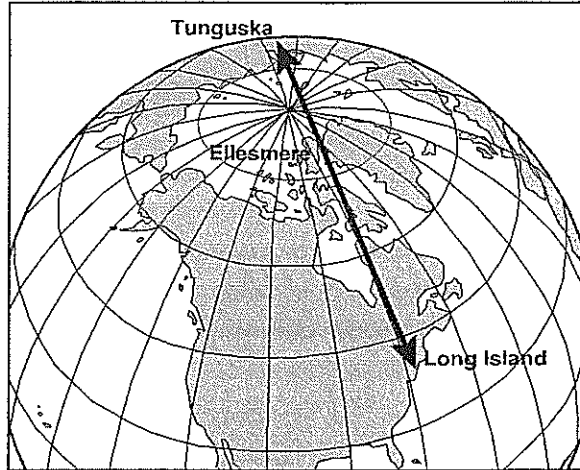
The lighting of the ocean ... is only one of the less important results to be achieved by the use of this invention [the transmitter]. I have planned many of the details of a plant which might be erected at the Azores and which would be amply sufficient to illuminate the entire ocean so that such a disaster as that of the Titanic would not be repeated. The light would be soft and of very small intensity, but quite adequate to the purpose.³⁵

When Tesla used his high power transmitter as a directed energy weapon he drastically altered the normal electrical condition of the earth. By making the electrical charge of the planet vibrate in tune with his transmitter he was able to build up electric fields that effected compasses and caused the upper atmosphere to behave like the gas filled lamps in his laboratory. He had turned the entire globe into a simple electrical component that he could control.

Given Tesla's general pacifistic nature it is hard to understand why he would carry out a test harmful to both animals and the people who herded the animals even when he was in the grip of financial desperation. The answer is that he probably intended no harm, but was aiming for a publicity coup and, literally, missed his target.

At the end of 1908, the whole world was following the daring attempt of Peary to reach the North Pole which he claimed in the Spring of 1909. If Tesla wanted the attention of the international press, few things would have been more impressive than the Peary expedition sending out word of a cataclysmic explosion on the ice near or at the North Pole.³⁶ Tesla, then, if he could not be hailed as the master creator that he was, could be seen as the master of a mysterious new force of destruction.

The test, it seems, was not a complete success. It must have been difficult controlling the vast amount of power in transmitter to the exact spot Tesla intended. The North Pole lies close to a great circle line connecting Shoreham, Long Island and the Tunguska region. That path passes close by Alert on Ellesmere Island where Peary spent the winter.³⁷ The uninhabited region between Alert and the North Pole might have been the intended target for a test firing of the wireless transmission system. However, "the accepted terrestrial measurements" of that day were not precise enough for the task. The destructive electrical wave overshot its target.



Magnifying Transmitter's Test Path

Whoever was privy to Tesla's energy weapon demonstration must have been dismayed either because it missed the intended target and would be a threat to inhabited regions of the planet, or because it worked too well in devastating such a large area at the mere throwing of a switch thousands of miles away. Whatever was the case, Tesla never received the notoriety he sought for his power transmitter.

The evidence is only circumstantial. Perhaps Tesla never did achieve wireless power transmission through the earth. Maybe he made a mistake in interpreting the results of his radio tests in Colorado Springs and really saw a low frequency phenomenon, Schumann oscillations, and not an effect engineers believe a scientific impossibility. Perhaps the mental stress he suffered caused him to retreat into a fantasy world from which he would send out preposterous claims to reporters who gathered for his yearly pronouncements on his birthday. Maybe the atomic bomb size explosion in Siberia near the turn of the century was the result of a meteorite nobody saw fall.

Or, perhaps, Nikola Tesla did shake the world in a way that has been kept secret for almost 100 years.

†

Notes

1. *New York Times*, "Wireless Caused Iena Disaster?", Mar. 19, 1907, p. 4, col. 4.
2. *New York Times*, "Signor Ulivi First Blew Up Gas Meter," Nov. 2, 1913, III, p. 4, col. 5.
3. *New York Times*, "Tells Death Power of 'Diabolical Rays'," May 21, 1924, pg. 1.
4. Note 3.
5. *Popular Mechanics*, "'Death Ray' Is Carried by Shafts of Light," Aug. 1924, pgs. 189-192.
6. *Current Opinion*, "A Violet Ray That Kills," June 1924, pgs. 828-829.
7. Note 6.
8. *New York Times*, "Second British Inventor Reveals a Death Ray," May 25, 1924, p. 1, col. 2.
9. *New York Times*, "Suggests Russia Has A 'Ray'," May 28, 1924, pg. 25.
10. *Colorado Springs Gazette*, "Tesla Discovered 'Death Ray' In Experiments Made Here," May 30, 1924, pg. 1.
11. Goldman, Harry L., "Nikola Tesla's Bold Adventure," *The American West*, Mar. 1971, pgs. 4-9; Reprinted by Nick Basura, 3414 Alice St., Los Angeles, Ca. 90065, 1974.
12. Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, Feb. 1919, pgs. 692f.
13. Tesla, Nikola, "A Machine to End War," as told to George Sylvester Viereck, *Liberty*, Feb. 1935, p. 5-7.
14. Tesla, Nikola, "The Problem of Increasing Human Energy - Through Use of the Sun's Energy," *The Century Illustrated Magazine*, reprinted in *Lectures, Patents, and Articles*, Nikola Tesla Museum, Belgrade, 1956; reprinted by Health Research (Mokelumme Hill, Calif., 95245), 1973, pg. A-143.
15. Nicholson, Oliver, "Nikola Tesla's Later Energy Generation Designs," IECEC, 1991.
16. *American Examiner*, Copyright 1911, no date, no pg.
17. Tesla, Nikola, *New York Times*, "How to Signal Mars," May 23, 1909, pg. 10. He claims to have sent "a current around the globe " on the order of "15,000,000" horsepower or 11 billion watts.
18. Secor, H. Winfield, "The Tesla High Frequency Oscillator," *The Electrical Experimenter*, March 1916, pg. 615.
19. Wait, James R., "Propagation of ELF Electromagnetic Waves and Project Sanguine/Seafarer," *IEEE Journal of Oceanic Engineering*, vol. OE-2, no. 2, April 1977, pgs. 161-172.
20. Marinic, Aleksandar, *Nikola Tesla, Colorado Springs Notes 1899-1900*, Nikola Tesla Museum, Published by Nolit, Beograd, Yugoslavia, pg. 19.
21. Corum, James F., and Corum, Kenneth L., "Disclosures Concerning the Operation of an ELF Oscillator," *Tesla '84: Proceedings of the Tesla Centennial Symposium*, Dr. Elizabeth Rauscher and Mr. Toby Grotz, editors, International Tesla Society, Inc., Colorado Springs, 1985, pgs. 41-49.

22. Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, Feb. 1919, pg. 732.
23. Note 22.
24. Nicholson, Oliver, "Tesla's Wireless Transmission Method," 1992.
25. Tesla, Nikola, "Tesla's Wireless Torpedo," *New York Times*, Mar. 20, 1907, pg. 8.
26. Tesla, Nikola, *New York Times*, "Mr. Tesla's Vision," April 21, 1908, pg. 5.
27. Seifer, Marc J., "Nikola Tesla: The Lost Wizard," *Tesla '84: Proceedings of the Tesla Centennial Symposium*, op. cit., pgs. 31-40. Seifer, a psychologist, believes Tesla suffered a nervous breakdown catalyzed by the death of one of the partners in the Tesla Electric Company and the shooting of Stanford White, the noted architect, who had designed Wardenclyffe. Seifer places this in 1906 and cites as evidence a letter from George Scherff, Tesla's secretary:

Wardenclyffe, 4/10/1906
Dear Mr. Tesla:

I have received your letter and am glad to know you are vanquishing
your illness. I have scarcely ever seen you so out of sorts
as last Sunday; and I was frightened.
28. Cheney, Margaret, *Tesla: Man out of Time*, Dell Publishing Co., N.Y., 1983, pg. 187. Cheney sees a mental change taking place about 1907. Having lost most of his money and many of his friends and seeing less talented people praised for achievements based on his inventions "exerted a corrosive and lasting effect on his personality."
29. Tesla, Nikola, "Tesla's New Device Like Bolts of Thor," *New York Times*, Dec. 8, 1915, pg. 8.
30. Baxter, John and Atkins, Thomas, *The Fire Came By*, Warner Books, N.Y., 1977, pg. 27.
31. Note 30, pg. 26.
32. Spenser Russell quoted in Baxter and Atkins, *The Fire Came By*, page 28, from the *Royal Meteorological Society Quarterly*, 1930.
33. Note 30.
34. The earliest mention of lighting the ocean appears to have been in 1911 in a *N.Y. American* article (Sept. 3rd by Marcel Roland). Ratzlaff, John and Anderson, Leland, *Dr. Nikola Tesla Bibliography*, Ragusan Press, 1979, pg. 93.
35. *New York American*, "Tesla Light to Rob Oceans of Every Danger," Dec. 7, 1914, no pg.
36. Tesla suggested a similar test of his power transmission system aimed at the moon where everyone could see "the splash and volatilization of matter." See note 19, pg. 255.
37. Bayshore, L.I. is at 40 N 43, 73 W 13; Alert, Canada (Ellesmere Island) 82 N 31, 62 W 05, and Tunguska at 60 N 55, 101 E 57.

Nikola Tesla: Great Scientist, Forgotten Genius

**Christopher Bird
Oliver Nicholson**

In the Pike's Peak mountain range, overlooking Colorado Springs, an eccentric Serbian-born inventor began at the dawn of the twentieth century a series of experiments on electrical properties of the atmosphere in a newly built laboratory 8,000 feet above sea level.

Ringed the laboratory were freshly painted signs warning all who chanced to stumble onto the premises that their lives were in danger.

Probing the heavens from atop the laboratory's roof was a 154-foot mast, anchored by guy-wires, supporting at its peak a hollow copper ball 4 feet in diameter. Its purpose was to collect and store an electrical charge inconceivably large for its day.

The new installation was the brain-child of Nikola Tesla, the immigrant from Austro-Hungary who, only a few years earlier, had developed the means to found a new electrical industry in North America. The invention making this possible was the alternating current generator which today generates powers for billions of people all over the globe.

Paired to the generator was Tesla's alternating current motor without which lathes, dentists drills, revolving doors, water pumps, elevators, and thousands of other instruments now so crucial to our civilization would not operate.

The twin inventions transformed electricity, known since long before Benjamin Franklin had hoisted his kite and key skyward, from a scientific curiosity to the principal agent of a technological revolution which altered the lifestyle of humanity.

Up to that time, electricity had been delivered only in the form of direct current through a method developed by the American genius, Thomas Edison, to power that famous product of his imagination: the light bulb. The drawback of Edison's system was its inability to transmit direct current - which quickly turns to heat when pushed through wires - over any appreciable distance with the assistance of a booster generator for every mile of distance traveled.

Tesla's new approach to the problem rendered Edison's method obsolete at a stroke. By harnessing alternating current, Tesla was able, as early as 1895, to relay a massive quantity of electricity produced by the hydroelectric turbines at Niagara Falls, to users in Buffalo, 22 miles distant, without interceding generating stations.

The man who almost singlehandedly wrought a revolution in applying electricity to man's needs was an enigma to his contemporaries. So advanced were his concepts that the science and industry of his

day were unable to comprehend the essence and scope. Half a century before they became widely known, he was experimenting with radar, robots, particle accelerators, and high-temperature plasma. Possessed of such unfathomable power to anticipate the future of technology, Tesla has caused many to wonder whether he might not have been an extra-worldly superbeing visiting for a time among lesser earthly creatures.

Born in 1856 in the village of Smiljan -- in today's Yugoslavian Croatia -- the young Tesla was urged to study theology by his father, a former professional soldier turned priest. As a child, he continually had strange visions. Frequently, it was only necessary for a word to be spoken in order for him to actually see the object which it represented appear in phantom guise before his eyes and remain there for hours.

To banish unsolicited mental pictures, Tesla conjured up his own images, but, because of his limited experience in the world, they soon became repetitive. Later he recalled that it was as if he could no longer add more frames to a movielike reel in his mind. To surmount this problem, he decided to create new thought-forms from a world beyond the day-to-day life he knew. Of these he later wrote:

I saw new scenes. These were at first blurred and indistinct and would flit away when I tried to concentrate my attention upon them. They gained strength and distinctness and finally assumed the concreteness of real things. I soon discovered that my best comfort was attained if I simply went on in my vision further and further, getting new impressions all the time, and so I began to travel; of course, in my mind. Every night, and sometimes during the day, when alone, I would start on my journeys, see new places, cities and countries, live there, meet people and make friendships and acquaintances and, however unbelievable, it is a fact that they were just as dear to me as those in actual life, and not a bit less intense in their manifestations.

