

Tesla's Magnifying Transmitter

- part 3: "The Tesla Code" -



- an analysis of Nikola Tesla's work -

by Ernst
2016

Table of Contents

Introduction.....	3
References to the article.....	4
Writing the article.....	7
Best Wishes.....	8
Ether and the medium.....	9
Energy from the medium.....	13
The Problem of Increasing Human Energy.....	15
the onward movement of man.....	15
the first problem: how to increase the human mass.....	21
the second problem: how to reduce the force retarding the human mass.....	25
the third problem: how to increase the force accelerating the human mass.....	31
the source of human energy.....	32
great possibilities offered by iron for increasing human performance.....	33
economical production of iron by a new process.....	33
the coming age of aluminium.....	35
efforts toward obtaining more energy from coal.....	37
energy from the medium.....	38
a departure from known methods.....	41
first efforts to produce the self-acting engine.....	43
discovery of unexpected properties of the atmosphere.....	48
"wireless" telegraphy.....	50
development of a new principle.....	52
transmission of electrical energy to any distance without wires.....	56
Voltage and Temperature.....	58
Some additional quotes 'n stuff.....	59
on the magnifying transmitter construction.....	59
Key points:.....	61
on earth conductivity.....	62
on tesla's magnifying transmitter diagrams.....	62
Conclusions on Tesla's Magnifying Transmitter.....	65

Introduction

Nikola Tesla, the forgotten scientist who lived over a century ago has given us electricity as we know it today. Most notably, the power distribution network, AC-motors and AC-generators. But he also laid the foundations for radio and radio control and many other things that we so much rely on today.

will meet all requirements. It will soon materialize, and when it does it will give an impetus to manufacture and commerce such as was never witnessed before, provided only that the Governments do not resort to the methods of the Spanish Inquisition, which have already proved so disastrous to the wireless art, the ideal means for making man absolute master of the air.

NICOLA TESLA.

New York, Sept. 18, 1908.

But although it seems like some influential people do not want him remembered, like we all know James Watt, Heinrich Hertz, Guglielmo Marconi, Thomas Edison etc., it is mostly Tesla's unfinished work that now draws attention. In his articles in various magazines we can read that Tesla had much more to give if only he was allowed to.

Of course Tesla knew that he would not live forever, so would he let all his valuable discoveries and insights die with him? Or would he try to communicate with the future? The latter is the most likely, by far.

So what would he have done?

What would you do in his place?

There are a number of ways.

Articles in newspapers and magazines will live forever, so do patents. So these are the most obvious means to communicate with the future.

You only need some sort of code, not too obvious and not too secret. Next, you must make sure that someone will try to crack your code.

You must draw attention.

Tesla's Wardenclyffe did take care of that part. Of course Tesla had hoped to complete this project, but even if it did not, it would still serve a purpose.

After Tesla came back from Colorado Springs he knew he had something of immense value. He also knew that the chances to complete this work were slim.

He hoped J.P. Morgan's desire for money would see him through, but to make sure his ideas would not be lost he wrote this article for Century Illustrated Magazine in which he disclosed most of his knowledge.

The article was written in a different age. Many things that we have now clear ideas of were not so well defined back then. And this is only one of the obstacles that one will encounter in trying to understand his work.

But today, in the age of information technology and the internet, we have access to most of his articles, his notebook, part of his correspondence, his lectures and his patents and by combining all of these an incredible picture appears.

TESLA'S FLASHES STARTLING.

But He Won't Tell What He Is Trying For at Wardenclyffe.

WARDENCLIFFE, L. I., July 16.—Natives hereabouts are intensely interested in the nightly electrical display shown from the tall tower and poles in the grounds where Nicola Tesla is conducting his experiments in wireless telegraphy and telephony. All sorts of lightning were flashed from the tall tower and poles last night. For a time the air was filled with blinding streaks of electricity which seemed to shoot off into the darkness on some mysterious errand. The display was continued until after midnight.

This morning workmen about the plant declined to say anything. It is understood that Tesla has a well more than 200 feet deep driven beneath the tower and that the electrical waves are sent both underground and through the air.

Mr. Tesla said last evening that the evidences of experiments which have been seen by the people of Wardenclyffe, near which his laboratory is located, have been going on for some time there, but that he had no announcement to make at this time as to their character or the success that had been achieved.

"It is true," said Mr. Tesla, "that some of them have had to do with wireless telegraphy and that in addition to the tower and poles there is a hole dug in the ground. This is 150 feet deep and is used in these experiments. The people about there, had they been awake instead of asleep, at other times would have seen even stranger things. Some day, but not at this time, I shall make an announcement of something that I never once dreamed of."

References to the article

There is one article by Nikola Tesla, that he refers to far more often than any other article or lecture. It is "the Problem of Increasing Human Energy", published in the June 1900 edition of Century Illustrated Magazine. Here are a few examples:



1901-02-09: *Talking with Planets*

Collier's Weekly

The accompanying illustrations, with their descriptive titles, taken from an article I wrote for the "Century Magazine," ["The Problem of Increasing Human Energy"] may serve to convey an idea of the results I obtained in the directions indicated.

1904-02-06: *A Striking Tesla Manifesto*

Electrical World and Engineer

The second quotation is from his article on the problem of increasing human energy, which appeared in the Century Magazine in June, 1900, dealing with virtually the same subject (the transmission of intelligible signals and power to any distance without the use of wires).

1904-03-05: *The Transmission of Electrical Energy Without Wires*

Electrical World and Engineer

Progress though of necessity slow was steady and sure, for the objects aimed at were in a direction of my constant study and exercise. It is, therefore, not astonishing that before the end of 1899 I completed the task undertaken and reached the results which I have announced in my article in the Century Magazine of June, 1900, every word of which was carefully weighed.

The last addition "every word of which was carefully weighed" immediately draws extra attention. Why would every word be carefully weighed? Was it because there was a maximum number of words Tesla was allowed for the article? There is no reason to assume this. The article has been rewritten a number of times before the final version was settled on. But would this phrase refer to that? I would say that is unlikely. No, the most likely explanation is that this article is carrying a message.

1905-01-07: *The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace*

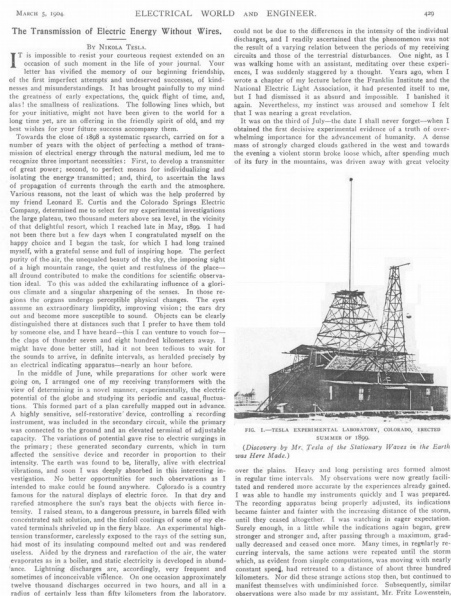
Electrical World and Engineer

At that time I had already announced in The Century Magazine of June, 1900, my successful "girdling" of the globe with electrical impulses (stationary waves), and my "telautomata" had been publicly exhibited.

1907-03: *Signalling to Mars – A Problem of Electrical Engineering*

Harvard Illustrated

In the early part of 1900, still vividly impressed by certain observations, I had made shortly before, and feeling that the time had come to prepare the world for an experiment which will soon be undertaken, I dwelt on the practicability of interplanetary signalling in an article which appeared in the June number of Century Magazine of the same year.



1916: Pre-Hearing Interview.

It was along this line that I finally arrived at the results described in my article in the [Century Magazine of June 1900](#).



1917-02-25: Electric Drive for Battle Ships

New York Herald

During many years the scheme was declared to be impracticable and I was assailed in a manner as vicious as incompetent. In [1900](#), when an article from me advocating the electric drive appeared in the [Century Magazine](#), Marine Engineering pronounced the plan to be the "climax of asininity," and such was the fury aroused by my proposals that the editor of another technical periodical resigned and severed his connection rather than to allow the publication of some attacks.

1919: My Inventions

Electrical Experimenter

Those who are interested will find some information in regard to the experiments I conducted there in my article, "[The Problem of Increasing Human Energy](#)" in the [Century Magazine of June, 1900](#), to which I have referred on a previous occasion.

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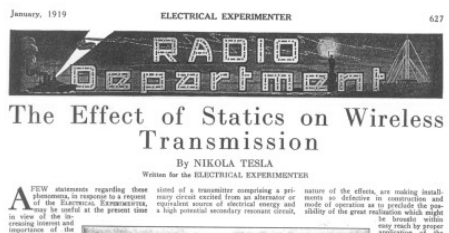
This machine was illustrated and described in my article in the [Century Magazine of June, 1900](#), and other periodicals of that time and, when first shown in the beginning of 1898, it created a sensation such as no other invention of mine has ever produced.



1919-01: The Effect of Statics on Wireless Transmission

Electrical Experimenter

The discoveries made and experimental results attained I made with a wireless power-plant erected in 1899, some of which were disclosed in the [Century Magazine of June, 1900](#), and several U. S. patents subsequently granted to me have, I believe, borne-out strikingly my foresight.



1919-05: The True Wireless

Electrical Experimenter

My original plan of transmitting energy without wires is shown in the upper diagram of Fig. 7, while the lower one illustrates its mechanical analogue, first published in my article in the [Century Magazine of June, 1900](#).



1921-09-24: Interplanetary Communication

Electrical World

Those who are interested in the subject may be referred to my articles in the [Century Magazine of June, 1900](#), Collier's Weekly of Feb. 9, 1901, the Harvard Illustrated Magazine of March, 1907, the New York Times of May 23, 1909, and the New York Herald of Oct. 12, 1919.

1927-10-16: World System of Wireless Transmission of Energy

Telegraph and Telegraph Age

Since I began the construction of the first power plant in 1899 I have expressed myself repeatedly in regard to it and the plans I had previously formed through the medium of the [Electrical Review](#), [Electrical World](#), [Electrical Experimenter](#), [Science and Invention](#) and other periodicals, notably the [Century Magazine of June, 1900](#), to which I contributed a lengthy article on the "Problem of Increasing Human Energy"; but certain facts must still be told.

The Waldorf-Astoria
New York.

June 10 1902.

Dear Luka,

The method seems to have been suggested by my article that 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

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

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Nikola

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Looking up page 200, we do find mention of two novel facts. But we'll get into more details later.

200

THE CENTURY MAGAZINE.

tions show, with the approach to the center at the rate of approximately 1° C. for every hundred feet of depth. The difficulties of sinking shafts and placing boilers at depths of, say, twelve thousand feet, corresponding to an increase in temperature of about 120° C., are not insuperable, and we could certainly avail ourselves in this way of the internal heat of the globe. In fact, it would not be necessary to go to any depth at all in order to derive energy from the stored terrestrial heat. The superficial layers of the earth and the air strata close to the same are at a temperature sufficiently high to evaporate some extremely volatile substances, which we might use in our boilers instead of water. There is no doubt that a vessel might be propelled on the ocean by an engine driven by such a volatile fluid, no other energy being used but the heat abstracted from the water. But the amount of power which could be obtained in this manner would be, without further provision, very small.

Electricity produced by natural causes is another source of energy which might be rendered available. Lightning discharges involve great amounts of electrical energy, which we could utilize by transforming and storing it. Some years ago I made known a method of electrical transformation which renders the first part of this task easy, but the storing of the energy of lightning discharges will be difficult to accomplish. It is well known, furthermore, that electric currents circulate constantly through the earth, and that there exists between the earth and any air stratum a difference of electrical pressure, which varies in proportion to the height.

In recent experiments I have discovered two novel facts of importance in this connection. One of these facts is that an electric current is generated in a wire extending from the ground to a great height by the axial, and probably also by the translatory, movement of the earth. No appreciable current, however, will flow continuously in the wire unless the electricity is allowed to leak out into the air. Its escape is greatly facilitated by providing at the elevated end of the wire a conducting terminal of great surface, with many sharp edges or points. We are thus enabled to get a continuous supply of electrical energy by merely supporting a wire at a height, but, unfortunately, the amount of electricity which can be so obtained is small.

The second fact which I have ascertained is that the upper air strata are permanently charged with electricity opposite to that of

the earth. So, at least, I have interpreted my observations, from which it appears that the earth, with its adjacent insulating and outer conducting envelope, constitutes a highly charged electrical condenser containing, in all probability, a great amount of electrical energy which might be turned to the uses of man, if it were possible to reach with a wire to great altitudes.

It is possible, and even probable, that there will be, in time, other resources of energy opened up, of which we have no knowledge now. We may even find ways of applying forces such as magnetism or gravity for driving machinery without using any other means. Such realizations, though highly improbable, are not impossible. An example will best convey an idea of what we can hope to attain and what we can never attain. Imagine a disk of some homogeneous material turned perfectly true and arranged to turn in frictionless bearings on a horizontal shaft above the ground. This disk, being under the above conditions perfectly balanced, would rest in any position. Now, it is possible that we may learn how to make such a disk rotate continuously and perform work by the force of gravity without any further effort on our part, but it is perfectly impossible for the disk to turn and to do work without any force from the outside. If it could do so, it would be what is designated scientifically as a "perpetuum mobile," a machine creating its own motive power. To make the disk rotate by the force of gravity we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one half of the disk, and the rotation of the latter would follow. At least, we cannot deny such a possibility until we know exactly the nature of the force of gravity. Suppose that this force were due to a movement comparable to that of a stream of air passing from above toward the centre of the earth. The effect of such a stream upon both halves of the disk would be equal, and the latter would not rotate ordinarily; but if one half should be guarded by a plate arresting the movement, then it would turn.

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

When I began the investigation of the subject under consideration, and when the preceding or similar ideas presented themselves

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Writing the article

Notice the way Robert U. Johnson writes to Tesla:

New York, March 12th, 1900
46 & 48 East Houston Str.

Mr. R. U. Johnson,
the Century Company, N. Y. City.

My dear Luka:-

I shall send you soon after lunch the second part of the text, which is to be followed shortly with the concluding chapter.

I have recognized, that to preserve unity, I must have only three chapters after the first introductory part. Each of the chapters will thus deal with a specific problem and its solution, and they ought to be, to preserve balance, of not widely different lengths. You will recognize the great advantage of this mode of treatment. The reader will not lose sight of the whole plan of the article and by making the last chapter, dealing with the technical advances towards the solution of the third part of the great human problem defined from the outset, very concentrated, and omitting all sub-headings, he will gain a better insight into the whole as well as the technical part.

I would have liked to weave into the chapter dealing with the food problem a philosophical idea which, I believe, would have interested the readers. Perhaps there is still time for it.

Hoping that you have enjoyed your outing,

Sincerely yours,

NIKOLA.

From R.U. Johnson, March 6, 1900;

--- Trust me + my knowledge of what the public is eager to have from you. They ask bread (nitrogen) and you give them a stone (philosophy). ---

He says "They ask bread and you give them a stone" and he explains bread stands for nitrogen and stone for philosophy. But would the public really want nitrogen? No, it is obvious that nitrogen stands for something else and reading Tesla's article it could stand for (the source of) food, which more or less matches with the initial "bread". But of course that too is not what the public wants. Reading on it

becomes clear that the public wants to read "something practical". So this phrase has to be decoded as: "They ask something practical and you give them philosophy." Apparently Tesla and R.U. Johnson are used to speaking in this kind of "analogies".

From R.U. Johnson, April 17, 1900;

--- We have now finished with Pp. 175 to 200. We are reserving for you 10 1/4 pp. more. ---

As I said, there is no reason to assume Tesla did not have enough space for his article.

Best Wishes

You will see that Tesla often creates a somewhat vague paragraph closing with a final sentence that, when interpreted separately contains the true message as in this great example in the “Electrical World and Engineer ” of 1904-03-05:

MARCH 5, 1904.

ELECTRICAL WORLD

The Transmission of Electric Energy Without Wires.

BY NIKOLA TESLA.

It is impossible to resist your courteous request extended on an occasion of such moment in the life of your journal. Your letter has vivified the memory of our beginning friendship, of the first imperfect attempts and undeserved successes, of kindnesses and misunderstandings. It has brought painfully to my mind the greatness of early expectations, the quick flight of time, and, alas! the smallness of realizations. The following lines which, but for your initiative, might not have been given to the world for a long time yet, are an offering in the friendly spirit of old, and my best wishes for your future success accompany them.

Towards the close of 1898 a systematic research, carried on for a number of years with the object of perfecting a method of transmission of electrical energy through the natural medium, led me to recognize three important necessities: First, to develop a transmitter of great power; second, to perfect means for individualizing and isolating the energy transmitted; and, third, to ascertain the laws of propagation of currents through the earth and the atmosphere. Various reasons, not the least of which was the help proffered by

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Note that this is supposed to be addressed to the magazine (?). What purpose does it serve to publish this paragraph? This does not at all match with Tesla's systematic and logic reasoning.

Now note how the time difference is stressed:

“for a long time”

“spirit”

“of old”

“your future success”

= non-material remains

Now forget about the paragraph and just read the last line. What do you read?

The same “technique” is used when Tesla sums up a list of things, examples, or diagrams, the last item listed is the most important one.

Ether and the medium

Before trying to understand Tesla's writings, there are a few things that we should know. The first thing is that Tesla distinguishes between the ether, which is very similar to vedic akasha, and "the medium", a term Tesla employs when talking about the cause of electric effects. The latter looks somewhat like the photon gas or electron gas that we know today.

1891-05-20: Experiments with Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination

American Institute Of Electrical Engineers - Transactions
May 20, 1891

*A lecture delivered before the American Institute
of Electrical Engineers, at Columbia College,
N. Y., May 20th, 1891, Vice-President Lockwood
in the Chair.*

EXPERIMENTS WITH ALTERNATE CURRENTS OF VERY HIGH FREQUENCY AND THEIR APPLICATION TO METHODS OF ARTIFICIAL ILLUMINATION.

BY NIKOLA TESLA.

There is no subject more captivating, more worthy of study than nature. To understand this great mechanism, to discover the forces which are active, and the laws which govern them, is the highest aim of the intellect of man.