When at age seventeen Tesla first turned to invention, he realized that his childhood ability to visualize objects in three dimensions, once a curse, had become a precious gift, allowing him to materialize mentally the design of any machine he wished to create, to take it apart and put it back together, or simply to observe it in action. When he built real-life machines to the specifications of his own imagining, they operated exactly as he had foreseen.

The acute sensitivity which allowed Tesla to convert his mental constructs to hardware was not unaccompanied by a host of bothersome impressions, known to few other mortals. In a biographical sketch written in 1919, he described his violent aversion to women's earrings and his obsessive fascination for crystals and plain surfaces, his revulsion at touching the hair of another person, the fever simply looking at a peach would arouse, and the nausea brought on by merely glancing at small squares of paper floating in a liquid. Evil spirits, ghosts, and ogres filled him with unremitting dread.

It was not until Tesla read, in Serbian translation, a remarkable novel, *Aoafi*, by the Hungarian writer Josika that he was given a clue about how to control the random unearthly forces coursing through him. The novelist's observations introduced him to an ingredient of the human psyche the existence and force of which he had not yet suspected: *will-power*. Extrapolating from hints in the

text, he began to practice inner control his resolution to separate his intent from the clutch of habit at first would fade all too easily, but after doggedly pursuing his effort over several years, he was able to reach a state in which will became identical with desire.

He had so perfected this ability in later life that he could control his body as adroitly as any circus acrobat. At fifty-nine, while walking from his New York laboratory to his residence, he suddenly slipped on the ice and saw his legs go out from under him. As this was happening his mind, calmly observing his predicament, sent instant messages to his muscles. He twisted his body in midair and was seen by stunned passersby to land on the sidewalk in a handstand.

The extraordinary exercise of will-power was not always at Tesla's command; it was especially lacking during times of illness. As chief engineer at the first telephone exchange in Budapest in 1881, he worked himself around the clock to a nervous breakdown, at which point he was again visited by sensations only detectable to an individual of his special sensitivity. As he later recounted:

In Budapest I could hear the ticking of a watch with three rooms between me and the time-piece. A fly alighting on a table in the room would cause a dull thud in my ear. A carriage passing at a distance of a few miles fairly shook my whole body. The whistle of a locomotive twenty or thirty miles away made the bench or chair on which I sat vibrate so strongly that the pain was unbearable. The ground under my feet trembled continuously. In the dark I had the sense of a bat, and could detect the presence of an object at a distance of twelve feet by a peculiar creepy sensation on the forehead."

It was also in Budapest that Tesla, his health recovered, experienced a flash of illumination which first revealed to him how his alternating current devices might work.

While strolling in a park with a friend, he was suddenly moved to declaim lines from Goethe's Faust:

*The glow retreats,
Done is the day of toil.
It yonder hastes, new fields of life exploring.
Ah, that a wing could lift me from the soil
Upon its track to follow, follow soaring.*

Hardly were the words out of his mouth than he was struck by a vision of a magnetic whirlwind turning a motor. Excited, he exhorted his friend to watch the motor run, first in one, then in the opposite direction, and to observe carefully all the parts playing a role in its action.

The companion, who could only see Tesla staring inanely at the setting sun, became so alarmed that he began dragging the engineer towards a park bench. Snapping out his trance, Tesla refused to sit down and went on and on with a detailed description of his vision, which, over the next several

days, he worked up in detailed blueprints in his mind, where they remained stored for the next six years.

This vision was the foundation upon which Tesla invented the rotating magnetic field so fundamental to his alternating current devices.

All his life Tesla worked in privacy so strict that it bordered on secrecy. A recluse by nature, he lived for many years in New York City's Waldorf Astoria, where he could be seen dining alone, in full evening dress, at a table set aside for him by the maitre d'.

He maintained his remoteness from the world in his Rocky Mountain retreat, where he discovered new principles of energy and its transmission which have never been fully elaborated or understood to this day because Tesla and his few surviving collaborators, managed to keep them as hermetically veiled as the teachings of secret societies.

From what is known, it appears that by calculating the speed of thunderstorms, he realized that electrical waves emitted from distant lightning bolts came through in bursts of energy depending on how far away from his receiver the clouds producing them had moved .

It was after observing the electrical effects in the earth of thunderbolts that Tesla discovered the presence of stationary waves in the planet. Some of his conclusions must have mystified even his assistants, for his memoirs reveal that his supersensory powers were still fully active during his sojourn in the Rocky Mountains:

In 1899, when I was past forty and carrying on my experiments in Colorado, I could hear very distinctly thunderclaps at a distance of 550 miles. The limit of audition for my young assistants was scarce more than 150 miles. My ear was thus over three times more sensitive, yet at that time I was, so to speak, stone deaf in comparison with the acuteness of my hearing, while under the nervous strain.

The supersensitive receiver invented by Tesla to track electrical storms also was the first manmade device to detect radio signals coming from the cosmos, over thirty years before a Bell Laboratories researcher, Karl Jansky, picked up similar signals and came to be recognized as the "father of radio astronomy."

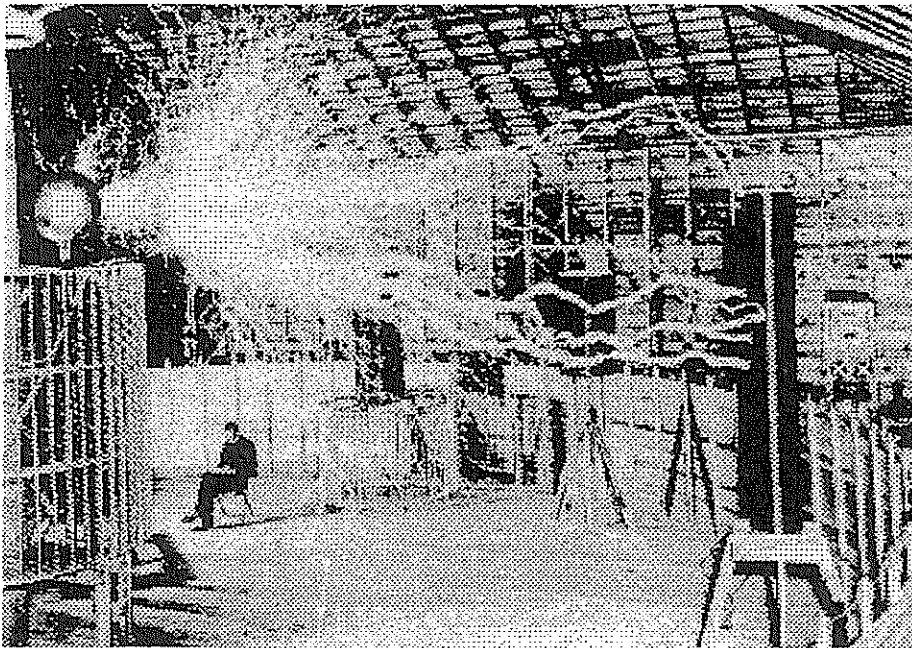
Soon after the article appeared, Tesla was granted U.S. Patent No. 685,957 for a version of his receiver, the somewhat cryptic title of which was "Apparatus for the Utilization of Radiant Energy." In the technical idiom of the Victorian Age, he described the operation of the receiver as follows:

By carefully observing well-known rules of scientific design of instruments, the apparatus may be made extremely sensitive and capable of responding to the feeblest influences or disturbances from very great distances and too feeble to be detected or utilized in any of the ways heretofore known,

and on this account the method here described lends itself to many scientific and practical uses of great value.

In Colorado, Tesla was also the first and only person to create fire balls, phenomena which remain a complete puzzle to science. These balls often appear in the wake of thunderstorms; moving slowly, they bounce when they strike the earth or any solid object. No one knows why they are more common in certain parts of the earth, such as Sweden or Australia, or why they only average a lifetime of no more than five seconds, although some have been observed to last up to five minutes.

To produce ball lightning, Tesla built a huge model of what the world knows as the "Tesla coil," a radio frequency transformer of unheard-of dimensions and power. It produced 12 million volts and created sparks, or artificial lighting bolts, over 100 feet long. When first energized, it blew out the generator of the Colorado Springs Lighting and Power Company; Tesla supervised the rebuilding.



Tesla's record output has only recently [1975] been equaled in Utah, where in a 60,000 square-foot hangar at Wendover Air force Base, 16 miles from Great Salt Lake's Bonneville Flats, Robert Golka, a Massachusetts-born engineer working under a classified contract, has achieved the production of 15 million volts.

Golka hopes that by duplicating Tesla's equipment as exactly as documentation will allow he can be the second man to produce ball lightning for U.S. government agencies interested in its possible application to thermonuclear power generation.

Golka made a careful study of Tesla's Colorado Springs diary at the Nikola Tesla Museum on Proletarian Brigade Street in Belgrade, Yugoslavia, where his entire inventive and literary estate was transferred after his death.

The estate comprises 100,000 documents, or more than enough to keep researchers with a technical understanding of the four foreign languages in which they were written busy for years. Included are 13,780 pages of biographical material; 75,000 pages of letters to 6,900 correspondents; 34,552 pages of scientific articles, notes, drafts articles, and patents; all of Tesla's diplomas, scientific honors, and newspaper clippings; 5,297 pages of technical drawings and plans; and over 1,000 photographs.

While in his Colorado experimental station, Tesla realized that the earth's atmosphere is analogous to an electric wire of *specific length*. Such a wire can only accommodate a set number of electrical frequencies and their harmonics, just as a string pressed at a fret, and thus shortened or lengthened, will reverberate only a specific family of sound.

Tesla therefore believed that, were enough electrical energy pumped into the earth's atmosphere - which stretches from the ground to the ionosphere, an electrically conducting set of layers 30 miles, and higher, above it - and oscillated at specific frequencies, a growing number of harmonic waves would be set in motion within it. Propagated around the globe, they could then be used, thought Tesla, not only for radio transmission but for wireless broadcast of electricity into homes and industrial plants, as well as to ships at sea and aircraft, if all were equipped with suitable receivers. As he wrote:

Impossible as it seemed, this planet, despite its vast extent, behaves like a conductor of limited dimensions. The tremendous significance of this fact in the transmission of energy in my system had already become quite clear to me. Not only was it possible to telegraphic messages to any distance without wires, as I recognized long ago, but also to impress on the entire globe the faint modulation of the human voice. Far more significant is the ability to transmit power in unlimited amounts to almost any terrestrial distance and without loss.

More importantly, Tesla's research led him to the conclusion that the electrical properties of the negatively charged earth and its positively charged upper atmosphere could be used to supply an almost unlimited quantity of electricity.

To test his ideas, Tesla built a mammoth 75-million-watt "magnifying transmitter" able to light a bank of two hundred 50-watt light bulbs, of his own design, for a total of 10,000 watts of energy, at a distance of 26 miles. (The California Institute of Technology has only recently achieved an optimal figure of 43% in the transmission of microwaves over a maximum distance of 1 mile.) No wires of any kind were utilized. The energy passed right through the ground. And Tesla claimed that only 5% of it was wasted.

If Tesla's design was correct, his scheme could supplant burgeoning projects for solar heating going forward in a number of countries and for which the United States Energy Research and Development Agency has budgeted more than \$125 million dollars for the fiscal year 1977.

The same system, Tesla hinted, could be adapted to military purposes in the form of a defensive weapon. He wrote in *Liberty* magazine (9 February 1935):

My invention requires a large plant, but once it is established it will be possible to destroy anything, men or machines, approaching within a radius of 200 miles. It will, so to speak, provide a wall of power offering an insuperable obstacle against any effective aggression.

What effect such a system would have on intercontinental ballistic missiles is anyone's guess.

The possibility that the Soviet Union may already be at work on potential military aspects of a Tesla system was suggested, however tangentially, by a story appearing 29 October 1976 in the *Washington Star*, headlined: "Who's Fouling Up Global Radio? - FCC Prods Soviets on Mystery Signal."

The article called attention to a "superpowerful mysterious radio signal" emanating from somewhere in the region between Minsk and the Baltic Sea which, over several months, had been disrupting maritime, aeronautical, and amateur radio communications to the point where various channels have become virtually useless. All attempts by the United States Federal Communications Commission, which received several hundred complaints, the International Amateur Radio Union in England, and the International Telecommunications Union in Geneva, to elicit precise information from the Russians about the exact location and purpose of the signal have failed.