Nature has stored up in the universe infinite energy. The eternal recipient and transmitter of this infinite energy is the

Nature has stored up in the universe infinite energy. The eternal recipient and transmitter of this infinite energy is the ether. The recognition of the existence of ether, and of the functions it performs, is one of the most important results of modern scientific research. The mere abandoning of the idea of action at a distance, the assumption of a medium pervading all space and connecting all gross matter, has freed the minds of thinkers of an ever present doubt, and, by opening a new horizon—new and unforeseen possibilities—has given fresh interest to phenomena with which we are familiar of old. It has been a great step towards the understanding of the forces of nature and their manifold manifestations to our senses.

In this first quote we read that Tesla was a firm believer in the ether. And the last quote here will show that Tesla remained so until he died in 1943. But something changed over the years. Tesla found that this ether does not perform many of the functions that were attributed to it.

Here is a second quote from the same article:

What is electricity, and what is magnetism? These questions have been asked again and again. The most able intellects have ceaselessly wrestled with the problem; still the question has not as yet been fully answered. But while we cannot even to-day state what these singular forces are, we have made good headway towards the solution of the problem. We are now confident that electric and magnetic phenomena are attributable to ether, and we are perhaps justified in saying that the effects of static electricity are effects of ether under strain, and those of dynamic electricity and electro-magnetism effects of ether in motion. But this still leaves the question, as to what electricity and magnetism are, unanswered.

First, we naturally inquire, What is electricity, and is there such a thing as electricity? In interpreting electric phenomena: we may speak of electricity or of an electric condition, state or effect. If we speak of electric effects we must distinguish two such effects, opposite in character and neutralizing each other, as observation shows that two such opposite effects exist. This is unavoidable, for in a medium of the properties of ether, we cannot possibly exert a strain, or produce a displacement or motion of any kind, without causing in the surrounding medium an equivalent and opposite effect. But if we speak of electricity, meaning a thing, we must, I think, abandon the idea of two electricities, as the existence of two such things is highly improbable. For how can we imagine that there should be two things, equivalent in amount, alike in their properties, but of opposite character, both clinging to matter, both attracting and completely neutralizing each other? Such an assumption, though suggested by many phenomena, though most convenient for explaining them, has little to commend it. If there is such a thing as electricity, there can be only one such thing, and; excess and want of that one thing, possibly; *but more probably* its condition determines the positive and negative character. The old theory of Franklin, though falling short in some respects; is, from a certain point of view, after all, the most plausible one. Still, in spite of this, the theory of the two electricities is generally accepted, as it apparently explains electric phenomena in a more satisfactory manner. But a theory which better explains the facts is not necessarily true. Ingenious minds will invent theories to suit observation, and almost every independent thinker has his own views on the subject. It is not with the, object of advancing an opinion; but with the desire of acquainting you better with some of the results, which I will describe, to show you the reasoning I have followed, the departures I have made—that I venture to express, in a few words, the views and convictions which have led me to these results.

I adhere to the idea that there is a thing which we have been in the habit of calling electricity. The question is, What is that thing? or, What, of all things, the existence of which we know, have we the best reason to call electricity? We know that it acts like an incompressible fluid; that there must be a constant quantity of it in nature; that it can be neither produced nor destroyed; and, what is more important, the electro-magnetic theory of light and all facts observed teach us that electric and ether phenomena are identical. The idea at once suggests itself, therefore, that electricity might be called ether. In fact, this view has in a certain sense

been advanced by Dr. Lodge. His interesting work has been read by everyone and many have been convinced by his arguments. His great ability and the interesting nature of the subject, keep the reader spellbound; but when the impressions fade, one realizes that he has to deal only with ingenious explanations. I must confess, that I cannot believe in two electricities, much less in a doubly-constituted ether. The puzzling behaviour of the ether as a solid to waves of light and heat, and as a fluid to the motion of bodies through it, is certainly explained in the most natural and satisfactory manner by assuming it to be in motion, as Sir William Thomson has suggested; but regardless of this, there is nothing which would enable us to conclude with certainty that, while a fluid is not capable of transmitting transverse vibrations of a few hundred or thousand per second, it might not be capable of transmitting such vibrations when they range into hundreds of million millions per second. Nor can anyone prove that there are transverse ether waves emitted from an alternate current machine, giving a small number of alternations per second; to such slow disturbances, the ether, if at rest, may behave as a true fluid.

Returning to the subject, and bearing in mind that the existence of two electricities is, to say the least, highly improbable, we must remember, that we have no evidence of electricity, nor can we hope to get it, unless gross matter is present. Electricity, therefore, cannot be called ether in the broad sense of the term; but nothing would seem to stand in the way of calling electricity ether associated with matter, or bound to it; or, in other words, that the so-called static charge of the molecule is ether associated in some way with the molecule. Looking at it in that light, we would be justified in saying, that electricity is concerned in all molecular actions.

Now, precisely what the ether surrounding the molecules is, wherein it differs from ether in general, can only be conjectured. It cannot differ in density, ether being incompressible; it must, therefore, be under some strain or in motion, and the latter is the most probable. To understand its functions, it would be necessary to have an exact idea of the physical construction of matter, of which, of course, we can only form a mental picture.

But of all the views on nature, the one which assumes one matter and one force, and a perfect uniformity throughout, is the most scientific and most likely to be true. An infinitesimal world, with the molecules and their atoms spinning and moving in orbits, in much the same manner as celestial bodies, carrying with them and probably spinning with them ether, or in other words; carrying with them static charges, seems to my mind the most probable view, and one which, in a plausible manner, accounts for most of the phenomena observed. The spinning of the molecules and their ether sets up the ether tensions or electrostatic strains; the equalization of ether tensions sets up ether motions or electric currents, and the orbital movements produce the effects of electro and permanent magnetism.

About fifteen, years ago, Prof. Rowland demonstrated a most interesting and important fact; namely, that a static charge carried around produces the effects of an electric current. Leaving out of consideration the precise nature of the mechanism, which produces the attraction and repulsion of currents, and conceiving the electro-statically charged molecules in motion, this experimental fact gives us a fair idea of magnetism. We can conceive lines or tubes of force which physically exist, being formed of rows of directed moving molecules; we can see that these lines must be closed, that they must tend to shorten and expand, etc. It likewise explains in a reasonable way, the most puzzling phenomenon of all, permanent magnetism, and, in general, has all the beauties of the Ampere theory without possessing the vital defect of the same, namely, the assumption of molecular currents. Without enlarging further upon the subject, I would say, that I look upon all electrostatic, current and magnetic phenomena as being due to electrostatic molecular forces.

[Tesla's view here is not yet matured as we can read about 1 year later in his lecture of 1892-02-03: "Experiments with Alternate Currents of High Potential and High Frequency "](#)

JOURNAL		
OF THE		
Institution of Electrical Engineers.		
Founded 1871. Incorporated 1883.		
Vol. XXI.	February 3, 1892.	No. 97.
An Extraordinary General Meeting of the Institution was held at the Royal Institution, Albemarle Street, on Wednesday evening, February 3rd—Professor W. E. AYRTON, F.R.S., President, in the Chair.		
The following lecture was delivered by NIKOLA TESLA, Foreign Member, on		
EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.		
Ladies and Gentlemen,—I cannot find words to express how		

What impresses the investigator most in the course of these experiences is the behaviour of gases when subjected to great rapidly alternating electrostatic stresses. But he must remain in doubt as to whether the effects observed are due wholly to the molecules, or atoms, of the gas which chemical analysis discloses to us, or whether there enters into play **another medium of a gaseous nature, comprising atoms, or molecules, immersed in a fluid** pervading the space. Such a medium, surely must exist, and I am convinced that, for instance, even if air were absent, the surface and neighbourhood of a body in space would be heated by rapidly alternating the potential of the body; but no such heating of the

surface or neighbourhood could occur if all free atoms were removed and only a homogeneous, incompressible, and elastic fluid—such as ether is supposed to be—would remain, for then there would be no impacts, no collisions. In such a case, as far as the body itself is concerned, only frictional losses in the inside could occur.

Again 1 year later in his lecture of 1893-02-24: "On Light and Other High Frequency Phenomena"

May 31, 1893.]

THE ELECTRICAL ENGINEER.

ON LIGHT AND OTHER HIGH FREQUENCY PHENOMENA¹—I.

BY NIKOLA TESLA.

INTRODUCTORY.—SOME THOUGHTS ON THE EYE.

When we look at the world around us, on Nature, we are impressed with its beauty and grandeur. Each thing we perceive, though it may be vanishingly small, is in itself a world, that is, like the whole of the visible universe, matter and force governed by law,—a world, the contemplation of which fills us with feelings of awe and admiration.

phenomena, but a still more profound spirit of scientific inquiry is the cause of the effects. It is the physicist, for whom the eye is a window into the world of the mind.

Two facts about the eye in physics, notwithstanding imperfect optical instruments, of that which is perfect or through this same instrument positive knowledge goes, due to that subtle medium, which space; secondly, it is the sense of hearing which is the organ of smell the taste and the organs of taste, and or at least some interference true even in those instances of these organs are developing perfection. This being so, it might seem that the other organs are powerless to part in all natural phenomena. It is not so, however, which has properties such as it cannot help drawing a distinct matter. Considering merely its marvelous power, which perception far beyond the limits of the eye, to embrace myriads of

It is certainly more in accordance with many phenomena observed with high frequency currents to hold that all space is pervaded with free atoms, rather than to assume that it is devoid of these, and dark and cold, for so it must be, if filled with a continuous medium, since in such there can be neither heat nor light. Is then energy transmitted by independent carriers or by the vibration of a continuous medium? This important question is by no means as yet positively answered. But most of the effects which are here considered, especially the light effects, incandescence, or phosphorescence, involve the presence of free atoms and would be impossible without these.

Remember that the word atom had an entirely different association in these days than it has today.

In 1905-01-07: "The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace" Tesla is quite clear on the subject:

Our accepted estimates of the duration of natural metamorphoses, or changes in general, have been thrown in doubt of late. The very foundations of science have been shaken. We can no longer believe in the Maxwellian hypothesis of transversal ether-undulations of electrical vibrations, this most important field of human endeavour, particularly in the advancement of philanthropy and peace, was in no small measure retarded by that fascinating illusion, which I since long hoped to dispel. I have noted with satisfaction the first signs of a change of scientific opinion. The brilliant discovery of the exceptionally "radio-active" substances, radium and polonium, by Mrs. Sklodowska Curie, has likewise afforded me much personal gratification, being an eclatant confirmation of my early experimental demonstrations, of electrified radian streams of primary matter or corpuscular emanations (Electrical Review, New York, 1896-1897), which were then received with incredulity. They have awakened us from the poetical dream of an intangible conveyor of energy, weightless, structureless ether, to the plain, palpable reality of a ponderous medium of coarse particles, or bodily carriers of force. They have led us to a radically new interpretation of the changes and transformations we perceive. Enlightened by this recognition, we cannot say the sun is hot, the moon is cold, the star is bright, for all these might be purely electrical phenomena. If this be the case, then even our conceptions of time and space may have to be modified.

If this were the last article we would have to conclude that Tesla no longer believed in the ether. But this does not appear true. Tesla no longer believed in the ether as a carrier of electric and magnetic effects. But he did still believe in an ether which is the ultimate building block of matter as defined by Lord Kelvin and before him in the Vedas. Electric and magnetic effects are caused by what Tesla now refers to as "the medium", a gaseous medium consisting of minute particles. Probably a much smaller scale than that of electrons. In May 1919 an article called "True Wireless"

In 1900, however, after I had evolved a wireless transmitter which enabled me to obtain electro-magnetic activities of many millions of horse-power, I made a last desperate attempt to prove that the disturbances emanating from the oscillator were ether vibrations akin to those of light, but met again with utter failure. For more than eighteen years I have been reading treatises, reports of scientific transactions, and articles on Hertz-wave telegraphy, to keep myself informed, but they have always impress me like works of fiction.

Ten years later in 1929-09-22: "Nikola Tesla Tells of New Radio Theories"

When Dr. Heinrich Hertz undertook his experiments from 1887 to 1889 his object was to demonstrate a theory postulating a medium filling all space, called the ether, which was structureless, of inconceivable tenuity and yet solid and possessed of rigidity incomparably greater than that of the hardest steel. He obtained certain results and the whole world acclaimed them as an experimental verification of that cherished theory. But in reality what he observed tended to prove just its fallacy.

I had maintained for many years before that such a medium as supposed could not exist, and that we must rather accept the view that all space is filled with a gaseous substance. On repeating the Hertz experiments with much improved and very powerful apparatus, I satisfied myself that what he had observed was nothing else but effects of longitudinal waves in a gaseous medium, that is to say, waves, propagated by alternate compression and expansion. He had observed waves in the ether much of the nature of sound waves in the air.

Up to 1896, however, I did not succeed in obtaining a positive experimental proof of the existence of such a medium. But in that year I brought out a new form of vacuum tube capable of being charged to any desired potential, and operated it with effective pressures of about 4,000,000 volts. I produced cathodic and other rays of transcending intensity. The effects, according to my view, were due to minute particles of matter

carrying enormous electrical charges, which, for want of a better name, I designated as matter not further decomposable. Subsequently those particles were called electrons.

One of the first striking observations made with my tubes was that a purplish glow for several feet around the end of the tube was formed, and I readily ascertained that it was due to the escape of the charges of the particles as soon as they passed out into the air; for it was only in a nearly perfect vacuum that these charges could be confined to them. The coronal discharge proved that there must be a medium besides air in the space, composed of particles immeasurably smaller than those of air, as otherwise such a discharge would not be possible. On further investigation I found that this gas was so light that a volume equal to that of the earth would weigh only about one- twentieth of a pound.⁷

The velocity of any sound wave depends on a certain ratio between elasticity and density, and for this ether or universal gas the ratio is 800,000,000,000 times greater than for air. This means that the velocity of the sound waves propagated through the ether is about 300,000 times greater than that of the sound waves in air, which travel at approximately 1,085 feet a second. Consequently the speed in ether is 900,000 x 1,085 feet, or 186,000 miles, and that is the speed of light.

[In an article of 1930-07-06: "Man's Greatest Achievement" Tesla still talks about the ether. This is important because now his view is more matured and he distinguishes between the ether and "the medium".](#)

Long ago he recognized that all perceptible matter comes from a primary substance, of a tenuity beyond conception and filling all space - the Akasa or luminiferous ether - which is acted upon by the life-giving Prana or creative force, calling into existence, in never ending cycles, all things and phenomena. The primary substance, thrown into infinitesimal whirls of prodigious velocity, becomes gross matter; the force subsiding, the motion ceases and matter disappears, reverting to the primary substance.

[Only 2 years later he mixes them up again. It seems Tesla is still struggling with the nature of matter, or rather with explaining it.](#)

[1932-09-11: "Pioneer Radio Engineer Gives Views On Power"](#)

The assumption of the Maxwellian ether was thought necessary to explain the propagation of light by transverse vibrations, which can only occur in a solid. So fascinating was this theory that even at present it has many supporters, despite the manifest impossibility of a medium, perfectly mobile and tenuous to a degree inconceivable, and yet extremely rigid, like steel. As a result some illusionary ideas have been formed and various phenomena erroneously interpreted. The so-called Hertz waves are still considered a reality proving that light is electrical in its nature, and also that the ether is capable of transmitting transverse vibrations of frequencies however low. This view has become untenable since I showed that the universal medium is a gaseous body in which only longitudinal pulses can be propagated, involving alternating compressions and expansions similar to those produced by sound waves in the air. Thus, a wireless transmitter does not emit Hertz waves which are a myth, but sound waves in the ether, behaving in every respect like those in the air, except that, owing to the great elastic force and extremely small density of the medium, their speed is that of light.

[Remember that the ether was defined as an incompressible fluid and obviously in such a medium there can be no longitudinal waves. Tesla refers to his gaseous medium but calls it "ether".](#)

[1937-07-10: Prepared Statement by Nikola Tesla](#)

Supposing that the bodies act upon the surrounding space causing curvature of the same, it appears to my simple mind that the curved spaces must react on the bodies and, producing the opposite effects, straighten out the curves. Since action and reaction are coexistent, it follows that the supposed curvature of space is entirely impossible. But even if it existed it would not explain the motions of the bodies as observed. Only the existence of a field of force can account for them and its assumption dispenses with space curvature. All literature on this subject is futile and destined to oblivion. So are also all attempts to explain the workings of the universe without recognizing the existence of the ether and the indispensable function it plays in the phenomena.

⁷ 2.09374·10⁻²⁶ g/ml

Energy from the medium

1891-05-20: Experiments with Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination

But there is a possibility of obtaining energy not only in the form of light, but motive power, and energy of any other form, in some more direct way from the medium. The time will be when this will be accomplished, and the time has come when one may utter such words before an enlightened audience without being considered a visionary. We are whirling through endless space with an inconceivable speed, all around us everything is spinning, everything is moving, everywhere is energy. There must be some way of availing ourselves of this energy more directly. Then; with the light obtained from the medium, with the power derived from it, with every form of energy obtained without effort, from the store forever inexhaustible, humanity will advance with giant strides. The mere contemplation of these magnificent possibilities expands our minds, strengthen our hopes and fills our hearts with supreme delight.

1892-02-03: Experiments with Alternate Currents of High Potential and High Frequency

Ere many generations pass, our machinery will be driven by a power obtainable at any point of the universe. This idea is not novel. Men have been led to it long ago by instinct or reason; it has been expressed in many ways, and in many places, in the history of old and new. We find it in the delightful myth of Antheus, who derives power from the earth; we find it among the subtle speculations of one of your splendid mathematicians and in many hints and statements of thinkers of the present time. Throughout space there is energy. Is this energy static or kinetic? If static our hopes are in vain; if kinetic—and this we know it is, for certain—then it is a mere question of time when men will succeed in attaching their machinery to the very wheelwork of nature. Of all, living or dead, Crookes came nearest to doing it. His radiometer will turn in the light of day and in the darkness of the night; it will turn everywhere where there is heat, and heat is everywhere. But, unfortunately, this beautiful little machine, while it goes down to posterity as the most interesting, must likewise be put on record as the most inefficient machine ever invented!

Tesla draws our attention to the myth of Antheus by calling it delightful. There is hardly anything delightful in a story about a half-giant who collects the skulls of passers-by who he challenged to a wrestling match. And to say that he derives power from the Earth is not exactly accurate in my opinion. But this is what is on Tesla's mind and what he wants to share with us.

In 1896 almost exactly 1 year after the burning of Tesla's laboratory an interesting article appears in *The World Sunday Magazine*: "Earth electricity to kill monopoly":

A Way to Harness Free Electric Currents Discovered by Nikola Tesla

The World is on the eve of an astounding revelation. The conditions under which we exist will be changed. The end has come to telegraph and telephone monopolies with a crash. Incidentally, all the other monopolies that depend on power of any kind will come to a sudden stop. The earth currents of electricity are to be harnessed. Nature supplies them free of charge. The cost of power and light and heat will be practically nothing.

It is a bit vague article and not written by Tesla, but still it is quite a remarkable article.

1897-01-27: On Electricity

We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, which I have long ago recognized, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts since a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered.

Having examined for a long time 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, I find that even under the theoretically best conditions such a method of obtaining power can not equal in economy, simplicity and many other features the present method, involving a conversion of the mechanical energy of running water into electrical energy and the transmission of the latter in the form of currents of very high tension to great distances.

In the main article of this document you will read that Tesla changed his mind on this last statement.

1916: Pre-hearing interview

I have an idea that [you] will get the best picture of the process in my system of transmission if you will imagine that the earth is a reservoir, say, of fluid under pressure -- that is the potential energy -- and at my plant, operating a distant tuned circuit, I must open a valve and enable that energy to flow in. It is exactly that way. The energy is all conserved, whether it is vibrating or purely potential. Whatever the transmitter does in the receiver, the effect is simply to open a valve, as it were, and permit energy to flow in.

1931-12-00: Our Future Motive Power

It was clear to me many years ago that a new and better source of power had to be discovered to meet the ever increasing demands of mankind. In a lecture delivered before the American Institute of Electrical Engineers at Columbia University May 20, 1891, I said: "We are whirling through endless space with inconceivable speed, all around us everything is spinning, everything is moving, everywhere is energy. There must be some way of availing ourselves of this energy more directly. Then, with the light obtained from the medium, with the power derived from it, with every form of energy obtained without effort, from the store forever inexhaustible, humanity will advance with giant strides." I have thought and worked with this object in view unremittingly and am glad to say that I have sufficient theoretical and experimental evidence to fill me with hope, not to say confidence, that my efforts of years will be rewarded and that we shall have at our disposal a new source of power, superior even to the hydro-electric, which may be obtained by means of simple apparatus everywhere and in almost constant and unlimited amount.

This contradicts Tesla's earlier remark of 1897. As we now know, Tesla perfected both the generation of electricity from energy from the medium and the transmission of electrical energy by using the Earth as conductor.

The Problem of Increasing Human Energy

With Special Reference to the Harnessing of the Sun's Energy.

By Nikola Tesla

Illustrated by the writer's electrical experiments, now first published.

THE ONWARD MOVEMENT OF MAN

—THE ENERGY OF THE MOVEMENT—THE THREE WAYS OF INCREASING HUMAN ENERGY.

Of all the endless variety of phenomena which nature presents to our senses, there is none that fills our minds with greater wonder than that inconceivably complex movement which, in its entirety, we designate as human life; Its mysterious origin is veiled in the forever impenetrable mist of the past, its character is rendered incomprehensible by its infinite intricacy, and its destination is hidden in the unfathomable depths of the future. Whence does it come? What is it? Whither does it tend? are the great questions which the sages of all times have endeavoured to answer.

Main subject here is "human life", while Tesla was obviously more knowledgeable in the field of electricity. This is the first clue that we have to read this article in a different way. Then we see that for electricity goes the same: we don't know its origin, its character and its destination...

Modern science says: The sun is the past, the earth is the present, the moon is the future. From an incandescent mass we have originated, and into a frozen mass we shall turn. Merciless is the law of nature, and rapidly and irresistibly we are drawn to our doom. Lord Kelvin, in his profound meditations, allows us only a short span of life, something like six million years, after which time the sun's bright light will have ceased to shine, and its life giving heat will have ebbed away, and our own earth will be a lump of ice, hurrying on through the eternal night. But do not let us despair. There will still be left upon it a glimmering spark of life, and there will be a chance to kindle a new fire on some distant star. This wonderful possibility seems, indeed, to exist, judging from Professor Dewar's beautiful experiments with liquid air, which show that germs of organic life are not destroyed by cold, no matter how intense; consequently they may be transmitted through the interstellar space. Meanwhile the cheering lights of science and art, ever increasing in intensity, illuminate our path, and marvels they disclose, and the enjoyments they offer, make us measurably forgetful of the gloomy future.

All things go from a high energy level to a low energy level. In a much later article Tesla wonders if there would be a mechanism that raises the level again.

In the beginning of this article, we will take a few sidesteps to increase our understanding of how Tesla saw things in his time.

1932-10-13: The Eternal Source of Energy of the Universe, Origin and Intensity of Cosmic Rays

A little over one century ago many astronomers, including Laplace still thought that the system of heavenly bodies was unalterable and that they would perform their motions in the same manner through an eternity. But the gradual perfection of instruments and refinement of methods of investigation, achieved since that time, has led to the recognition that there is a continuous change going on in the celestial regions subjecting all bodies to ever varying influence. Where this change is leading to, and what is to be its final phase, have become questions of supreme scientific interest. In a communication to the Royal Society of Edinburgh dated April 19, 1852 and the Philosophical Magazine of October of the same year, Lord Kelvin drew attention to the general tendency in nature towards dissipation of mechanical energy, a fact borne out in daily observation of thermo-dynamic and dynamo-thermic processes and one of ominous significance. It meant that the driving force of the universe was steadily decreasing and that ultimately all of its motive energy will be exhausted none remaining available for mechanical work. In the macro-cosmos, with its countless conception, this process might require billions of years for its consummation; but in the infinitesimal worlds of the micro-cosmos it must have been quickly completed. Such being the case then, according to an experimental findings and deductions of positive science, any material substance (cooled down to the absolute zero of temperature) should be devoid of an internal movement and energy, so to speak, dead.

On a few more occasions Tesla talks about the death of matter. This shines light on how he sees matter.

1893-02-24: On Light and Other High Frequency Phenomena

So, the atom, the ulterior element of the Universe's structure, is tossed about in space eternally, a play to external influences, like a boat in a troubled sea. Were it to stop its motion it would die: matter at rest, if such a thing could exist, would be matter dead. Death of matter! Never has a sentence of

deeper philosophical meaning been uttered. This is the way in which Prof. Dewar forcibly expresses it in the description of his admirable experiments, in which liquid oxygen is handled as one handles water, and air at ordinary pressure is made to condense and even to solidify by the intense cold: Experiments, which serve to illustrate, in his language, the last feeble manifestations of life, the last quiverings of matter about to die. But human eyes shall not witness such death. There is no death of matter, for throughout the infinite universe, all has to move, to vibrate, that is, to live.

This last phrase is an interesting one. What makes Tesla so sure of this?

1908-04-21: Mr. Tesla's Vision

According to an adopted theory, every ponderable atom is differentiated from a tenuous fluid, filling all space merely by spinning motion, as a whirl of water in a calm lake. By being set in movement this fluid, the ether, becomes gross matter. Its movement arrested, the primary substance reverts to its normal state. It appears, then, possible for man through harnessed energy of the medium and suitable agencies for starting and stopping ether whirls to cause matter to form and disappear. At his command, almost without effort on his part, old worlds would vanish and new ones would spring into being. He could alter the size of this planet, control its seasons, adjust its distance from the sun, guide it on its eternal journey along any path he might choose, through the depths of the universe. He could make planets collide and produce his suns and stars, his heat and light; he could originate life in all its infinite forms. To cause at will the birth and death of matter would be man's grandest deed, which would give him the mastery of physical creation, make him fulfil his ultimate destiny.

back to 1932:

This idea of the great philosopher, who later honoured me with his friendship, had a fascinating effect on my mind and in meditating over it I was struck by the thought that if there is energy within the substance it can only come from without. This truth was so manifest to me that I expressed it in the following axiom: "There is no energy in matter except that absorbed from the medium." Lord Kelvin gave us a picture of a dying universe, of a clockwork wound up and running down, inevitably doomed to come to a full stop in the far, far off future. It was a gloomy view incompatible with artistic, scientific and mechanical sense. I asked myself again and again, was there not some force winding up the clock as it runs down? The axiom I had formulated gave me a clue. If all energy is supplied to matter from without then this all important function must be performed by the medium. Yes--but how? I pondered over this oldest and greatest of all riddles of physical science a long time in vain, despairingly remind of the words of the poet:

Wo fass ich dich unendliche Natur?
Euch Brust wo Ihr Quellen alles Lebens
An denen Himmel und Erdë hangt. . .

Where, boundless nature, can I hold you fast?
And where you breasts? Wells that sustain
All life--the heaven and the earth are nursed.
Goethe. Faust

What I strove for seemed unattainable, but a kind fate favoured me and a few inspired experiments lifted the veil. It was a revelation wonderful and incredible explaining many mysteries of nature and disclosing as in a lightening flash the illusionary character of some modern theories incidentally also bearing out the universal truth of the above axiom.

When radio-active rays were discovered their investigators believed them to be due to liberation of atomic energy in the form of waves. This being impossible in the light of the preceding I concluded that they were produced by some external disturbance and composed of electrified particles⁸. My theory was not seriously taken although it appeared simple and plausible. Suppose that bullets are fired against a wall. Where a missile strikes the material is crushed and spatters in all directions radial from the place of impact. In this example it is perfectly clear that the energy of the flying pieces can only be derived from that of the bullets. But in manifestation of radio-activity no such proof could be advanced and it was, therefore, of the first importance to demonstrate experimentally the existence of this miraculous disturbance in the medium. I was rewarded in these efforts with quick success largely because of the efficient method I adopted which consisted in deriving from a great mass of air, ionized by the disturbance, a current, storing its energy in a condenser and discharging the same through an indicating device. This plan did away with the limitations and incertitude of the electroscope first employed and was described by me in articles and patents from 1900 to 1905.⁹

8 Primary Cosmic Rays

9 the Century Magazine article of 1900, and a number of patents related to his wireless system; 685.012, 787.412, 723.188, 725.605, 685.957, 685.958 and 1.119.732.

Tesla explains how to verify his discovery... This method looks very familiar:

1932-07-10: "Tesla Cosmic Ray Motor May Transmit Power 'Round Earth"

"I will tell you in the most general way," he said. "The cosmic ray ionizes the air, setting free many charges—ions and electrons. These charges are captured in a condenser which is made to discharge through the circuit of the motor."

Back October that same year:

It was logical to expect, judging from the behaviour of known radiations, that the chief source of the new rays would be the sun, but this supposition was contradicted by observations and theoretical considerations which disclosed some surprising facts in this connection.

Light and heat rays are absorbed in their passage through a medium in a certain proportion to its density. The ether, although the most tenuous of all substances, is no exception to this rule. Its density has been first estimated by Lord Kelvin and conformably to his finding a column of one square centimetre cross section and of a length such that light, travelling at a rate of three hundred thousands kilometres per second, would require one year to traverse it, should weigh 4.8 grams.¹⁰ This is just about the weigh of a prism of ordinary glass of the same cross section and two centimetres length which, therefore, may be assumed as the equivalent of the ether column in absorption. A column of the ether one thousand times longer would thus absorb as much light as twenty meters of glass. However, there are suns at distances of many thousands of light years and it is evident that virtually no light from them can reach the earth. But if these suns emit rays immensely more penetrative than those of light they will be slightly dimmed and so the aggregate amount of radiations pouring upon the earth from all sides will be overwhelmingly greater than that supplied to it by our luminary. If light and heat rays would be as penetrative as the cosmic, so fierce would be the perpetual glare and so scorching the heat that life on this and other planets could not exist.

Rays in every respect similar to the cosmic are produced by my vacuum tubes when operated at pressures of ten millions of volts or more, but even if it were not confirmed by experiment, the theory I advanced in 1897 would afford the simplest and most probable explanation of the phenomena. Is not the universe with its infinite and impenetrable boundary a perfect vacuum tube of dimensions and power inconceivable? Are not its fiery suns electrodes at temperatures far beyond any we can apply in the puny and crude contrivances of our making? Is it not a fact that the suns and stars are under immense electrical pressures transcending any that man can ever produce and is this not equally true of the vacuum in celestial space? Finally, can there be any doubt that cosmic dust and meteoric matter present an infinitude of targets acting as reflectors and transformers of energy? If under ideal working conditions, and with apparatus on a scale beyond the grasp of the human mind, rays of surpassing intensity and penetrative power would not be generated, then, indeed, nature has made an unique exception to its laws.

It has been suggested that the cosmic rays are electrons or that they are the result of creation of new matter in the interstellar deserts. These views are too fantastic to be even for a moment seriously considered. They are natural outcroppings of this age of deep but unrational thinking, of impossible theories, the latest of which might, perhaps, deal with the curvature of time. What this world of ours would be if time were curved!

As there exists considerable doubt in regard to the manner in which the intensity of the cosmic rays varies with altitude the following simple formula derived from my early experimental data may be welcome to those who are interested in the subject.

$$I = (W+P) / (W+p) \tag{1}$$

In this expression W is the weight in kilograms of a column of lead of one square centimetre cross section and one hundred and eighty centimetres length, P the normal pressure of the atmosphere at sea level in kilograms per square centimetre, p the atmospheric pressure at the altitude under consideration and in like measure and I the intensity of the radiation in terms of that at sea level which is taken as unit. Substituting the actual values for W and P, respectively 1.9809 and 1.0133 kilograms, the formula reduces to $I = 2.99421 / (1.9809 + p)$

Obviously, at sea level $p = P$ hence the intensity is equal to 1, this being the unit of measurement. On the other hand, at the extreme limit of the atmosphere $p = 0$ and the intensity $I = 1.5115$.

The maximum increase with height is, consequently, a little over fifty-one percent. This formula, based on my finding that the absorption is proportionate to the density of the medium whatever it be, is fairly accurate. Other investigators might find different values for W but they will undoubtedly observe the same character of dependence, namely, that the intensity increases proportionately to the height for a few kilometres and then at a gradually lessening rate.

¹⁰ Kelvin's ether weighs $5.074 \cdot 10^{-18}$ g/ml while Tesla's estimate is $2,094 \times 10^{-26}$ g/ml (in 1929-09-22: Nikola Tesla Tells of New Radio Theories).

With a few side steps we have already located an inexhaustible source of energy, one of his axioms and how he sees matter. The primary source of energy is what I shall refer to as “primary cosmic radiation” (PCR). These are rays of minute charged particles, travelling faster than light. They are immensely penetrative and are the cause of radioactive decay. Also they are the cause of “secondary cosmic radiation” (SCR) which is released as bremsstrahlung during the interaction with matter. They could also be the cause of gravity, as we will see later. This PCR is emitted by highly charged conductors in high vacuum. Formula (1) cannot apply to PCR, Tesla probably refers to SCR here but even then it can not apply. Tesla probably wants to convey his belief that there is a constant ‘pressure’ of these rays outside our atmosphere.

His axiom “There is no energy in matter except that absorbed from the medium” is one of two important axioms to always keep in mind when reading Tesla's work. The other one is “Matter cannot act where it is not.” (see the first quote from his lecture on May 20th 1891 in chapter “Ether and the medium”)

This brings us to the question “what is matter?”, to which Tesla answers “every ponderable atom is differentiated from a tenuous fluid, filling all space merely by spinning motion, as a whirl of water in a calm lake.” Notice that Tesla says “fluid”, so he refers to ether as defined by Lord Kelvin, and with “atom” he refers to an elementary particle, not an atom as we know today. This view can be extended to astronomical scale. An atom has a positively charged nucleus around which negative charge revolves. Likewise, the Sun is a positively charged nucleus around which negatively charged planets revolve. The most likely reason for this rotation can be that the Sun generates a rotation in the ether surrounding it and that the planets are being dragged along in this ether movement. This concept is in accordance with the results of the Michelson-Morley experiment.

Back to the article.

We were talking about “human life”, and Tesla returns to that in saying that we have only a short span of life, possibly referring to his own. This article would then be the “glimmering spark” that could “kindle a new fire” in a distant future.

Though we may never be able to comprehend human life, we know certainly that it is a movement, of whatever nature it be. The existence of movement unavoidably implies a body which is being moved and a force which is moving it. Hence, wherever there is life, there is a mass moved by a force. All mass possesses inertia, all force tends to persist. Owing to this universal property and condition, a body, be it at rest or in motion, tends to remain in the same state, and a force, manifesting itself anywhere and through whatever cause, produces an equivalent opposing force, and as an absolute necessity of this it follows that every movement in nature must be rhythmical. Long ago this simple truth was clearly pointed out by Herbert Spencer, who arrived at it through a somewhat different process of reasoning. It is borne out in everything we perceive—in the movement of a planet, in the surging and ebbing of the tide, in the reverberations of the air, the swinging of a pendulum, the oscillations of an electric current, and in the infinitely varied phenomena of organic life. Does not the whole of human life attest to it? Birth, growth, old age, and death of an individual, family, race, or nation, what is it all but a rhythm? All life-manifestation, then, even in its most intricate form, as exemplified in man, however involved and inscrutable, is only a movement, to which the same general laws of movement which govern throughout the physical universe must be applicable.

The exact same goes for electricity; it is a movement, thus there must be a body being moved by a force. This body must possess inertia. A force acting on a body, creates motion, this motion is met with a counter-force and thus the resulting motion must be rhythmical.

When we speak of man, we have a conception of humanity as a whole, and before applying scientific methods to, the investigation of his movement we must accept this as a physical fact. But can anyone doubt to-day that all the millions of individuals and all the innumerable types and characters constitute an entity, a unit? Though free to think and act, we are held together, like the stars in the firmament, with ties inseparable. These ties cannot be seen, but we can feel them. I cut myself in the finger, and it pains me: this finger is a part of me. I see a friend hurt, and it hurts me, too: my friend and I are one. And now I see stricken down an enemy, a lump of matter which, of all the lumps of matter in the universe, I care least for, and it still grieves me. Does this not prove that each of us is only part of a whole?