Tesla also alluded to the fact that his ultra sensitive receiver could be modified to pick-up, store, and amplify the natural vibrations constantly going on in the upper reaches of the earth's gaseous envelope. Such a "solar collector" making use of charged particles instead of heat or light energy, would work night and day and in any weather. Containing not a single moving part, it would have the unnerving appearance of just "sitting there" and putting out electricity- seemingly creating something from nothing.

If Tesla had been the only person to have made such a claim, his evidence might have been discounted and forgotten. However, others, inspired after reading of his achievement, have followed in his footsteps.

Writing on 10 June 1902 to his friend Robert U. Johnson, editor of *Century Magazine*, Tesla included a clipping from the previous day's *New York Herald* about one Clemente Figueras, a woods and forests engineer in Las Palmas, capital of the Canary Islands, who had invented a device for generating electricity without burning fuel.

Figueras's subsequent history is not known, but his achievement prompted Tesla, in his letter to Johnson, to claim priority for first having developed a device similar to the one produced at Las Palmas and, especially, for having revealed the physical laws underlying it.

On 29 July 1920 the Seattle Post Intelligencer ran a front-page spread, including a three-column-wide picture under the title "Hubbard Coil Runs Boat on Portage Bay Ten Knots an Hour; Auto Test Next." The boat, 18 feet long, was propelled across Seattle's Lake Union by a 35 HP electric motor attached to the mysterious coil, the invention of Alfred M. Hubbard, a nineteen year-old gadgeteer.

The newspaper account provides a fascinating description of a small "fuelless" power unit generating a very large amount of electricity. It also recounts some of the difficulties Hubbard experienced in overheating of wires:

The boat circled about the bay and returned to the wharf with never a slackening of speed. The wires connecting coil and motor had begun to heat under the excessive current, and fearing that some part of the coil might give way under the extra heavy strain put on it, Hubbard declined to permit the motor to be run continuously for any length of time. It was tried out later several times, after brief periods, which allowed the wires to cool, and its power apparently showed no diminution.

Hubbard's coil, no larger than a small wastebasket, measured only 11 inches in diameter and 14 inches in length. Its output of current totaled 35,000 watts (280 amperes at 125 volts), or enough power to light 350 100-watt bulbs. The electric motor had to be specially reconstructed for use in conjunction with the coil (however, no details were given).

The inventor maintained that his power unit could operate for years, and that it could drive a large touring car at normal speed, illuminate a medium sized office building, heat seven two room apartments, and allow an airplane to fly all the way around the world without stopping.

Because his device derived its energy from the surrounding air, Hubbard called it an "atmospheric power generator." From the *Post-Intelligencer* account it is clear that the young Washingtonian's generator was quite different, as far as the principle of its construction was concerned, from Tesla's concept. "In general," allowed Hubbard, "it is made up of a group of eight electro-magnets, each with primary and secondary windings of copper wire, which are arranged around a large steel core."

Obviously, the Seattle newspaper accounts do not provide sufficient data to allow us to reconstruct the Hubbard coil or even to learn the amount of wire used, its size, or the number of turns around the axis.

In July 1973 a former resident of Seattle then living in Houston, Texas, wrote to the *Post-Intelligencer* to inquire whether it had published any additional data on Hubbard since the appearance of the articles in the 1920s. In answer to this query, Don Carter, a staff reporter, wrote a follow-up story, dated 16 July 1973 and headlined "Saga of a Boy Inventor and His Mystery Motor." Carter hints that the Hubbard invention was remanded to oblivion by officialdom. "As the Texas reader remembers it," he wrote, "the marvelous invention was quickly squelched by the federal government, which wisely acted to prevent the manufacture and sale of this static electric generator to avert a national financial panic." Carter also dug up the fact that, after making a trip to Washington, D.C., to press for a patent on his device, Hubbard was indicted for using his talents to

produce and operate radio transmitters over which rumrunners out of Canadian territory were advised, during Prohibition, when and where it was safe to land their boats and offload contraband liquor. He was cleared of this charge by a federal jury in 1928.

Shortly after Hubbard's exoneration, the *Detroit Free Press* ran a story on 25 July 1928 with a banner headline "Engine Works, Needs No Gas Nor Any Other Fuel - Whirling of Globe May Be Utilized for Driving Planes, Automobiles and Other Machinery at High Speeds."

The new "fuelless motor" had been designed by one Lester Jennings Hendershot of West Elizabeth, Pennsylvania, and successfully tested at Selfridge Army Airfield outside Detroit in a demonstration witnessed by the world-famous aviator Charles Lindbergh, who testified that the motor worked.

When the Seattle Post-Intelligencer published the same story, Hubbard, suspecting that his own invention might have been purloined by Hendershot, complained to a staff reporter, R. B. Bermann, who three days later wrote an article headlined "Hubbard Believes Mystery Motor Based upon His Own Invention."

Though Hubbard waffled on exactly how the energy for his motor was actually acquired, he continued to insist that there was no great difference between the instrument tested in Detroit and his own. Trying to establish a link between his work and Hendershot, he did provide a vivid description of the obstacles he had come up against. As he told the *Post Intelligencer* reporter:

I never heard of this Lester J. Hendershot who is demonstrating the motor, but it must be remembered that I worked on the invention for two years in Pittsburgh, in 1921 and 1922. It was Dr. Greenslade who represented the people who were financing me at the time - but, of course, if the people who bought out most of my interest in the invention were to bring it out as their own machine, they would probably do it through a man with whom I never worked. When I made my discovery I was only sixteen years old, and until that time I never even had an ice cream soda. So you can imagine that a couple of thousand dollars looked mighty big to me. I never hesitated for an instant when the people who were financing me insisted on taking fifty percent interest from the start, and I didn't protest when they kept demanding that I sign over more and more of my rights. But at last I just quit them cold.

Hendershot was not more forthcoming than his Seattle predecessor when it came to clearly explaining the principle of his motor's functioning. He maintained that it would run for more than 2,000 hours before any recharging of the magnet was required," that it could "make its own electricity" to "start itself," and that, "based on electromagnetism applied to the rotary motion of the earth," the energy which drove it was the same as that which caused a magnetic compass to rotate.