I believe Tesla wants to convey the idea that an electric current or static charge acts as a unit but consists of a multitude of charges. Or perhaps that this applies to mass as is expressed in the next paragraph.

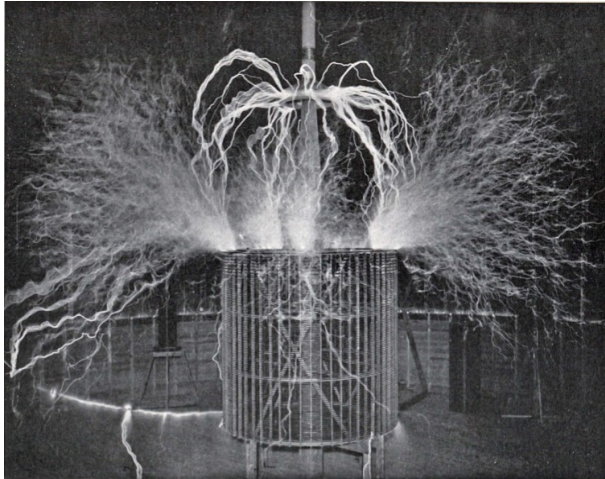


FIG. 1. BURNING THE NITROGEN OF THE ATMOSPHERE.

Note to Fig. 1.—This result is produced by the discharge of an electrical oscillator giving twelve million volts. The electrical pressure, alternating one hundred thousand times per second, excites the normally inert nitrogen, causing it to combine with the oxygen. The flame-like discharge shown in the photograph measures sixty-five feet across.

65 ft is 19.8 meters. The diameter of the primary and secondary coils are 15 meters. This picture does not show the size that Tesla mentions. The 12 million volt is frequently mentioned by Tesla in various articles there may be a special reason for that.

For ages this idea has been proclaimed in the consummately wise teachings of religion, probably not alone as a means of insuring peace and harmony among men, but as a deeply founded truth. The Buddhist expresses it in one way, the Christian in another, but both say the same: We are all one. Metaphysical proofs are, however, not the only ones which we are able to bring forth in support of this idea. Science, too, recognizes this connectedness of separate individuals, though not quite in the same sense as it admits that the suns, planets, and moons of a constellation are one body, and there can be no doubt that it will be experimentally confirmed in times to come, when our means and methods for investigating psychical and other states and phenomena shall have been brought to great perfection. Still more: this one human being lives on and on. The individual is ephemeral, races and nations come and pass away, but man remains. Therein lies the profound difference between the individual and the whole. Therein, too, is to be found the partial explanation of many of those marvellous phenomena of heredity which are the result of countless centuries of feeble but persistent influence.

The parts that make up the whole may come and go but the whole remains. This most probably also goes for an electric current.

Conceive, then, man as a mass urged on by a force. Though this movement is not of a translatory character, implying change of place, yet the general laws of mechanical movement are applicable to it, and the energy associated with this mass can be measured, in accordance with well-known principles, by half the product of the mass with the square of a certain velocity. So, for instance, a cannon-ball which is at rest possesses a certain amount of energy in the form of heat, which we measure in a similar way. We imagine the ball to consist of innumerable minute particles, called atoms or molecules, which vibrate or whirl around one another. We determine their masses and velocities, and from them the energy of each of these minute systems, and adding them all together, we get an idea of the total heat-energy contained in the ball, which is only seemingly at rest. In this purely theoretical estimate this energy may then be calculated by multiplying half of the total mass—that is half of the sum of all the small masses—with the square of a velocity which is determined from the velocities of the separate particles. In like manner we may conceive of human energy being measured by half the human mass multiplied with the square of the velocity which we are not yet able to compute. But our deficiency in this knowledge will not vitiate the truth of the deductions I shall draw, which rest on the firm basis that the same laws of mass and force govern throughout nature.

Here we get a new view on electricity; it has or is a temperature, an average kinetic energy of the constituting particles, and these particles are the “atoms” of what he calls “the medium”.

Man, however, is not an ordinary mass, consisting of spinning atoms and molecules, and containing merely heat-energy. He is a mass possessed of certain higher qualities by reason of the creative principle of life with which he is endowed. His mass, as the water in an ocean wave, is being continuously exchanged, new taking the place of the old.

Again; there is a whole that is made up of particles that come and go, so there must be a higher principle that defines the whole.

Not only this, but he grows propagates, and dies, thus altering his mass independently, both in bulk and density. What is most wonderful of all, he is capable of increasing or diminishing his velocity of movement by the mysterious power he possesses by appropriating more or less energy from other substance, and turning it into motive energy. But in any given moment we may ignore these slow changes and assume that human energy is measured by half the product of man's mass with the square of a certain hypothetical velocity. However we may compute this velocity, and whatever we may take as the standard of its measure, we must, in harmony with this conception, come to the conclusion that the great problem of science is, and always will be, to increase the energy thus defined. Many years ago, stimulated by the perusal of that deeply interesting work, Draper's "History of the Intellectual Development of Europe," depicting so vividly human movement, I recognized that to solve this eternal problem must ever be the chief task of the man of science. Some results

of my own efforts to this end I shall endeavour briefly to describe here.

Tesla refers to his axiom that there is no energy in mass other than that absorbed from the medium.

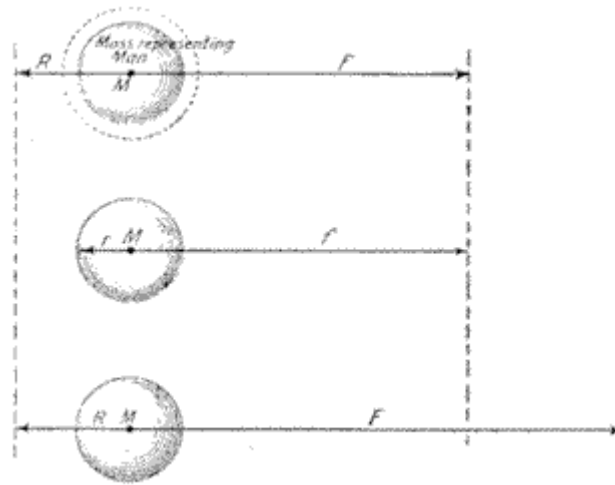


DIAGRAM a. THE THREE WAYS OF INCREASING HUMAN ENERGY.

Let, then, in diagram a, M represent the mass of man. This mass is impelled in one direction by a force f , which is resisted by another partly frictional and partly negative force R , acting in a direction exactly opposite, and retarding the movement of the mass. Such an antagonistic force is present in every movement and must be taken into consideration. The difference between these two forces is the effective force which imparts a velocity V to the mass M in the direction of the arrow on the line representing the force f . In accordance with the preceding, the human energy will then be given by the product $\frac{1}{2} MV^2 = \frac{1}{2} MV \times V$, in which M is the total mass of man in the ordinary interpretation of the term "mass," and V is a certain hypothetical velocity, which, in the present state of science, we are unable exactly to define and determine. To increase the human energy is, therefore, equivalent to increasing this product, and there are, as will readily be seen, only three ways possible to attain this result, which are illustrated in the above diagram. The first way shown in the top figure, is to increase the mass (as indicated by the dotted circle), leaving the two opposing forces the same. The second way is to reduce the retarding force R to a smaller value r , leaving the mass and the impelling force the same, as diagrammatically shown in the middle figure. The third way, which is illustrated in the last figure, is to increase the impelling force f to a higher value F , while the mass and the retarding force R remain unaltered. Evidently fixed limits exist as regards increase of mass and reduction of retarding force, but the impelling force can be increased indefinitely. Each of these three possible solutions presents a different aspect of the main problem of increasing human energy, which is thus divided into three distinct problems, to be successively considered.

Exactly the same can be said for electrical energy; to increase it we either increase the mass (charge or current), reduce all retarding forces (such as resistance) or increase the propelling force (voltage).

THE FIRST PROBLEM: HOW TO INCREASE THE HUMAN MASS —THE BURNING OF ATMOSPHERIC NITROGEN.

Viewed generally, there are obviously two ways of increasing the mass of mankind: first, by aiding and maintaining those forces and conditions which tend to increase it; and, second, by opposing and reducing those which tend to diminish it. The mass will be increased by careful attention to health, by substantial food, by moderation, by regularity of habits, by promotion of marriage, by conscientious attention to children, and, generally stated, by the observance of all the many precepts and laws of religion and hygiene. But in adding new mass to the old, three cases again present themselves. Either the mass added is of the same velocity as the old, or it is of a smaller or of a higher velocity. To gain an idea of the relative importance of these cases, imagine a train composed of, say, one hundred locomotives running on a track, and suppose that, to increase the energy of the moving mass, four more locomotives are added to the train. If these four move at the same velocity at which the train is going, the total energy will be increased four per cent.; if they are moving at only one half of that velocity, the increase will amount to only one per cent.; if they are moving at twice that velocity, the increase of energy will be sixteen per cent. This simple illustration shows that it is of greatest importance to add mass of a higher velocity. Stated more to the point, if, for example, the children be of the same degree of enlightenment as the parents,—that is, mass of the "same velocity,"—the energy will simply increase proportionately to the number added. If they are less intelligent or advanced, or mass of "smaller velocity," there will be a very slight gain in the energy; but if they are further advanced, or mass of "higher velocity," then the new generation will add very considerably to the sum total of human energy. any addition of mass of "smaller velocity," beyond that indispensable amount required by the law expressed in the proverb, "Mens sana in corpore sano," should be strenuously opposed. For instance, the mere development of muscle, as aimed at in some of our colleges, I consider equivalent to adding mass of "smaller velocity," and I would not commend it, although my views were different when I was a student myself. Moderate exercise, insuring the right balance between mind and body, and the highest efficiency of performance, is, of course, a prime requirement. The above example shows that the most important result to be attained is the education, or the increase of the "velocity," of the mass newly added.

The first part is on how to increase charge or current, and special attention is given to adding new charge at a higher potential or temperature so to increase the average. This is done in the Magnifying Transmitter when it creates a standing wave in the Earth's charge. An analogy would be a hammer which we use to collect kinetic energy and pass it on to the nail in an extremely short interval, thus with tremendous power.

Conversely, it scarcely need be stated that everything that is against the teachings of religion and the laws of hygiene is tending to decrease the mass. Whisky, wine, tea coffee, tobacco, and other such stimulants are responsible for the shortening of the lives of many, and ought to be used with moderation. But I do not think that rigorous measures of suppression of habits followed through many generations are commendable. It is wiser to preach moderation than abstinence. We have become accustomed to these stimulants, and if such reforms are to be effected, they must be slow and gradual. Those who are devoting their energies to such ends could make themselves far more useful by turning their efforts in other directions, as, for instance, toward providing pure water.

For every person who perishes from the effects of a stimulant, at least a thousand die from the consequences of drinking impure water. This precious fluid, which daily infuses new life into us, is likewise the chief vehicle through which disease and death enter our bodies. The germs of destruction it conveys are enemies all the more terrible as they perform their fatal work unperceived. They seal our doom while we live and enjoy. The majority of people are so ignorant or careless in drinking water, and the consequences of this are so disastrous, that a philanthropist can scarcely use his efforts better than by endeavouring to enlighten those who are thus injuring themselves. By systematic purification and sterilization of the drinking water the human mass would be very considerably increased. It should be made a rigid rule—which might be enforced by law—to boil or to sterilize otherwise the drinking water in every household and public place. The mere filtering does not afford sufficient security against infection. All ice for internal uses should be artificially prepared from water thoroughly sterilized. The importance of eliminating germs of disease from the city water is generally recognized, but little is being done to improve the existing conditions, as no satisfactory method of sterilizing great quantities of water has yet been brought forward. By improved electrical appliances we are now enabled to produce ozone cheaply and in large amounts, and this ideal disinfectant seems to offer a happy solution of the important question.

It is interesting to note that electricity has often been seen as a fluid and then reread the above paragraph. Could it be that there is something in a current that also causes its destruction? If an electric current is seen as a 'higher principle' that causes electrons to move, then this movement of the electrons is necessarily met with resistance and thus slows down the higher principle.

It could also refer to using electrical power (fluid) that is generated in a way that also brings destruction in one way or another (burning fuel, toxic or radio-active waste etc.), as in the next paragraph.

Gambling, business rush, and excitement, particularly on the exchanges, are causes of much mass reduction, all the more so because the individuals concerned represent units of higher value. Incapacity of observing the first symptoms of an illness, and careless neglect of the same, are important factors of mortality. In noting carefully every new sign of approaching danger, and making conscientiously every possible effort to avert it, we are not only following wise laws of hygiene in the interest of our well-being and the success of our labours, but we are also complying with a higher moral duty. Everyone should consider his body as a priceless gift from one whom he loves above all, as a marvellous work of art, of indescribable beauty and mastery beyond human conception, and so delicate and frail that a word, a breath, a look, nay, a thought, may injure it. Uncleanliness, which breeds disease and death, is not only a self destructive but highly immoral habit. In keeping our bodies free from infection, healthful, and pure, we are expressing our reverence for the high principle with which they are endowed. He who follows the precepts of hygiene in this spirit is proving himself, so far, truly religious. Laxity of morals is a terrible evil, which poisons both mind and body, and which is responsible for a great reduction of the human mass in some countries. Many of the present customs and tendencies are productive of similar hurtful results. For example, the society life, modern education and pursuits of women, tending to draw them away from their household duties and make men out of them, must needs detract from the elevating ideal they represent, diminish the artistic creative power, and cause sterility and a general weakening of the race. A thousand other evils might be mentioned, but all put together, in their bearing upon the problem under discussion, they could not equal a single one, the want of food, brought on by poverty, destitution, and famine. Millions of individuals die yearly for want of food, thus keeping down the mass. Even in our enlightened communities, and not withstanding the many charitable efforts, this is still, in all probability, the chief evil. I do not mean here absolute want of food, but want of healthful nutriment.

[Our society requires energy \(food\) and what is more important; "sustainable energy" \(healthful nutriment\).](#)

How to provide good and plentiful food is, therefore, a most important question of the day. On the general principles the raising of cattle as a means of providing food is objectionable, because, in the sense interpreted above, it must undoubtedly tend to the addition of mass of a "smaller velocity." It is certainly preferable to raise vegetables, and I think, therefore, that vegetarianism is a commendable departure from the established barbarous habit. That we can subsist on plant food and perform our work even to advantage is not a theory, but a well-demonstrated fact. Many races living almost exclusively on vegetables are of superior physique and strength. There is no doubt that some plant food, such as oatmeal, is more economical than meat, and superior to it in regard to both mechanical and mental performance. Such food, moreover, taxes our digestive organs decidedly less, and, in making us more contented and sociable, produces an amount of good difficult to estimate. In view of these facts every effort should be made to stop the wanton and cruel slaughter of animals, which must be destructive to our morals. To free ourselves from animal instincts and appetites, which keep us down, we should begin at the very root from which we spring: we should effect a radical reform in the character of the food.

[The burning of fossil fuels must be stopped and changed into something less destructive and barbaric. Also note that Tesla tries to tell us to get our energy as close as possible from the source.](#)

There seems to be no philosophical necessity for food. We can conceive of organized beings living without nourishment, and deriving all the energy they need for the performance of their life functions from the ambient medium. In a crystal we have the clear evidence of the existence of a formative life-principle, and though we cannot understand the life of a crystal, it is none the less a living being. There may be, besides crystals, other such individualized, material systems of beings, perhaps of gaseous constitution, or composed of substance still more tenuous. In view of this possibility,—nay, probability, we cannot apodictically deny the existence of organized beings on a planet merely because the conditions on the same are unsuitable for the existence of life as we conceive it. We cannot even, with positive assurance, assert that some of them might not be present here, in this our world, in the very midst of us, for their constitution and life-manifestation may be such that we are unable to perceive them.

[There must be a way to derive our energy directly from the ambient medium. The fact that we do not yet perceive this energy does not mean that it is not there. Tesla clearly refers to an ether-like medium here, in which life \(electricity\) exists.](#)

The production of artificial food as a means for causing an increase of the human mass naturally suggests itself, but a direct attempt of this kind to provide nourishment does not appear to me rational, at least not for the present. Whether we could thrive on such food is very doubtful. We are the result of ages of continuous adaptation, and we cannot radically change without unforeseen and, in all probability, disastrous consequences. So uncertain an experiment should not be tried. By far the best way, it seems to me, to meet the ravages of the evil, would be to find ways of increasing the productivity of the soil. With this object the preservation of forests is of an importance which cannot be overestimated, and in this connection, also, the utilization of water-power for purposes of electrical transmission, dispensing in many ways with the necessity

of burning wood, and tending thereby to forest preservation, is to be strongly advocated. But there are limits in the improvement to be effected in this and similar ways.

We should not change the sort of energy that we are using in any way. We must increase the productivity of that energy sources that we already have. Or perhaps this is a reference to using the Earth as a distribution channel, as it is in the next paragraph.

To increase materially the productivity of the soil, it must be more effectively fertilized by artificial means. The question of food-production resolves itself, then, into the question how best to fertilize the soil. What it is that made the soil is still a mystery. To explain its origin is probably equivalent to explaining the origin of life itself. The rocks, disintegrated by moisture and heat and wind and weather, were in themselves not capable of maintaining life. Some unexplained condition arose, and some new principle came into effect, and the first layer capable of sustaining low organisms, like mosses was formed. These, by their life and death, added more of the life sustaining quality to the soil, and higher organisms could then subsist, and so on and on, until at last highly developed plant and animal life could flourish. But though the theories are, even now, not in agreement as to how fertilization is effected, it is a fact, only too well ascertained, that the soil cannot indefinitely sustain life, and some way must be found to supply it with the substances which have been abstracted from it by the plants. The chief and most valuable among these substances are compounds of nitrogen, and the cheap production of these is, therefore, the key for the solution of the all-important food problem. Our atmosphere contains an inexhaustible amount of nitrogen, and could we but oxidise it and produce these compounds, an incalculable benefit for mankind would follow.

The source of our energy is to be found in our atmosphere, not in burning fuel. It is present in an 'inert' form, but it can be activated... Once activated we can 'fertilize' our Earth with it so that industries (plants) can grow. This is a beautiful analogy of his Wardencllyffe project. But how do we activate and collect this energy?

Long ago this idea took a powerful hold on the imagination of scientific men, but an efficient means for accomplishing this result could not be devised. The problem was rendered extremely difficult by the extraordinary inertness of the nitrogen, which refuses to combine even with oxygen. But here electricity comes to our aid: the dormant affinities of the element are awakened by an electric current of the proper quality. As a lump of coal which has been in contact with oxygen for centuries without burning will combine with it when once ignited, so nitrogen, excited by electricity, will burn. I did not succeed, however, in producing electrical discharges exciting very effectively the atmospheric nitrogen until a comparatively recent date, although I showed, in May, 1891, in a scientific lecture, a novel form of discharge or electrical flame named "St. Elmo's hotfire," which, besides being capable of generating ozone in abundance, also possessed, as I pointed out on that occasion, distinctly the quality of exciting chemical affinities. This discharge or flame was then only three or four inches long, its chemical action was likewise very feeble, and consequently the process of oxidation of nitrogen was wasteful. How to intensify this action was the question. Evidently electric currents of a peculiar kind had to be produced in order to render the process of nitrogen combustion more efficient.

"St. Elmo's fire" is a weather phenomenon in which luminous plasma is created by a coronal discharge from a sharp or pointed object in a strong electric field in the atmosphere (such as those generated by thunderstorms or created by a volcanic eruption)¹¹. Basically this is the result of a potential difference between the Earth and the atmosphere. First mentioned here:

1891-05-20: Experiments with Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination

The above plan necessitates the employment of a primary of comparatively small size, and it is apt to heat when powerful effects are desirable for a certain length of time. In such a case it is better to employ a larger coil, Fig. 16b, and introduce it from one side of the tube, until the streams begin to appear. In this case the nearest terminal of the secondary may be connected to the primary or to the ground, which is practically the same thing, if the primary is connected directly to the machine. In the case of ground connections it is well to determine experimentally the frequency which is best suited under the conditions of the test. Another way of obviating the streams, more or less, is to make the primary in sections and supply it from separate, well insulated sources.

In many of these experiments, when powerful effects are wanted for a short time, it is advantageous to use iron cores with the primaries. In such case a very large primary coil may be wound and placed side by side with the secondary, and, the nearest terminal of the latter being connected to the primary, a laminated iron core is introduced through the primary into the secondary as far as the streams will permit. Under these conditions an excessively powerful brush, several inches long, which may be appropriately called "St. Elmo's hot fire", may be caused to appear at the other terminal of the secondary, producing striking effects. It is a most powerful ozonizer, so powerful

11 Source: wikipedia

indeed, that only a few minutes are sufficient to fill the whole room with the smell of ozone, and it undoubtedly possesses the quality of exciting chemical affinities.

For the production of ozone, alternating currents of very high frequency are eminently suited, not only on account of the advantages they offer in the way of conversion but also because of the fact, that the ozonizing action of a discharge is dependent on the frequency as well as on the potential, this being undoubtedly confirmed by observation.

Then after the burning of Tesla's lab Thomas Commerford Martin writes in his article of April 1895, "Tesla's Oscillator and Other Inventions":

PART of Mr. Tesla's more recent work has been in the direction here indicated; for in his oscillator he has not simply a new practical device, but a new implement of scientific research. With the oscillator, if he has not as yet actually determined the earth's electrical charge or —capacity,— he has obtained striking effects which conclusively demonstrate that he has succeeded in disturbing it. He connects to the earth, by one of its ends, a coil (see Fig. 15) in which rapidly vibrating currents are produced, the other end being free in space. With this coil he does actually what one would be doing with a pump forcing air into an elastic football. At each alternate stroke the ball would expand and contract. But it is evident that such a ball, if filled with air, would, when suddenly expanded or contracted, vibrate at its own rate. Now if the strokes of the pump be so timed that they are in harmony with the individual vibrations of the ball, an intense vibration or surging will be obtained. The purple streamers electricity thus elicited from the earth and pouring out to the ambient air are marvellous.

This quote refers to a picture that Tesla shows in his pre-hearing interview of 1916 saying:

Apparatus in action illustrating the first step in the evolution of the magnifying transmitter in the laboratory at 35 South Fifth Avenue.

The first advance was made in ascertaining that the chemical activity of the discharge was very considerably increased by using currents of extremely high frequency or rate of vibration. This was an important improvement, but practical considerations soon set a definite limit to the progress in this direction. Next, the effects of the electrical pressure of the current impulses, of their wave-form and other characteristic features, were investigated. Then the influence of the atmospheric pressure and temperature and of the presence of water and other bodies was studied, and thus the best conditions for causing the most intense chemical action of the discharge and securing the highest efficiency of the process were gradually ascertained.

Naturally, the improvements were not quick in coming; still, little by little, I advanced. The flame grew larger and larger, and its oxidizing action grew more intense. From an insignificant brush-discharge a few inches long it developed into a marvellous electrical phenomenon, a roaring blaze, devouring the nitrogen of the atmosphere and measuring sixty or seventy feet¹² across. Thus slowly, almost imperceptibly, possibility became accomplishment. All is not yet done, by any means, but to what a degree my efforts have been rewarded an idea may be gained from an inspection of Fig. 1, which, with its title, is self explanatory. The flame-like discharge visible is produced by the intense electrical oscillations which pass through the coil shown, and violently agitate the electrified molecules of the air. By this means a strong affinity is created between the two normally indifferent constituents of the atmosphere, and they combine readily, even if no further provision is made for intensifying the chemical action of the discharge. In the manufacture of nitrogen compounds by this method, of course, every possible means bearing upon the intensity of this action and the efficiency of the process will be taken advantage of, and, besides, special arrangements will be provided for the fixation of the compounds formed, as they are generally unstable, the nitrogen becoming again inert after a little lapse of time. Steam is a simple and effective means for fixing permanently the compounds. The result illustrated makes it practicable to oxidise the atmospheric nitrogen in unlimited quantities, merely by the use of cheap mechanical power and simple electrical apparatus. In this manner many compounds of nitrogen may be manufactured all over the world, at a small cost, and in any desired amount, and by means of these compounds the soil can be fertilized and its productiveness indefinitely increased. An abundance of cheap and healthful food, not artificial, but such as we are accustomed to, may thus be obtained. This new and inexhaustible source of food-supply will be of incalculable benefit to mankind, for it will enormously contribute to the increase of the human mass, and thus add immensely to human energy. Soon, I hope, the world will see the beginning of an industry which, in time to come, will, I believe, be in importance next to that of iron.

Considering the fact that the coil in Fig. 1 consumed 200 KW or thereabout, this may not be as cheap as one might think. But Tesla is not talking about food, he is talking about energy production from an inexhaustible source. This would be the beginning of an industry which in importance is next to that of iron.

Although I do not think it is relevant, it is interesting to note that $\text{N}^+ \rightarrow \text{N} + \text{e}^- + 134 \text{ KJ/mol}$ and for example $\text{O} + \text{e}^- \rightarrow \text{O}^- + 141 \text{ KJ/mol}$. In other words there is energy in nitrogen ions.

12 60 ft = 18.29 m, 70 ft = 21.34 m

THE SECOND PROBLEM: HOW TO REDUCE THE FORCE RETARDING THE HUMAN MASS —THE ART OF TELAUTOMATICS.

As before stated, the force which retards the onward movement of man is partly frictional and partly negative. To illustrate this distinction I may name, for example, ignorance, stupidity, and imbecility as some of the purely frictional forces, or resistances devoid of any directive tendency. On the other hand, visionariness, insanity, self-destructive tendency, religious fanaticism, and the like, are all forces of a negative character, acting in definite directions. To reduce or entirely overcome these dissimilar retarding forces, radically different methods must be employed. One knows, for instance, what a fanatic may do, and one can take preventive measures, can enlighten, convince, and, possibly direct him, turn his vice into virtue; but one does not know, and never can know, what a brute or an imbecile may do, and one must deal with him as with a mass, inert, without mind, let loose by the mad elements. A negative force always implies some quality, not infrequently a high one, though badly directed, which it is possible to turn to good advantage; but a directionless, frictional force involves unavoidable loss. Evidently, then, the first and general answer to the above question is: turn all negative force in the right direction and reduce all frictional force.

After the introduction and first chapter we have now arrived at the second chapter dealing with retarding forces. There are two types, non-directable and wrongly directed forces. There is a parallel here with particles: neutral particles that can not be electrically 'motivated' and charged particles that can be directed.

There can be no doubt that, of all the frictional resistances, the one that most retards human movement is ignorance. Not without reason said that man of wisdom, Buddha: "Ignorance is the greatest evil in the world." The friction which results from ignorance, and which is greatly increased owing to the numerous languages and nationalities, can be reduced only by the spread of knowledge and the unification of the heterogeneous elements of humanity. No effort could be better spent. But however ignorance may have retarded the onward movement of man in times past, it is certain that, nowadays, negative forces have become of greater importance. Among these there is one of far greater moment than any other. It is called organized warfare. When we consider the millions of individuals, often the ablest in mind and body, the flower of humanity, who are compelled to a life of inactivity and unproductiveness, the immense sums of money daily required for the maintenance of armies and war apparatus, representing ever so much of human energy, all the effort uselessly spent in the production of arms and implements of destruction, the loss of life and the fostering of a barbarous spirit, we are appalled at the inestimable loss to mankind which the existence of these deplorable conditions must involve. What can we do to combat best this great evil?

Unification of heterogeneous elements (electrically motivate particles to move in the same direction) and stop war and all that is related to it. But what does war stand for?

Law and order absolutely require the maintenance of organized force. No community can exist and prosper without rigid discipline. Every country must be able to defend itself, should the necessity arise. The conditions of to-day are not the result of yesterday, and a radical change cannot be effected to-morrow. If the nations would at once disarm, it is more than likely that a state of things worse than war itself would follow. Universal peace is a beautiful dream, but not at once realizable. We have seen recently that even the noble effort of the man invested with the greatest worldly power has been virtually without effect. And no wonder, for the establishment of universal peace is, for the time being, a physical impossibility. War is a negative force, and cannot be turned in a positive direction without passing through, the intermediate phases. It is a problem of making a wheel, rotating one way, turn in the opposite direction without slowing it down, stopping it, and speeding it up again the other way.

As with many paragraphs in this article, the key-phrase is the last in a paragraph.

It has been argued that the perfection of guns of great destructive power will stop warfare. So I myself thought for a long time, but now I believe this to be a profound mistake. Such developments will greatly modify, but not arrest it. On the contrary, I think that every new arm that is invented, every new departure that is made in this direction, merely invites new talent and skill, engages new effort, offers new incentive, and so only gives a fresh impetus to further development. Think of the discovery of gun-powder. Can we conceive of any more radical departure than was effected by this innovation? Let us imagine ourselves living in that period: would we not have thought then that warfare was at an end, when the armour of the knight became an object of ridicule, when bodily strength and skill, meaning so much before, became of comparatively little value? Yet gunpowder did not stop warfare: quite the opposite—it acted as a most powerful incentive. Nor do I believe that warfare can ever be arrested by any scientific or ideal development, so long as similar conditions to those prevailing now exist, because war has itself become a science, and because war involves some of the most sacred sentiments of which man is capable. In fact, it is doubtful whether men who would not be ready to fight for a high principle would be good for anything at all. It is not the mind which makes man, nor is it the body; it is mind and body. Our virtues and our failings are inseparable, like force and matter.

When they separate, man is no more.

Again, the key-phrase is the last in this paragraph, but besides that, Tesla also emphasizes that war cannot be stopped by providing more powerful means. But again; what does war stand for?

Another argument, which carries considerable force, is frequently made, namely, that war must soon become impossible because the means of defence are outstripping the means of attack. This is only in accordance with a fundamental law which may be expressed by the statement that it is easier to destroy than to build. This law defines human capacities and human conditions. Were these such that it would be easier to build than to destroy, man would go on unresisted, creating and accumulating without limit. Such conditions are not of this earth. A being which could do this would not be a man: it might be a god. Defence will always have the advantage over attack, but this alone, it seems to me, can never stop war. By the use of new principles of defence we can render harbours impregnable against attack, but we cannot by such means prevent two warships meeting in battle on the high sea. And then, if we follow this idea to its ultimate development, we are led to the conclusion that it would be better for mankind if attack and defence were just oppositely related; for if every country, even the smallest, could surround itself with a wall absolutely impenetrable, and could defy the rest of the world, a state of things would surely be brought on which would be extremely unfavourable to human progress. It is by abolishing all the barriers which separate nations and countries that civilization is best furthered.

Taken literally, this sounds strange. It looks as if he compares defence to destruction and attack to building. But here lies the key to understanding this part. Defence stands for maintaining the status quo and thus it means to destroy the electric effect that we want to build (attack). Any electric effect is always met with resistance because otherwise its energy could increase indefinitely. War then, stands for our attempt to create a new (electrical) situation. The solution to which is not in more powerful means.

Again, it is contended by some that the advent of the flying-machine must bring on universal peace. This, too, I believe to be an entirely erroneous view. The flying-machine is certainly coming, and very soon, but the conditions will remain the same as before. In fact, I see no reason why a ruling power, like Great Britain, might not govern the air as well as the sea. Without wishing to put myself on record as a prophet, I do not hesitate to say that the next years will see the establishment of an "air-power," and its centre may be not far from New York. But, for all that, men will fight on merrily.

Again, the key-phrase is almost the last in this paragraph. And it is a beauty this time: "the next years will see the establishment of an "air-power," and its centre may be not far from New York." Tesla had started building Wardenclyffe not far from New York. Air-power, not air-force, will be established. Wardenclyffe was to become a power-plant to derive energy from air.

The ideal development of the war principle would ultimately lead to the transformation of the whole energy of war into purely potential, explosive energy, like that of an electrical condenser. In this form the war-energy could be maintained without effort; it would need to be much smaller in amount, while incomparably more effective.

A word about capacitors. They can store energy (measured in Joules) and release it in an incredible short time, thus at a tremendous rate (measured in Watts, but Tesla also uses HP). This is our means to create the desired effect.

As regards the security of a country against foreign invasion, it is interesting to note that it depends only on the relative, and not the absolute, number of the individuals or magnitude of the forces, and that, if every country should reduce the war-force in the same ratio, the security would remain unaltered. An international agreement with the object of reducing to a minimum the war-force which, in view of the present still imperfect education of the masses, is absolutely indispensable, would, therefore, seem to be the first rational step to take toward diminishing the force retarding human movement.

If we would need a very high voltage, we should try to keep the apparatus as small as possible. That way we need less energy and will be met with less resistance. In other words we should try to reach our desired effect on an as small as possible scale.

Fortunately, the existing conditions cannot continue indefinitely, for a new element is beginning to assert itself. A change for the better is eminent, and I shall now endeavour to show what, according to my ideas, will be the first advance toward the establishment of peaceful relations between nations, and by what means it will eventually be accomplished.

Let us go back to the early beginning, when the law of the stronger was the only law. The light of reason was not yet kindled, and the weak was entirely at the mercy of the strong. The weak individual then began to learn how to defend himself. He made use of a club, stone, spear, sling, or bow and arrow, and in the course of time, instead of physical strength, intelligence became the chief deciding factor in the battle. The wild character was gradually softened by the awakening of noble sentiments, and so, imperceptibly, after ages of

continued progress, we have come from the brutal fight of the unreasoning animal to what we call the "civilized warfare" of today, in which the combatants shake hands, talk in a friendly way, and smoke cigars in the entr'actes, ready to engage again in deadly conflict at a signal. Let pessimists say what they like, here is an absolute evidence of great and gratifying advance.

With electricity it is much the same. First we used "brute force" techniques but as our understanding increased, we started using more intelligent ways. Think for example of the brush-less motor and generators (invented by Tesla) and especially of the AC distribution network.

But now, what is the next phase in this evolution? Not peace as yet, by any means. The next change which should naturally follow from modern developments should be the continuous diminution of the number of individuals engaged in battle. The apparatus will be one of specifically great power, but only a few individuals will be required to operate it. This evolution will bring more and more into prominence a machine or mechanism with the fewest individuals as an element of warfare, and the absolutely unavoidable consequence of this will be the abandonment of large, clumsy, slowly moving, and unmanageable units. Greatest possible speed and maximum rate of energy-delivery by the war apparatus will be the main object. The loss of life will become smaller and smaller, and finally, the number of the individuals continuously diminishing, merely machines will meet in a contest without blood-shed, the nations being simply interested, ambitious spectators. When this happy condition is realized, peace will be assured. But, no matter to what degree of perfection rapid-fire guns, high-power cannon, explosive projectiles, torpedo-boats, or other implements of war may be brought, no matter how destructive they may be made, that condition can never be reached through any such development. All such implements require men for their operation; men are indispensable parts of the machinery. Their object is to kill and to destroy. Their power resides in their capacity for doing evil. So long as men meet in battle, there will be bloodshed. Bloodshed will ever keep up barbarous passion. To break this fierce spirit, a radical departure must be made, an entirely new principle must be introduced, something that never existed before in warfare—a principle which will forcibly, unavoidably, turn the battle into a mere spectacle, a play, a contest without loss of blood. To bring on this result men must be dispensed with: machine must fight machine. But how accomplish that which seems impossible? The answer is simple enough: produce a machine capable of acting as though it were part of a human being—no mere mechanical contrivance, comprising levers, screws, wheels, clutches, and nothing more, but a machine embodying a higher principle, which will enable it to perform its duties as though it had intelligence, experience, judgement, a mind! This conclusion is the result of my thoughts and observations which have extended through virtually my whole life, and I shall now briefly describe how I came to accomplish that which at first seemed an unrealisable dream.

We do not want the greatest power in an absolute sense but in a relative sense; the maximum *rate* of energy delivery. (See also "Rare Notes Oct 15th, 1901") Thus we need only few 'individuals'. That is why Tesla uses capacitors, to store energy and to release it in the shortest possible time. That way we need little energy (Joules) and get a lot of power (Watts). Also "machine must fight machine"; one machine must create electrical effects in another machine, as if it had a mind. That way we create an entirely new distribution system for electrical energy.