Seattle Post-Intelligencer

NO. 1019 NO. 106 SEATTLE, WASHINGTON, THURSDAY, JULY 26, 1935. 12 PAGES DAILY, MONDAY 10

MYSTERY MOTOR RUN WITHOUT GAS

Meisnest To Resign U. W. Post Today

**GRADUATE
HEAD TO JOIN
COAST FIRM**

**Snow-Laden
Gale Sweeps
Mid-Oregon**

**CALDWELL IS
FINED \$50
BY BOURQUIN**

**Two Labeled
As Wales And
Brothers Hunt**

**MUD-SLINGING
INCREASES IN
MAYOR RACE**

**More Seeking
Gold In City
Of Snobomish**

**LINDY TESTS
ELECTRIFIED
AIR ENGINE**

THE POST-INTELLIGENCER

**ACTION STARTED
ON WATER POWER
AT WASHINGTON**

The Bureau of Federal Conservation, Bureau of Reclamation, Washington, D. C., today announced that it has started action on the proposed water power project at Washington, D. C.

The project, which is being developed by the United States Army Corps of Engineers, would provide for the construction of a dam and the installation of a power plant.

The project is being developed as a part of the National Park Service's plan to develop the area as a national park.

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DRIVES BOAT WITH NEW ELECTRIC GENERATOR



Hubbard Coil Runs Boat On Portage Bay Ten Knots An Hour; Auto Test Next

The Hubbard Coil, a new type of electric generator, was tested today on Portage Bay. The generator, which is being developed by the United States Army Corps of Engineers, was found to be capable of running a boat at ten knots an hour.

The generator is being developed as a part of the National Park Service's plan to develop the area as a national park.

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**GERMANS BACK
SPA AGREEMENT
BY BIG MAJORITY**

The German government today announced that it has agreed to a new spa agreement with the United States. The agreement, which was signed by the German government and the United States government, provides for the construction of a new spa in Germany.

The agreement is being developed as a part of the National Park Service's plan to develop the area as a national park.

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**Harding to Quit His Porch
For Long Speaking Tour
Through Principal Cities**

Calvin Coolidge today announced that he would be leaving his porch to go on a long speaking tour through the principal cities of the United States. The tour, which is being organized by the United States government, will last for several months.

The tour is being developed as a part of the National Park Service's plan to develop the area as a national park.

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It appeared that Hendershot had first conceived of his motor, not in a waking illumination like Tesla, but in a dream, while experimenting in 1925 on ways of building an improved compass for airplanes.

The officer in command of Selfridge Field, Major Thomas Lanphier, at first highly sceptical, was soon impressed with Hendershot's motor. "I believe," he told the press, "that the invention is something more than the pipe dream I thought it was when I first heard of it. It has no hidden batteries or other phony business. Anyone can convince himself of its efficacy by just throwing the switch and watching it run."

The Hendershot motor attracted the attention of personages of national stature who deprecated or extolled it, depending on whether they viewed it as a threat to their security (financial or otherwise) or as a boon to mankind. On the one hand, the Guggenheim Fund for the Promotion of Aeronautics announced that it would examine the motor. On the other, William S. Knudsen, soon to become president of General Motors, denounced it as impractical "bunk," not failing to add that the internal combustion motor would be around for a long time. Another antagonist was Dr. Frederick Hoffstetter, who, as head of his own research laboratory in Pittsburgh, went to the length of hiring a lecture hall in New York City, where he announced to a large audience that the whole Hendershot story reported in the press was a fraud. He exhibited a model of the motor which he had brought with him, showed that it would not work, and, to clinch his argument, reported that he had found a carbon pencil battery concealed within it.

The furor surrounding the motor led Hendershot to dismantle it and conceal it in a location known only to him. The Free Press announced that, within thirty days, it would be put in operation in an airplane.

Then, on 9 March 1928, the same paper's Washington correspondent reported that Hendershot was lying in serious condition in the District of Columbia's Emergency Hospital, where he had been taken after receiving a severe electric shock from his motor while demonstrating it to patent attorneys.

After his recovery, Hendershot disappeared from public view for more than thirty years, resurfacing only once in 1945, when he sent a letter to the Free Press from the Standard Ship Company's U. S. Navy Office in San Pedro, California. The letter accused scientists who had earlier belittled his efforts of now repeating his statements word for word.

At the end of 1960, Hendershot's device, now called a "magnatronic generator," became the object of a research grant proposal made to the U. S. Navy's Office of Naval Research. The submission was made by Force Research, a group of some twenty Californians who, to quote the proposal, were "united in one centrally administered body to correlate their findings on experiments and problems which otherwise have been unsolved."

Organized by Lloyd E. Cannon, a retired department head at the Weyerhaeuser Lumber Company, it included the controller of Capitol Records in Hollywood, the owner of the Precision Tool and

Clock Company in Pasadena, an oil tycoon from Long Beach, a research engineer at the California Institute of Technology's Jet Propulsion Labs in Sierra Madre, the president of McCaffrey Research Corporation in Palm Springs, and Dr. Daniel Fry, who a few years earlier had written about his incredible contact with an Unidentified Flying Object in his classic, *The White Sands Incident*.

Fry was to be project manager, Hendershot project engineer, for the development of the magnatronic generator for which the group sought \$150,000 from the navy. The proposal provided the names of twenty-two persons (including businessmen, attorneys, contractors, publishers, and engineers) who had witnessed the generator in action, including a Colonel Lanphier, now retired.

The generator was reported to have lit a 100-watt lamp with "induced radio frequency energy. " A Federal Communications Commission engineer who investigated the locale of the experiment told his superiors that he could find "no condition which could account for such a phenomenon," and Bernard Linden, the engineer in charge of the FCC's Los Angeles office, wrote to one of the experiment's witnesses, Dr. Robert Fondiller, a New York engineer, for information on the apparatus used "when observing the above condition. "

The Force Research project came to an end in 1961, when Lester Jennings Hendershot, his dream of providing the world with free energy still unrealized, committed suicide.

One year before Hendershot's death, a book, *The Sea of Energy in Which the Earth Floats*, was privately printed in Salt Lake City by its author, T. Henry Moray, Doctor of Electrical Engineering, who had earned his degree at the University of Uppsala in Sweden while on a stint as a missionary for the Mormon Church.