A long time ago, when I was a boy, I was afflicted with a singular trouble, which seems to have been due to an extraordinary excitability of the retina. It was the appearance of images which, by their persistence, marred the vision of real objects and interfered with thought. When a word was said to me, the image of the object which it designated would appear vividly before my eyes, and many times it was impossible for me to tell whether the object I saw was real or not. This caused me great discomfort and anxiety, and I tried hard to free myself of the spell. But for a long time I tried in vain, and it was not, as I clearly recollect, until I was about twelve years old that I succeeded for the first time, by an effort of the will, in banishing an image which presented itself. My happiness will never be as complete as it was then, but, unfortunately (as I thought at that time), the old trouble returned, and with it my anxiety. Here it was that the observations to which I refer began. I noted, namely, that whenever the image of an object appeared before my eyes I had seen something that reminded me of it. In the first instances I thought this to be purely accidental, but soon I convinced myself that it was not so. A visual impression, consciously or unconsciously received, invariably preceded the appearance of the image. Gradually the desire arose in me to find out, every time, what caused the images to appear, and the satisfaction of this desire soon became a necessity. The next observation I made was that, just as these images followed as a result of something I had seen, so also the thoughts which I conceived were suggested in like manner. Again, I experienced the same desire to locate the image which caused the thought, and this search for the original visual impression soon grew to be a second nature. My mind became automatic, as it were, and in the course of years of continued, almost unconscious performance, I acquired the ability of locating every time and, as a rule, instantly the visual impression which started the thought. Nor is this all. It was not long before I was aware that also all my movements were prompted in the same way, and so, searching, observing, and verifying continuously, year by year, I have, by every thought and every act of mine, demonstrated, and do so daily, to my absolute satisfaction, that I am an

automaton endowed with power of movement, which merely responds to external stimuli beating upon my sense organs, and thinks and acts and moves accordingly. I remember only one or two cases in all my life in which I was unable to locate the first impression which prompted a movement or a thought, or even a dream.

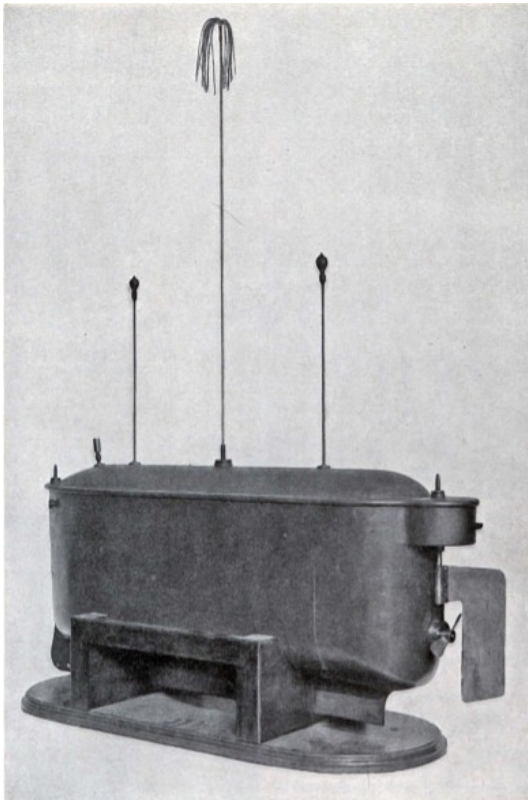


FIG. 2. THE FIRST PRACTICAL TELAUTOMATON.

A machine having all the bodily or translatory movements and the operations of the interior mechanism controlled from a distance without wires. The crewless boat shown in the photograph contains its own motive power, propelling and steering machinery, and numerous other accessories, all of which are controlled by transmitting from a distance, without wires, electrical oscillations to a circuit carried by the boat and adjusted to respond only to these oscillations.

With these experiences it was only natural that, long ago, I conceived the idea of constructing an automaton which would mechanically represent me, and which would respond, as I do myself, but, of course, in a much more primitive manner, to external influences. Such an automaton evidently had to have motive power, organs for locomotion, directive organs, and one or more sensitive organs so adapted as to be excited by external stimuli. This machine would, I reasoned, perform its movements in the manner of a living being, for it would have all the chief mechanical characteristics or elements of the same. There was still the capacity for growth, propagation, and, above all, the mind which would be wanting to make the model complete. But growth was not necessary in this case, since a machine could be manufactured full grown, so to speak. As to the capacity for propagation, it could likewise be left out of consideration, for in the mechanical model it merely signified a process of manufacture. Whether the automation be of flesh and bone, or of wood and steel, it mattered little, provided it could perform all the duties required of it like an intelligent being. To do so, it had to have an element corresponding to the mind, which would effect the control of all its movements and operations, and cause it to act, in any unforeseen case that might present itself, with knowledge, reason, judgement, and experience. But this element I could easily embody in it by conveying to it my own intelligence, my own understanding. So this invention was evolved, and so a new art came into existence, for which the name "telautomatics" has been suggested, which means the art of controlling the movements and operations of distant automatons. This principle evidently was applicable to any kind of machine that moves on land or in the water or in the air. In applying it practically for the first time, I selected a boat (see Fig. 2).

A storage battery placed within it furnished the motive power. The propeller, driven by a motor, represented the locomotive organs. The rudder, controlled by another motor likewise driven by the battery, took the place of the directive organs. As to the sensitive organ, obviously the first thought was to utilize a device responsive to rays of light, like a selenium cell, to represent the human eye. But upon closer inquiry I found that, owing to experimental and other difficulties, no thoroughly satisfactory control of the automaton could be effected by light, radiant heat, hertzian radiations, or by rays in general, that is, disturbances which pass in straight lines through space. One of the reasons was that any obstacle coming between the operator and the distant automaton would place it beyond his control. Another reason was that the sensitive device representing the eye would have to be in a definite position with respect to the distant controlling apparatus, and this necessity would impose great limitations in the control. Still another and very important reason was that, in using rays, it would be difficult, if not impossible, to give to the automaton individual features or characteristics distinguishing it from other machines of this kind. Evidently the automaton should respond only to an individual call, as a person responds to a name. Such considerations led me to conclude that the sensitive device of the machine should correspond to the ear rather than the eye of a human being, for in this case its actions could be controlled irrespective of intervening obstacles, regardless of its position relative to the distant controlling apparatus, and, last, but not least, it would remain deaf and unresponsive, like a faithful servant, to all calls but that of its master. These requirements made it imperative to use, in the control of the automaton, instead of light or other rays, waves or disturbances which propagate in all directions through space, like sound, or which follow a path of least resistance, however curved. I attained the result aimed at by means of an electric circuit placed within the boat, and adjusted, or "tuned," exactly to electrical vibrations of the proper kind transmitted to it from a distant "electrical oscillator." This circuit, in responding, however feebly, to the transmitted vibrations, affected magnets and other contrivances, through the medium of which were controlled the movements of the propeller and rudder, and also the operations of numerous other appliances.

In this very long, but interesting paragraph Tesla explains why he was experimenting with Telautomatics. The system he envisioned needed to be similar to a living organism, in the sense that it would need motive power, organs for locomotion, directive organs, one or more sensitive organs and a controlling organ; the mind. This system would be "the world system", Tesla would transform the Earth into a "living being". Tesla designed all these components, but in his time he could not build a "mind" as we can today using computers. For motive power Tesla designed his "self-acting machine". This power needed to be distributed, for which he designed a method to use the Earth as a single wire distribution system. Next you would desire to be able to send power to *specific* receivers, to demonstrate the solution to this problem Tesla built the first radio controlled boat. Tesla refers to this as "the art of individualization". The receivers are the sensitive organs. The only part missing, was the mind.

By the simple means described the knowledge, experience, judgement—the mind, so to speak—of the distant operator were embodied in that machine, which was thus enabled to move and to perform all its operations with reason and intelligence. It behaved just like a blindfolded person obeying directions received through the ear.

The automaton so far constructed had "borrowed minds," so to speak, as each merely formed part of the distant operator who conveyed to it his intelligent orders; but this art is only in the beginning. I purpose to show that, however impossible it may now seem, an automaton may be contrived which will have its "own mind," and by this I mean that it will be able, independent of any operator, left entirely to itself, to perform, in response to external influences affecting its sensitive organs, a great variety of acts and operations as if it had intelligence. It will be able to follow a course laid out or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do, and of making experiences or, otherwise stated, of recording impressions which will definitely affect its subsequent actions. In fact, I have already conceived such a plan.

Let's compare this to 1907-05-03: Tesla's Tidal Wave to Make War impossible

The telautomatic art is the result of endeavours to produce an automaton capable of moving and acting as if possessed of intelligence and distinct individuality. Disconnected from its higher embodiment, an organism, such as a human being, is a heat - or thermodynamic engine - comprising:- (1) a complete plant for receiving, transforming, and supplying energy; (2) apparatus for locomotion and other mechanical performance; (3) directive organs; and (4) sensitive instruments responsive to external influences, all these parts constituting a whole of marvellous perfection. The ambient medium is alive with movement and energy, in a state of unceasing agitation which is beyond comprehension.

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Its storage battery and motor furnished the power; the propeller and rudder, respectively, served as locomotive and directive organs, and a very delicate electrical device, actuated by a circuit tuned to a distant transmitter, took the place of the ear.

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The next step was to individualise the machine. The attunement of the controlling circuits gave it a special feature, but this was not sufficiently distinctive. An individuality implies a number of characteristic traits which, though perhaps extant elsewhere, are unique in that particular combination. Here again the animated automaton, with its nerve-signal system, was coarsely imitated. The action of the delicate device - the ear - was made dependent on a number of sensitised receiving circuits, each recognisable by its own free vibrations, and all together by the character of their operative combination. Correspondingly the transmitter was designed to emit a wave-complex exactly matching the combination in the number and pitch of individual vibrations, their groupment and order of succession.

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That much is done, but more is to come. A mechanism is being perfected which without operator in control, left to itself, will behave as if endowed with intelligence of its own. It will be responsive to the faintest external influences and from these, unaided, determine its subsequent actions as if possessed of selective qualities, logic, and reason. It will perform the duties of an intelligent slave. Many of us will live to see Bulwer's¹³ dream realised.

Tesla knew this was possible and it would necessarily come to be. Maybe he did not realise it would take so many years before the computer would be able to perform the functions he envisioned.

Although I evolved this invention many years ago and explained it to my visitors very frequently in my laboratory demonstrations, it was not until much later, long after I had perfected it, that it became known, when, naturally enough, it gave rise to much discussion and to sensational reports. But the true significance of this new art was not grasped by the majority, nor was the great force of the underlying principle

recognized. As nearly as I could judge from the numerous comments which appeared, the results I had obtained were considered as entirely impossible. Even the few who were disposed to admit the practicability of the invention saw in it merely an automobile torpedo, which was to be used for the purpose of blowing up battleships, with doubtful success. The general impression was that I contemplated simply the steering of such a vessel by means of Hertzian or other rays. There are torpedoes steered electrically by wires, and there are means of communicating without wires, and the above was, of course an obvious inference. Had I accomplished nothing more than this, I should have made a small advance indeed. But the art I have evolved does not contemplate merely the change of direction of a moving vessel; it affords means of absolutely controlling, in every respect, all the innumerable translatable movements, as well as the operations of all the internal organs, no matter how many, of an individualized automaton. Criticisms to the effect that the control of the automaton could be interfered with were made by people who do not even dream of the wonderful results which can be accomplished by use of electrical vibrations. The world moves slowly, and new truths are difficult to see. Certainly, by the use of this principle, an arm for attack as well as defence may be provided, of a destructiveness all the greater as the principle is applicable to submarine and aerial vessels. There is virtually no restriction as to the amount of explosive it can carry, or as to the distance at which it can strike, and failure is almost impossible. But the force of this new principle does not wholly reside in its destructiveness. Its advent introduces into warfare an element which never existed before—a fighting-machine without men as a means of attack and defence. The continuous development in this direction must ultimately make war a mere contest of machines without men and without loss of life—a condition which would have been impossible without this new departure, and which, in my opinion, must be reached as preliminary to permanent peace. The future will either bear out or disprove these views. My ideas on this subject have been put forth with deep conviction, but in a humble spirit.

People of his time only saw use of this invention as a torpedo in warfare. That is so typical. Here Tesla states that "it affords means of absolutely controlling, in every respect, all the innumerable translatable movements, as well as the operations of all the internal organs, no matter how many, of an individualized automaton." His world system could supply power and messages to every single specific receiver or group of receivers, and as soon as we would have computers (the "mind") the whole system could run without human interference.

The establishment of permanent peaceful relations between nations would most effectively reduce the force retarding the human mass, and would be the best solution of this great human problem. But will the dream of universal peace ever be realized? Let us hope that it will. When all darkness shall be dissipated by the light of science, when all nations shall be merged into one, and patriotism shall be identical with religion, when there shall be one language, one country, one end, then the dream will have become reality.

In 1907-10-25 "Tesla on Wireless" he elaborates a little on this art of individualization:

The underlying principle is to combine a number of vibrations, preferably slightly displaced, to reduce further the danger of interference, active and passive, and to make the operation of the receiver dependent on the co-operative effect of a number of attuned elements. Just to illustrate what can be done, suppose that only four vibrations were isolated on each transmitter. let those on one side be respectively a, b, c, and d. Then the following individualized lines would be ab, ac, ad, bc, bd, cd, abc, abd, acd, bcd and abcd.

THE THIRD PROBLEM: HOW TO INCREASE THE FORCE ACCELERATING THE HUMAN MASS —THE HARNESSING OF THE SUN'S ENERGY.

Of the three possible solutions of the main problem of increasing human energy, this is by far the most important to consider, not only because of its intrinsic significance, but also because of its intimate bearing on all the many elements and conditions which determine the movement of humanity. In order to proceed systematically, it would be necessary for me to dwell on all those considerations which have guided me from the outset in my efforts to arrive at a solution, and which have led me, step by step, to the results I shall now describe. As a preliminary study of the problem an analytical investigation, such as I have made, of the chief forces which determine the onward movement, would be of advantage, particularly in conveying an idea of that hypothetical "velocity" which, as explained in the beginning, is a measure of human energy; but to deal with this specifically here, as I would desire, would lead me far beyond the scope of the present subject. Suffice it to state that the resultant of all these forces is always in the direction of reason, which therefore, determines, at any time, the direction of human movement. This is to say that every effort which is scientifically applied, rational, useful, or practical, must be in the direction in which the mass is moving. The practical, rational man, the observer, the man of business, he who reasons, calculates, or determines in advance, carefully applies his effort so that when coming into effect it will be in the direction of the movement, making it thus most efficient, and in this knowledge and ability lies the secret of his success. Every new fact discovered, every new experience or new element added to our knowledge and entering into the domain of reason, affects the same and, therefore, changes the direction of movement, which, however, must always take place along the resultant of all those efforts which, at that time, we designate as reasonable, that is, self-preserving, useful, profitable, or practical. These efforts concern our daily life, our necessities and comforts, our work and business, and it is these which drive man onward.

[This last problem is obviously the most important, and Tesla starts out on a topic that looks like resonance. Also he states the importance of understanding that "hypothetical velocity", the voltage or temperature.](#)

But looking at all this busy world about us, on all this complex mass as it daily throbs and moves, what is it but an immense clock-work driven by a spring? In the morning, when we rise, we cannot fail to note that all the objects about us are manufactured by machinery: the water we use is lifted by steam-power; the trains bring our breakfast from distant localities; the elevators in our dwelling and our office building, the cars that carry us there, are all driven by power; in all our daily errands, and in our very life-pursuit, we depend upon it; all the objects we see tell us of it; and when we return to our machine-made dwelling at night, lest we should forget it, all the material comforts of our home, our cheering stove and lamp, remind us of how much we depend on power. And when there is an accidental stoppage of the machinery, when the city is snowbound, or the life sustaining movement otherwise temporarily arrested, we are affrightened to realize how impossible it would be for us to live the life we live without motive power. Motive power means work. To increase the force accelerating human movement means, therefore, to perform more work.

[This is the first mention of a clockwork driven by a spring. At this point it is not yet very clear what he means by this. In this paragraph everything around us, in fact us included, is the clockwork and motive power or energy is the spring. Both the natural world as the world that we have created require a constant supply of energy.](#)

So we find that the three possible solutions of the great problem of increasing human energy are answered by the three words: food, peace, work. Many a year I have thought and pondered, lost myself in speculations and theories, considering man as a mass moved by a force, viewing his inexplicable movement in the light of a mechanical one, and applying the simple principles of mechanics to the analysis of the same until I arrived at these solutions, only to realize that they were taught to me in my early childhood. These three words sound the key-notes of the Christian religion. Their scientific meaning and purpose now clear to me: food to increase the mass, peace to diminish the retarding force, and work to increase the force accelerating human movement. These are the only three solutions which are possible of that great problem, and all of them have one object, one end, namely, to increase human energy. When we recognize this, we cannot help wondering how profoundly wise and scientific and how immensely practical the Christian religion is, and in what a marked contrast it stands in this respect to other religions. It is unmistakably the result of practical experiment and scientific observation which have extended through the ages, while other religions seem to be the outcome of merely abstract reasoning. Work, untiring effort, useful and accumulative, with periods of rest and recuperation aiming at higher efficiency, is its chief and ever-recurring command. Thus we are inspired both by Christianity and Science to do our utmost toward increasing the performance of mankind. This most important of human problems I shall now specifically consider.

["Work with periods of rest", "carefully applied so that it will be in the direction of the movement". This clearly refers to resonant action.](#)

THE SOURCE OF HUMAN ENERGY

—THE THREE WAYS OF DRAWING ENERGY FROM THE SUN.

First let us ask: Whence comes all the motive power? What is the spring that drives all? We see the ocean rise and fall, the rivers flow, the wind, rain, hail, and snow beat on our windows, the trains and steamers come and go; we hear the rattling noise of carriages, the voices from the street; we feel, smell, and taste; and we think of all this. And all this movement, from the surging of the mighty ocean to that subtle movement concerned in our thought, has but one common cause. All this energy emanates from one single centre, one single source—the sun. The sun is the spring that drives all. The sun maintains all human life and supplies all human energy. Another answer we have now found to the above great question: To increase the force accelerating human movement means to turn to the uses of man more of the sun's energy. We honour and revere those great men of bygone times whose names are linked with immortal achievements, who have proved themselves benefactors of humanity—the religious reformer with his wise maxims of life, the philosopher with his deep truths, the mathematician with his formulæ, the physicist with his laws, the discoverer with his principles and secrets wrested from nature, the artist with his forms of the beautiful; but who honours him, the greatest of all,—who can tell the name of him,—who first turned to use the sun's energy to save the effort of a weak fellow-creature? That was man's first act of scientific philanthropy, and its consequences have been incalculable.

The Sun is the source of all our energy, so to get more energy we have to look at our Sun and find a means to draw more energy from it. Referring back to Tesla's article of 1932-10-13: "The Eternal Source of Energy of the Universe, Origin and Intensity of Cosmic Rays", where Tesla also speaks about a clockwork driven by a spring, we read that it is not just our Sun, but all stars in the universe that emit vast amounts of energy. Cosmic rays (PCR) are a constant source of energy, day and night.

From the very beginning three ways of drawing energy from the sun were open to man. The savage, when he warmed his frozen limbs at a fire kindled in some way, availed himself of the energy of the sun stored in the burning material. When he carried a bundle of branches to his cave and burned them there, he made use of the sun's stored energy transported from one to another locality. When he set sail to his canoe, he utilized the energy of the sun applied to the atmosphere or the ambient medium. There can be no doubt that the first is the oldest way. A fire, found accidentally, taught the savage to appreciate its beneficial heat. He then very likely conceived of the idea of carrying the glowing members to his abode. Finally he learned to use the force of a swift current of water or air. It is characteristic of modern development that progress has been effected in the same order. The utilization of the energy stored in wood or coal, or, generally speaking, fuel, led to the steam-engine. Next a great stride in advance was made in energy-transportation by the use of electricity, which permitted the transfer of energy from one locality to another without transporting the material. But as to the utilization of the energy of the ambient medium, no radical step forward has as yet been made known.

The three ways to obtain energy; using material in which energy is stored, transporting energy or using the energy present in our surrounding medium.

The ultimate results of development in these three directions are: first, the burning of coal by a cold process in a battery; second, the efficient utilization of the energy of the ambient medium; and, third the transmission without wires of electrical energy to any distance. In whatever way these results may be arrived at, their practical application will necessarily involve an extensive use of iron, and this invaluable metal will undoubtedly be an essential element in the further development along these three lines. If we succeed in burning coal by a cold process and thus obtain electrical energy in an efficient and inexpensive manner, we shall require in many practical uses of this energy electric motors—that is, iron. If we are successful in deriving energy from the ambient medium, we shall need, both in the obtainment and utilization of the energy, machinery—again, iron. If we realize the transmission of electrical energy without wires on an industrial scale, we shall be compelled to use extensively electric generators—once more, iron. Whatever we may do, iron will probably be the chief means of accomplishment in the near future, possibly more so than in the past. How long its reign will last is difficult to tell, for even now aluminium is looming up as a threatening competitor. But for the time being, next to providing new resources of energy, it is of the greatest importance to making improvements in the manufacture and utilization of iron. Great advances are possible in these latter directions, which, if brought about, would enormously increase the useful performance of mankind.

Note that the ultimate results number 2 and 3 are goals of the Wardencllyffe project. Compare the last sentence to this paragraph a few pages earlier to find the food-energy "code":

But for the time being, next to providing new resources of energy, it is of the greatest importance to making improvements in the manufacture and utilization of iron. Great advances are possible in these latter directions, which, if brought about, would enormously increase the useful performance of mankind.	This new and inexhaustible source of food-supply will be of incalculable benefit to mankind, for it will enormously contribute to the increase of the human mass, and thus add immensely to human energy. Soon, I hope, the world will see the beginning of an industry which, in time to come, will, I believe, be in importance next to that of iron.
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GREAT POSSIBILITIES OFFERED BY IRON FOR INCREASING HUMAN PERFORMANCE —ENORMOUS WASTE IN IRON MANUFACTURE.

Iron is by far the most important factor in modern progress. It contributes more than any other industrial product to the force accelerating human movement. So general is the use of this metal, and so intimately is it connected with all that concerns our life, that it has become as indispensable to us as the very air we breathe. Its name is synonymous with usefulness. But, however great the influence of iron may be on the present human development, it does not add to the force urging man onward nearly as much as it might. First of all, its manufacture as now carried on is connected with an appalling waste of fuel—that is, waste of energy. Then, again, only a part of all the iron produced is applied for useful purposes. A good part of it goes to create frictional resistances, while still another large part is the means of developing negative forces greatly retarding human movement. Thus the negative force of war is almost wholly represented in iron. It is impossible to estimate with any degree of accuracy the magnitude of this greatest of all retarding forces, but it is certainly very considerable. If the present positive impelling force due to all useful applications of iron be represented by ten, for instance, I should not think it exaggeration to estimate the negative force of war, with due consideration of all its retarding influences and results, at, say, six. On the basis of this estimate the effective impelling force of iron in the positive direction would be measured by the difference of these two numbers, which is four. But if, through the establishment of universal peace, the manufacture of war machinery should cease, and all struggle for supremacy between nations should be turned into healthful, ever active and productive commercial competition, then the positive impelling force due to iron would be measured by the sum of those two, numbers, which is sixteen—that is, this force would have four times its present value. This example is, of course, merely intended to give an idea of the immense increase in the useful performance of mankind which would result from a radical reform of the iron industries supplying the implements of warfare.

Iron now stands for electricity and this chapter is particularly interesting because Tesla gives us the general overview of his system. But first he mentions that we are wasting most of the energy that we have at our disposal. We should create the desired effects in a much more efficient way.

A similar inestimable advantage in the saving of energy available to man would be secured by obviating the great waste of coal which is inseparably connected with the present methods of manufacturing iron. In some countries, such as Great Britain, the hurtful effects of this squandering of fuel are beginning to be felt. The price of coal is constantly rising, and the poor are made to suffer more and more. Though we are still far from the dreaded "exhaustion of the coal-fields," philanthropy commands us to invent novel methods of manufacturing iron, which will not involve such barbarous waste of this valuable material from which we derive at present most of our energy. It is our duty to coming generations to leave this store of energy intact for them, or at least not to touch it until we shall have perfected processes for burning coal more efficiently. Those who are coming after us will need fuel more than we do. We should be able to manufacture the iron we require by using the sun's energy, without wasting any coal at all. As an effort to this end the idea of smelting iron ores by electric currents obtained from the energy of falling water has naturally suggested itself to many. I have myself spent much time in endeavouring to evolve such a practical process, which would enable iron to be manufactured at small cost. After a prolonged investigation of the subject, finding that it was unprofitable to use the currents generated directly for smelting the ore, I devised a method which is far more economical.

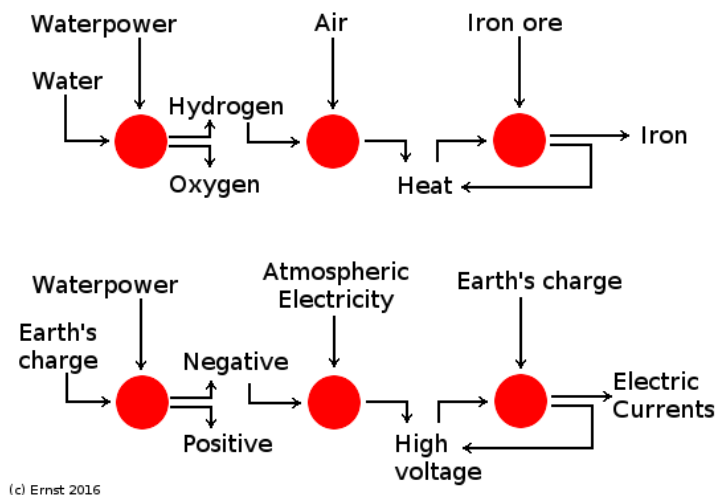
Note: "We should be able to manufacture the iron we require by using the sun's energy, without wasting any coal at all." That is what this article is all about; we should derive our electricity from the medium without burning fuel.

ECONOMICAL PRODUCTION OF IRON BY A NEW PROCESS.

The industrial project, as I worked it out six years ago, contemplated the employment of the electric currents derived from the energy of a waterfall, not directly for smelting the ore, but for decomposing water for a preliminary step. To lessen the cost of the plant, I proposed to generate the currents in exceptionally cheap and simple dynamos, which I designed for this sole purpose. The hydrogen liberated in the electrolytic decomposition was to be burned or recombined with oxygen, not with that from which it was separated, but with that of the atmosphere. Thus very nearly the total electrical energy used up in the decomposition of the water would be recovered in the form of heat resulting from the recombination of the hydrogen. This heat was to be applied to the smelting of ore. The oxygen gained as a by-product of the decomposition of the water I intended to use for certain other industrial purposes, which would probably yield good financial returns, inasmuch as this is the cheapest way of obtaining this gas in large quantities. In any event, it could be employed to burn all kinds of refuse, cheap hydrocarbon, or coal of the most inferior quality which could not be burned in air or be otherwise utilized to advantage, and thus again a considerable amount of heat would be made available for the smelting of the ore. To increase the economy of the process I contemplated, furthermore, using an arrangement such that the hot metal and the products of combustion, coming out of

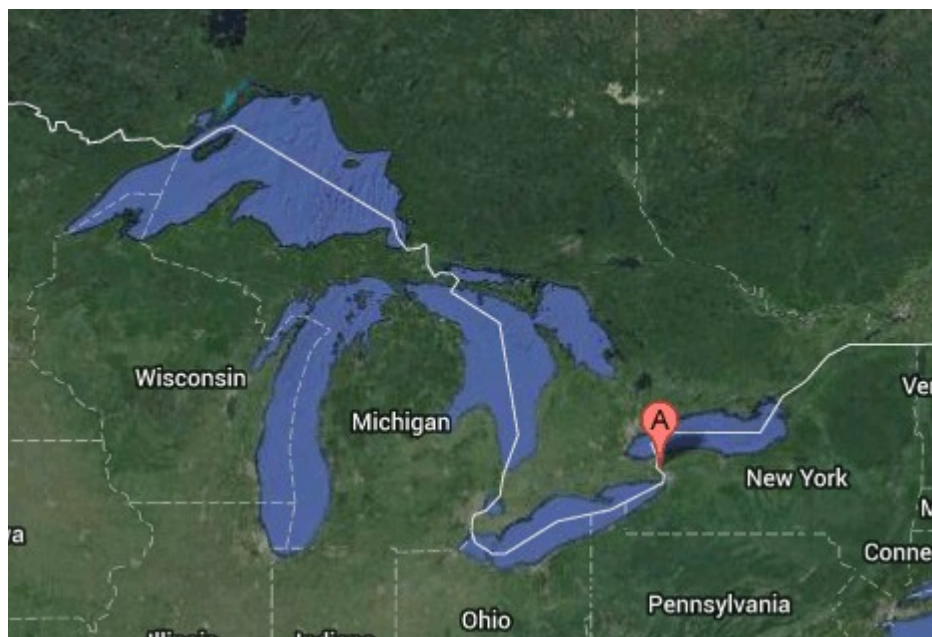
the furnace, would give up their heat upon the cold ore going into the furnace, so that comparatively little of the heat energy would be lost in the smelting. I calculated that probably forty thousand pounds of iron could be produced per horse-power per annum by this method. Liberal allowances were made for those losses which are unavoidable, the above quantity being about half of that theoretically obtainable. Relying on this estimate and on practical data with reference to a certain kind of sand ore existing in abundance in the region of the Great Lakes, including cost of transportation and labour, I found that in some localities iron could be manufactured in this manner cheaper than by any of the adopted methods. This result would be obtained all the more surely if the oxygen obtained from the water, instead of being used for smelting of ore, as assumed, should be more profitably employed. Any new demand for this gas would secure a higher revenue from the plant, thus cheapening the iron. This project was advanced merely in the interest of industry. Some day, I hope, a beautiful industrial butterfly will come out of the dusty and shrivelled chrysalis.

First notice the last sentence. This clearly indicates that Tesla was anticipating that he could not complete this during his days. He worked out the details and passed them on to a future 'discoverer'. Anyway, here we have the outline of his process:



We already know that iron stands for electricity but the other components are uncertain at this point. It is interesting to note that the self-acting machine seems to use cold instead of heat and in explaining that device Tesla also refers to splitting water into hydrogen and oxygen.

Next he says: “--- a certain kind of sand ore existing in abundance in the region of the Great Lakes ---”. Let me get a map¹⁴ of that area:



The marker “A” is set at the Niagara Falls where Tesla’s design for a water power plant was implemented. If iron stands for electricity, then iron-ore would be a source of electricity. But the ‘sand ore’ (water power) is not the ‘iron ore’ of the diagram. This iron ore is Earth electricity as will become more apparent later on.

The production of iron from sand ores by a process of magnetic separation is highly commendable in principle, since it involves no waste of coal; but the usefulness of this method is largely reduced by the necessity of melting the iron afterwards. As to the crushing of iron ore, I would consider it rational only if done by water-power, or by energy otherwise obtained without consumption of fuel. An electrolytic cold process, which would make it possible to extract iron cheaply, and also to mould it into the required forms without any fuel consumption, would, in my opinion, be a very great advance in iron manufacture. In common with some other metals, iron has so far resisted electrolytic treatment, but there can be no doubt that such a cold process will ultimately replace in metallurgy the present crude method of casting, and thus obviating the enormous waste of fuel necessitated by the repeated heating of metal in the foundries.

["The production of iron from sand ores by a process of magnetic separation", translates to "the production of electricity from water power by \(magnetic\) generators". After being generated it has to be transformed up for distribution and down to the required voltage for usage \(hence repeated melting\). Notice how Tesla mentions time and time again that energy must be obtained without burning of fuels, and also how he often describes waste as 'barbarous'. \(BTW., a 'radical departure' is also a common phrase\)](#)

Up to a few decades ago the usefulness of iron was based almost wholly on its remarkable mechanical properties, but since the advent of the commercial dynamo and electric motor its value to mankind has been greatly increased by its unique magnetic qualities. As regards the latter, iron has been greatly improved of late. The signal progress began about thirteen years ago, when I discovered that in using soft Bessemer steel instead of wrought iron, as then customary, in an alternating motor, the performance of the machine was doubled. I brought this fact to the attention of Mr. Albert Schmid, to whose untiring efforts and ability is largely due the supremacy of American electrical machinery, and who was then superintendent of an industrial corporation engaged in this field. Following my suggestion, he constructed transformers of steel, and they showed the same marked improvement. The investigation was then systematically continued under Mr. Schmid's guidance, the impurities being gradually eliminated from the "steel" (which was only such in name, for in reality it was pure soft iron), and soon a product resulted which admitted of little further improvement.

THE COMING AGE OF ALUMINIUM

—DOOM OF THE COPPER INDUSTRY—THE GREAT CIVILIZING POTENCY OF THE NEW METAL.

[What do Iron, Copper and Aluminium stand for? We know from the previous section that Iron stands for electric currents, we will see that all metals do. They are currents with different characteristics.](#)

With the advances made in iron of late years we have arrived virtually at the limits of improvement. We cannot hope to increase very materially its tensile strength, elasticity, hardness, or malleability, nor can we expect to make it much better as regards its magnetic qualities. More recently a notable gain was secured by the mixture of a small percentage of nickel with the iron, but there is not much room for further advance in this direction. New discoveries may be expected, but they cannot greatly add to the valuable properties of the metal, though they may considerably reduce the cost of manufacture. The immediate future of iron is assured by its cheapness and its unrivalled mechanical and magnetic qualities. These are such that no other product can compete with it now. But there can be no doubt that, at a time not very distant, iron, in many of its now uncontested domains, will have to pass the sceptre to another: the coming age will be the age of aluminium. It is only seventy years since this wonderful metal was discovered by Woehler, and the aluminium industry, scarcely forty years old, commands already the attention of the entire world. Such rapid growth has not been recorded in the history of civilization before. Not long ago aluminium was sold at the fanciful price of thirty or forty dollars per pound; today it can be had in any desired amount for as many cents. What is more, the time is not far off when this price, too, will be considered fanciful, for great improvements are possible in the methods of its manufacture. Most of the metal is now produced in the electric furnace by a process combining fusion and electrolysis, which offers a number of advantageous features, but involves naturally a great waste of the electrical energy of the current. My estimates show that the price of aluminium could be considerably reduced by adopting in its manufacture a method similar to that proposed by me for the production of iron. A pound of aluminium requires for fusion only about seventy per cent of the heat needed for melting a pound of iron, and inasmuch as its weight is only about one third of that of the latter, a volume of aluminium four times that of iron could be obtained from a given amount of heat-energy. But a cold electrolytic process of manufacture is the ideal solution, and on this I have placed my hope.

[The magnetic properties and transformation of voltage are mentioned here. Attention is drawn to aluminium...](#)

The absolutely unavoidable consequence of the advancement of the aluminium industry will be the annihilation of the copper industry. They cannot exist and prosper together, and the latter is doomed beyond any hope of recovery. Even now it is cheaper to convey an electric current through aluminium wires than through copper wires; aluminium castings cost less, and in many domestic and other uses copper has no chance of successfully competing. A further material reduction of the price of aluminium cannot but be fatal to

copper. But the progress of the former will not go on unchecked, for, as it ever happens in such cases, the larger industry will absorb the smaller one: the giant copper interests will control the pygmy aluminium interests, and the slow-pacing copper will reduce the lively gait of aluminium. This will only delay, not avoid the impending catastrophe.

Aluminium is cheaper for conveying electric energy. Copper is called slow-pacing and aluminium has a lively gait....

Aluminium, however, will not stop at downing copper. Before many years have passed it will be engaged in a fierce struggle with iron, and in the latter it will find an adversary not easy to conquer. The issue of the contest will largely depend on whether iron shall be indispensable in electric machinery. This the future alone can decide. The magnetism as exhibited in iron is an isolated phenomenon in nature. What it is that makes this metal behave so radically different from all other materials in this respect has not yet been ascertained, though many theories have been suggested. As regards magnetism, the molecules of the various bodies behave like hollow beams partly filled with a heavy fluid and balanced in the middle in the manner of a see-saw. Evidently some disturbing influence exists in nature which causes each molecule, like such a beam, to tilt either one or the other way. If the molecules are tilted one way, the body is magnetic; if they are tilted the other way, the body is non-magnetic; but both positions are stable, as they would be in the case of the hollow beam, owing to the rush of the fluid to the lower end. Now, the wonderful thing is that the molecules of all known bodies went one way, while those of iron went the other way. This metal, it would seem, has an origin entirely different from that of the rest of the globe. It is highly improbable that we shall discover some other and cheaper material which will equal or surpass iron in magnetic qualities.