The book was Moray's account of a nearly fifty-year-long, apparently successful effort to develop yet another collector of atmospheric energy. The inventor states that he took first inspiration from a statement made by Tesla in an 1892 lecture:

Ere many generations pass, our machinery win be driven by a power obtainable at any point of the universe. 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 win succeed in attaching their machinery to the very wheelwork of nature.

By the fall of 1910 Moray had collected sufficient power to operate small electrical devices which he demonstrated to friends. It was only after pursuing static energy for more than a year, however, that he finally came to agree with Tesla's statement. In his own words:

It was during the Christmas holidays of 1911 that I began to realize the fact that the energy I was working with was not of a static nature but of an oscillating nature, and that the energy was not coming out of the Earth but that it rather was coming in to the Earth from some outside source.

As principal owner of a Salt Lake electric company, Moray built, during the 1920s and 1930s, a number of radiant energy devices, the parts for each one cannibalized from its predecessor and supplemented with new components.

It was during the second term of President Franklin Delano Roosevelt that Moray, now become chief consulting engineer for the western branch of the Rural Electrification Agency, finally completed an instrument which, though it weighed only slightly over 55 pounds, could deliver up to 50,000 watts.

The new device so contravened the belief structures and training of Moray's fellow REA engineers that one of them, angered by Moray's assertion that he was obtaining energy straight from outer space, took a sledgehammer to the invention and smashed it to pieces. It has been estimated that its reconstruction would today cost over a million dollars.

Before its untimely demise, the Moray invention was said to have lit up a bank of thirty-five light bulbs with bright, cold light. Precisely how - or even whether - it really worked may never be known. However, in his book, Moray sandwiches into a long treatise on cosmic processes involved in the operation of his collector the claim that his early invention of a solid-state component - a type of valve, forerunner of the transistor - was the real key to its functioning. He also submitted that the energy collecting activity of his generator was initiated by stroking its first stage for a minute or so with a magnet to produce oscillations. What happened subsequently, Moray put forward - not entirely lucidly - in a lecture at Valley State College in Northridge, California, on 23 January 1962:

"The circuit is then balanced through synchronization until the oscillations are sustained by harmonic coupling with the energies of the universe. The reinforcing action of the harmonic coupling increases the amplitude of the oscillations until the peak pulses 'spill' over into the next stage through special detectors of valves which then prevent the return or feedback of the energy from the preceding stages. These oscillating pulsations drive each succeeding stage which oscillate at a controlled frequency and which are again reinforced by harmonic coupling with the everpresent energies of the Cosmos. "

The device could also be set going with power from an electric battery, but according to Moray's son, John, his father eschewed its use in demonstrations in favor of the magnet so that witnesses could not say afterwards - as they did about Hendershot's motor - that the invention was basically battery operated.

It is strange that witnesses have testified that both Hendershot's and Moray's inventions would work only with the inventors present. The ONR proposal noted that of many working models of Hendershot's motor built over thirty-five years, none gave sufficient performance "without the hand of Hendershot."

This statement was corroborated by Charles Fort, an original who spent his life collecting and collating unusual data by combing reports in several hundred newspapers on a day-to-day basis; in

his book *Wild Talents* Fort suggests that Hendershot might have possessed some power of mind over matter which caused the motor to run only when he was there to affect it.

The fact that Hendershot's motor operated at Selfridge Field only when oriented north-south by not east-west also seems to suggest that it may have been related in its underlying principle to Wilhelm Reich's motor, said to draw power from a nonelectrical energy called "orgone" which permeates the atmosphere above and rotates in an eastwest direction around the earth.

Whatever the case, since Hendershot's time, Fort's "wild talents" have now invaded the scientific laboratories of several countries where physicists have proved the ability of certain individuals to affect matter in as yet totally inexplicable manner. Despite protests made by professional magicians claiming that his feats are only sleight of hand, the Israeli Uri Geller has astounded scientific observers by bending metal at a distance. In controlled experiments throughout the world, a number of children have recently succeeded in equaling, and even surpassing, Geller's psychokinetic exploits. A book is now on its way to the publisher detailing the scope of what may lead to a Copernican revolution in science.

Late twentieth-century technology has not yet followed up on the trails blazed by Tesla, Hubbard, Hendershot, and Moray. It is not difficult to realize the havoc these inventors would have caused had they been put into operation at the time of their appearance. If "fuelless" power had been widely available in the first decades or even in the middle of this century, whole industries involving massive amounts of capital and employing thousands of workers might have gone under.

In the last quarter of the century it may be that, in the face of mounting costs for oil and uncertainty about the side effects of atomic power plants, new efforts will be made to probe behind the curtain with which Tesla so ingeniously surrounded himself.

Federal officials in Canada are presently studying some aspects of Tesla's power transmission system in the hope of obviating the construction of expensive transmission lines designed to carry hydroelectric power developed in the country's northern regions to the large urban centers concentrated in the south. They are also considering Tesla's charged particle collector as a way of furnishing electricity to Canada's remote Arctic regions, small prairie communities, and individual homes and factories. The potential of energy obtainable from Canadian waterfalls and rivers is so great that there is also the possibility of adapting the Tesla system to export energy to energy-short underdeveloped countries anywhere on earth.

A mystery shrouded the last thirty years of Tesla's life.

Reports leaking out on his Colorado experiments spurred J. Pierpont Morgan to put up money to finance similar work in the East. In 1901 Tesla began erecting a new experimental station on two hundred acres of Long Island land, donated by Morgan's fellow banker, James Warden. The Wardencliff development, almost an exact duplicate of the Pike's Peak installation, was to be the fulfillment of Tesla's dream of creating the hub for a "city beautiful."

When completed in 1905, the station was closed. It seems that Tesla, who had ignored practical monetary matters all his life, had consumed the entire sum made available by Morgan for the station's construction. Operating the laboratory would have required another large donation, not forthcoming.

Though chosen to share the 1912 Nobel Prize in Physics with Edison, Tesla refused it. The Nobel Committee, perhaps angered at this slight, turned its back on America and finally awarded the prize to the Swedish physicist Gustav Dalen. In *Prodigal Genius*, a biography of Tesla, John J. O'Neill speculated on Tesla's motive for turning down the honor:

Tesla made a very definite distinction between the inventor of useful appliances and the discoverer of new principles . . . a pioneer who opens up new fields of knowledge into which thousands of inventors flock to make commercial applications of the newly revealed information. Tesla declared himself discoverer and Edison an inventor; and he held the view that placing the two in the same category would completely destroy all sense of the relative value of the two accomplishments.

From this point on, Tesla's life presents a picture of steadily dwindling energy, though in the 1920s he still had enough forward motion to patent a helicopterlike flying machine and develop an advanced steam turbine.

Legal recognition for his pioneer work in wireless radio transmission came only one year before his death, when the United States Supreme Court wrote an opinion that several important features of Guglielmo Marconi's invention, for which he was awarded the Nobel Prize in 1909, had been anticipated by Tesla.

As recently as January 1976, at a Tesla Symposium held by the Institute for Electronic and Electrical Engineers in New York's Statler Hilton Hotel, J. Roland Morin, Chief Engineer for Large Lamps at Sylvania GTE International, announced that industrial firms are now reinvestigating Tesla's concept for electrodeless discharge lamps inductively coupled to a high-frequency power supply, developed way back in the 1880s but overshadowed by Edison's achievement.

What accounted for Tesla's decline? The only explanation given was based on a story told by the inventor to his biographer, O'Neill, who characterized it as "without parallel in human annals."

O'Neill had noticed that Tesla, poverty-stricken and lonely, spent hours feeding pigeons which he would call from under the Gothic tracery of St. Patrick's Cathedral and eaves of the New York Public Library. What, asked O'Neill, was his fascination with the birds?

'I have been feeding pigeons, thousands of them, for years, ' replied Tesla, 'but there was one pigeon, a beautiful bird, pure white with light gray tips on its wings. That one was different . . . No matter where I was that pigeon would find me; when I wanted her I had only to wish and call her and she would come flying to me . . . I loved that pigeon . . . I loved her as a man loves a woman, and she loved me.

'Then one night as I was lying in my bed in the dark, solving problems, as usual, she flew in through the open window and stood on my desk. I knew she wanted me; she wanted to tell me something important, so I got up and went to her. As I looked at her I knew she wanted to tell me - she was dying. And then, as I got her message, there came a light from her eyes - powerful beams of light . . . a light more intense than I had ever produced by the most powerful lamps in my laboratory.

'When that pigeon died, something went out of my life. Up to that time I knew with a certainty that I would complete my work, no matter how ambitious my program, but when that something went out of my life I knew my life's work was finished.'

Tesla's "World System of Wireless Transmission" as summarized in his article "The Problem of Increasing Human Energy through the Use of the Sun's Energy" (*Century Illustrated Monthly Magazine*, June 1900):

The World System has resulted from a combination of several original discoveries made by the inventor in the course of long-continued research and experimentation. It makes possible not only the instantaneous and precise wireless transmission of any kind of signals, messages, or characters, to all parts of the world, but also the interconnection of the existing telegraph, telephone, and other signal stations without any change in their present equipment. By its means, for instance, a telephone subscriber here may call up and talk to any other subscriber on the globe. An inexpensive receiver, no bigger than a watch, will enable him to listen anywhere, on land or sea, to a speech delivered or music played in some other place, however distant.

The World System is based on the application of certain important inventions and discoveries, including:

1. *The Tesla Transformer.* This apparatus is in the production of electrical vibrations as revolutionary as gunpowder in warfare.
2. *The Magnifying Transmitter.* This is Tesla's best invention - peculiar transformer specially adapted to excite the Earth, which is in the transmission of electrical energy what the telescope is in astronomical observation.
3. *The Wireless System.* This system comprises a number of improvements and is the only means known for transmitting economically electrical energy to a distance without wires

The first World System power plant can be put in operation in nine months. With this power plant it will be practicable to attain electrical activities up to 10 million horsepower (25 billion watts), and it is designed to serve for as many technical achievements as are possible without undue expense.

BIBLIOGRAPHY

- Aug, Stephen. "Who's Fouling Up Global Radio?" **Washington Star**, 29 October 1976, pp. 1, 4.
- Detroit Free Press**. Lester Hendershot stories: 25, 26, 28, 29 February 1928; 8, 9, 12 March 1928; 11 November 1962.
- Korac, Veljko. "The Inventions and Inspiration of Nikola Tesla." Paper read at the International Electronic and Electrical Engineers Nikola Tesla Symposium, 30 January 1976, New York City.
- Moray, T. Henry. **The Sea of Energy in Which the Earth Floats**. The Research Institute, Inc., 2505 South Fourth East, Salt Lake City, Utah 84115.
- _____. "Speech Given by T. Henry Moray, January 23, 1962, 8:00 P.M. in the Speech-Drama Building, Valley State College, Northridge, California."
- Morin, J.F. "Light Sources - Past, Present, and Future." Paper read at the International Electronic and Electrical Engineers Nikola Tesla Symposium, 30 January 1976, New York City.
- New York Times**. Lester Hendershot stories: 27, 28 February 1928.
- O'Neill, John J. **Prodigal Genius: The Life of Nikola Tesla**. Ives Washburn Inc., 1944.
- Puharich, Andrija. "The Work of Nikola Tesla Ca. 1900 and Its Relationship to Physics, Bioenergy and Healing." Paper read at the International Interdisciplinary Conference on Consciousness and Healing, 13 October 1976, University of Toronto.
- Seattle Post-Intelligencer**. Lester Hendershot stories: 25, 27 February 1928. Alfred Hubbard stories: 17 December 1919; 1 February 1920, 29 July 1920; 27 February 1928- 16 July 1973; 23 March 1975.
- Shunaman, Fred. "12-Million Volts." **Radio Electronics**, June 1976, pp.
- Tesla, Nikola⁴. Correspondence, Columbia University Library, Special Collections, Manuscript Section.
- _____. "My Inventions." **Electrical Experimenter**, February-June 1919.
- _____. **Lectures, Patents, and Articles**. Nikola Tesla Museum, Belgrade 1956; reprinted by Health Research, (Mokelumme Hill, Calif. 95245), 1973.
- _____. "A Machine to End War." **Liberty**, 9 February 1935, pp. 5-7.

_____. "Talking with the Planets. "Collier's, 9 February 1901, pp. 64-65

Tilson, Seymour. "Electricity and Weather Modification," IEEE **Spectrum** April 1969, pp. 26ff.

United States Reports, vol. 320, Cases Adjudged in the Supreme Court at October Term 1942 and October Term 1943, "Marconi Wireless Co. v. U. S.," pp. 1-80.

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