Can we use aluminium in our electric machinery? Notice the next sentence.

Unless we should make a radical departure in the character of the electric currents employed, iron will be indispensable. Yet the advantages it offers are only apparent. So long as we use feeble magnetic forces it is by far superior to any other material; but if we find ways of producing great magnetic forces, than better results will be obtainable without it. In fact, I have already produced electric transformers in which no iron is employed, and which are capable of performing ten times as much work per pound of weight as those of iron. This result is attained by using electric currents of a very high rate of vibration, produced in novel ways, instead of the ordinary currents now employed in the industries. I have also succeeded in operating electric motors without iron by such rapidly vibrating currents, but the results, so far, have been inferior to those obtained with ordinary motors constructed of iron, although theoretically the former should be capable of performing incomparably more work per unit of weight than the latter. But the seemingly insuperable difficulties which are now in the way may be overcome in the end, and then iron will be done away with, and all electric machinery will be manufactured of aluminium, in all probability, at prices ridiculously low. This would be a severe, if not fatal, blow to iron. In many other branches of industry, as ship-building, or wherever lightness of structure is required, the progress of the new metal will be much quicker. For such uses it is eminently suitable, and is sure to supersede iron sooner or later. It is highly probable that in the course of time we shall be able to give it many of those qualities which make iron so valuable.

Now we learn that in Tesla's opinion the future belongs to high frequency currents and aluminium. So copper may stand for low frequency alternating currents and aluminium for high frequency.

While it is impossible to tell when this industrial revolution will be consummated, there can be no doubt that the future belongs to aluminium, and that in times to come it will be the chief means of increasing human performance. It has in this respect capacities greater by far than those of any other metal. I should estimate its civilizing potency at fully one hundred times that of iron. This estimate, though it may astonish, is not at all exaggerated. First of all, we must remember that there is thirty times as much aluminium as iron in bulk, available for the uses of man. This in itself offers great possibilities. Then, again, the new metal is much more easily workable, which adds to its value. In many of its properties it partakes of the character of a precious metal, which gives it additional worth. Its electric conductivity, which, for a given weight, is greater than that of any other metal, would be alone sufficient to make it one of the most important factors in future human progress. Its extreme lightness makes it far more easy to transport the objects manufactured. By virtue of this property it will revolutionize naval construction, and in facilitating transport and travel it will add enormously to the useful performance of mankind. But its greatest civilizing property will be, I believe, in aerial travel, which is sure to be brought about by means of it. Telegraphic instruments will slowly enlighten the barbarian. Electric motors and lamps will do it more quickly, but quicker than anything else the flying-machine will do it. By rendering travel ideally easy it will be the best means for unifying the heterogeneous elements of humanity. As the first step toward this realization we should produce a lighter storage-battery or get more energy from coal.

EFFORTS TOWARD OBTAINING MORE ENERGY FROM COAL

—THE ELECTRIC TRANSMISSION—THE GAS-ENGINE—THE COLD-COAL BATTERY.

I remember that at one time I considered the production of electricity by burning coal in a battery as the greatest achievement toward the advancing civilization, and I am surprised to find how much the continuous study of these subjects has modified my views. It now seems to me that to burn coal, however efficiently, in a battery would be a mere makeshift, a phase in the evolution toward something much more perfect. After all, in generating electricity in this manner, we should be destroying material, and this would be a barbarous process. We ought to be able to obtain the energy we need without consumption of material. But I am far from underrating the value of such an efficient method of burning fuel. At the present time most motive power comes from coal, and, either directly or by its products, it adds vastly to human energy. Unfortunately, in all the process now adopted, the larger portion of the energy of the coal is uselessly dissipated. The best steam-engines utilize only a small part of the total energy. Even in gas-engines, in which, particularly of late, better results are obtainable, there is still a barbarous waste going on. In our electric-lighting systems we scarcely utilize one third of one per cent., and in lighting by gas a much smaller fraction, of the total energy of the coal. Considering the various uses of coal throughout the world, we certainly do not utilize more than two per cent of its energy theoretically available. The man who should stop this senseless waste would be a great benefactor of humanity, though the solution he would offer could not be a permanent one, since it would ultimately lead to the exhaustion of the store of material. Efforts toward obtaining more energy from coal are now being made chiefly in two directions—by generating electricity and by producing gas for motive-power purposes. In both of these lines notable success has already been achieved.

This first part, Tesla said before, the rest is about our 'barbarous waste of energy'.

It now seems to me that to burn coal, however efficiently, in a battery would be a mere makeshift, a phase in the evolution toward something much more perfect. After all, in generating electricity in this manner, we should be destroying material, and this would be a barbarous process. We ought to be able to obtain the energy we need without consumption of material.

1896-12-23: Mr. Tesla on Thermo Electricity

Even if we could, by combining carbon in a battery, convert the work of the chemical combination into electrical energy with very high economy, such mode of obtaining power would, in my opinion, be no more than a mere makeshift, bound to be replaced sooner or later by a more perfect method, which implies no consumption of any material whatever.

The advent of the alternating-current system of electric power-transmission marks an epoch in the economy of energy available to man from coal. Evidently all electrical energy obtained from a waterfall, saving so much fuel, is a net gain to mankind, which is all the more effective as it is secured with little expenditure of human effort, and as this most perfect of all known methods of deriving energy from the sun contributes in many ways to the advancement of civilization. But electricity enables us also to get from coal much more energy than was practicable in the old ways. Instead of transporting the coal to distant places of consumption, we burn it near the mine, develop electricity in the dynamos, and transmit the current to remote localities, thus effecting a considerable saving. Instead of driving the machinery in a factory in the old wasteful way of belts and shafting, we generate electricity by steam-power and operate electric motors. In this manner it is not uncommon to obtain two or three times as much effective motive power from the fuel, besides securing many other important advantages. It is in this field as much as in the transmission of energy to great distance that the alternating system, with its ideally simple machinery, is bringing about an industrial revolution. But in many lines this progress has not been yet fully felt. For example, steamers and trains are still being propelled by the direct application of steam-power to shafts or axles. A much greater percentage of the heat-energy of the fuel could be transformed into motive energy by using, in place of the adopted marine engines and locomotives, dynamos driven by specially designed high-pressure steam- or gas-engines and by utilizing the electricity generated for the propulsion. A gain of fifty to one hundred per cent in the effective energy derived from the coal could be secured in this manner. It is difficult to understand why a fact so plain and obvious is not receiving more attention from engineers. In ocean steamers such an improvement would be particularly desirable, as it would do away with noise and increase materially the speed and the carrying capacity of the liners.

The question would then be: "how do we transport electrical power to boats, airplanes etc.?"

Still more energy is now being obtained from coal by the latest improved gas-engine, the economy of which is, on the average, probably twice that of the best steam-engine. The introduction of the gas-engine is very much facilitated by the importance of the gas industry. With the increasing use of the electric light more and more of the gas is utilized for heating and motive-power purposes. In many instances gas is manufactured close to the coal-mine and conveyed to distant places of consumption, a considerable saving both in cost of transportation and in utilization of the energy of the fuel being thus effected. In the present state of the mechanical and electrical arts the most rational way of deriving energy from coal is evidently to manufacture gas close to the coal store, and to utilize it, either on the spot or elsewhere, to generate electricity for industrial uses in dynamos driven by gas engines. The commercial success of such a plant is largely dependent upon the production of gas-engines of great nominal horse-power, which, judging from the keen

activity in this field will soon be forthcoming. Instead of consuming coal directly, as usual, gas should be manufactured from it and burned to economize energy.

A parallel is drawn here between gas and electricity...

But all such improvements cannot be more than passing phases in the evolution toward something far more perfect, for ultimately we must succeed in obtaining electricity from coal in a more direct way, involving no great loss of heat-energy. Whether coal can be oxidized by a cold process is still a question. Its combination with oxygen always involves heat, and whether the energy of the combination of the carbon with another element can be turned directly into electrical energy has not yet been determined. Under certain conditions nitric acid will burn the carbon, generating an electric current, but the solution does not remain cold. Other means of oxidizing coal have been proposed, but they have offered no promise of leading to an efficient process. My own lack of success has been complete, though perhaps not quite so complete as that of some who have "perfected" the cold-coal battery. This problem is essentially one for the chemist to solve. It is not for the physicist, who determines all his results in advance, so that, when the experiment is tried, it cannot fail. Chemistry, though a positive science, does not yet admit of a solution by such positive methods as those which are available in the treatment of many physical problems. The result, if possible, will be arrived at through patient trying rather than through deduction or calculation. The time will soon come, however, when the chemist will be able to follow a course clearly mapped out beforehand, and when the process of his arriving at a desired result will be purely constructive. The cold-coal battery would give a great impetus to electrical development; it would lead very shortly to a practical flying-machine, and would enormously enhance the introduction of the automobile. But these and many other problems will be better solved, and in a more scientific manner, by a light storage battery.

In short, a light weight storage battery is to be preferred over the cold-coal battery. But how will we charge this storage-battery?

ENERGY FROM THE MEDIUM

—THE WINDMILL AND THE SOLAR ENGINE,—MOTIVE POWER FROM TERRESTRIAL HEAT— ELECTRICITY FROM NATURAL SOURCES.

Besides fuel, there is abundant material from which we might eventually derive power. An immense amount of energy is locked up in limestone, for instance, and machines can be driven by liberating the carbonic acid through sulphuric acid or otherwise. I once constructed such an engine, and it operated satisfactorily.

But, whatever our resources of primary energy may be in the future, we must, to be rational, obtain it without consumption of any material. Long ago I came to this conclusion, and to arrive at this result only two ways, as before indicated, appeared possible—either to turn to use the energy of the sun stored in the ambient medium, or to transmit, through the medium, the sun's energy to distant places from some locality where it was obtainable without consumption of material. At that time I at once rejected the latter method as entirely impracticable, and turned to examine the possibilities of the former.

Three ways were before indicated: using material in which energy is stored, transporting energy or using the energy present in our surrounding medium. The first option implies burning fuel, which is not what we want so that leaves us with two options. Compare this to the article of November 30th, 1898 "Tesla Describes his Efforts in Various Fields of Work":

Long ago I came to this conclusion, and to arrive at this result only two ways, as before indicated, appeared possible—either to turn to use the energy of the sun stored in the ambient medium, or to transmit, through the medium, the sun's energy to distant places from some locality where it was obtainable without consumption of material. At that time I at once rejected the latter method as entirely impracticable, and turned to examine the possibilities of the former.

In assailing the problem I found two possible ways of solving it. Either power was to be developed on the spot by converting the energy of the sun's radiations or the energy of vast reservoirs was to be transmitted economically to any distance. Though there were other possible sources of economical power, only the two solutions mentioned offer the ideal feature of power being obtained without any consumption of material. After long thought I finally arrived at two solutions, but on the first of these, namely, that referring to the development of power in any locality from the sun's radiations, I can not dwell at present.

So, initially Tesla did not believe that transmission of energy to any distance would be possible, yet later, while examining the possibilities of obtaining energy from the medium, he learned that it could be done. This exact moment can be traced in his Colorado Springs Notes to July 3rd, 1899 and in a number of articles like this one in the "Electrical World and Engineer" or 1904-03-05; "The Transmission of Electrical Energy Without Wires "

It was on the third of July—the date I shall never forget—when I obtained the first decisive experimental evidence of a truth of overwhelming importance for the advancement of humanity. A dense mass of strongly charged clouds gathered in the west and towards the evening a violent storm broke loose which, after spending much of its fury in the mountains, was driven away with

great velocity over the plains. Heavy and long persisting arcs formed almost in regular time intervals. My observations were now greatly facilitated and rendered more accurate by the experiences already gained. I was able to handle my instruments quickly and I was prepared. The recording apparatus being properly adjusted, its indications became fainter and fainter with the increasing distance of the storm, until they ceased altogether. I was watching in eager expectation. Surely enough, in a little while the indications again began, grew stronger and stronger and, after passing through a maximum, gradually decreased and ceased once more. Many times, in regularly recurring intervals, the same actions were repeated until the storm which, as evident from simple computations, was moving with nearly constant speed, had retreated to a distance of about three hundred kilometres. Nor did these strange actions stop then, but continued to manifest themselves with undiminished force. Subsequently, similar observations were also made by my assistant, Mr. Fritz Lowenstein, and shortly afterwards several admirable opportunities presented themselves which brought out, still more forcibly, and unmistakably, the true nature of the wonderful phenomenon. No doubt, whatever remained: I was observing stationary waves.

As the source of disturbances moved away the receiving circuit came successively upon their nodes and loops. Impossible as it seemed, this planet, despite its vast extent, behaved like a conductor of limited dimensions. The tremendous significance of this fact in the transmission of energy by my system had already become quite clear to me. Not only was it practicable to send telegraphic messages to any distance without wires, as I recognized long ago, but also to impress upon the entire globe the faint modulations of the human voice, far more still, to transmit power, in unlimited amounts, to any terrestrial distance and almost without loss.

[And later in the same magazine of 1905-01-07: "The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace"](#)

Over five years have elapsed since that providential lightning storm on the 3rd of July, 1899, of which I told in the article before mentioned, and through which I discovered the terrestrial stationary waves; nearly five years since I performed the great experiment which on that unforgettable day, the dark God of Thunder mercifully showed me in his vast, awe-sounding laboratory. I thought then that it would take a year to establish commercially my wireless girdle around the world.

It is difficult to believe, but it is, nevertheless, a fact, that since time immemorial man has had at his disposal a fairly good machine which has enabled him to utilize the energy of the ambient medium. This machine is the windmill. Contrary to popular belief, the power obtainable from wind is very considerable. Many a deluded inventor has spent years of his life in endeavouring to "harness the tides," and some have even proposed to compress air by tide- or wave-power for supplying energy, never understanding the signs of the old windmill on the hill, as it sorrowfully waved its arms about and bade them stop. The fact is that a wave- or tide-motor would have, as a rule, but a small chance of competing commercially with the windmill, which is by far the better machine, allowing a much greater amount of energy to be obtained in a simpler way. Wind-power has been, in old times, of inestimable value to man, if for nothing else but for enabling him, to cross the seas, and it is even now a very important factor in travel and transportation. But there are great limitations in this ideally simple method of utilizing the sun's energy. The machines are large for a given output, and the power is intermittent, thus necessitating the storage of energy and increasing the cost of the plant.

A far better way, however, to obtain power would be to avail ourselves of the sun's rays, which beat the earth incessantly and supply energy at a maximum rate of over four million horsepower per square mile.

[Today the energy production of the Sun has been estimated at \$3.846 \cdot 10^{26} \text{ W}\$. A sphere with a radius of 1 AU has a surface of \$2.81 \cdot 10^{23} \text{ m}^2\$. This means that on Earth we receive the Sun's energy at a rate of \$1369 \text{ W/m}^2\$, being 4.752 million horsepower per square mile. Tesla's estimate wasn't half bad!](#)

Although the average energy received per square mile in any locality during the year is only a small fraction of that amount, yet an inexhaustible source of power would be opened up by the discovery of some efficient method of utilizing the energy of the rays. The only rational way known to me at the time when I began the study of this subject was to employ some kind of heat- or thermodynamic-engine, driven by a volatile fluid evaporated in a boiler by the heat of the rays. But closer investigation of this method, and calculation, showed that, notwithstanding the apparently vast amount of energy received from the sun's rays, only a small fraction of that energy could be actually utilized in this manner. Furthermore, the energy supplied through the sun's radiations is periodical, and the same limitations as in the use of the windmill I found to exist here also. After a long study of this mode of obtaining motive power from the sun, taking into account the necessarily large bulk of the boiler, the low efficiency of the heat-engine, the additional cost of storing the energy and other drawbacks, I came to the conclusion that the "solar engine," a few instances excepted, could not be industrially exploited with success.

[When we think of the Sun's radiation we think of its electromagnetic radiations, but Tesla was convinced that](#)

there must be particle rays that are immensely penetrative. It is this kind of radiation that may cause the internal heat of the Earth, possibly by the electric currents and radioactive decay that it induces. So while thinking of ways to use the Sun's radiations it is only logical to think of the following:

Another way of getting motive power from the medium without consuming any material would be to utilize the heat contained in the earth, the water, or the air for driving an engine. It is a well-known fact that the interior portions of the globe are very hot, the temperature rising, as observations show, with the approach to the centre at the rate of approximately 1 degree C. for every hundred feet of depth. The difficulties of sinking shafts and placing boilers at depths of, say, twelve thousand feet, corresponding to an increase in temperature of about 120 degrees C., are not insuperable, and we could certainly avail ourselves in this way of the internal heat of the globe. In fact, it would not be necessary to go to any depth at all in order to derive energy from the stored terrestrial heat. The superficial layers of the earth and the air strata close to the same are at a temperature sufficiently high to evaporate some extremely volatile substances, which we might use in our boilers instead of water. There is no doubt that a vessel might be propelled on the ocean by an engine driven by such a volatile fluid, no other energy being used but the heat abstracted from the water. But the amount of power which could be obtained in this manner would be, without further provision, very small.

Electricity produced by natural causes is another source of energy which might be rendered available. Lightning discharges involve great amounts of electrical energy, which we could utilize by transforming and storing it. Some years ago I made known a method of electrical transformation which renders the first part of this task easy, but the storing of the energy of lightning discharges will be difficult to accomplish. It is well known, furthermore, that electric currents circulate constantly through the earth, and that there exists between the earth and any air stratum a difference of electrical pressure, which varies in proportion to the height.

All of these may be traced back to the PCR that Tesla believed the Sun is producing.

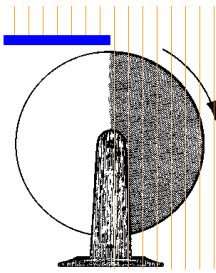
In recent experiments I have discovered two novel facts of importance in this connection. One of these facts is that an electric current is generated in a wire extending from the ground to a great height by the axial, and probably also by the translatory, movement of the earth. No appreciable current, however, will flow continuously in the wire unless the electricity is allowed to leak out into the air. Its escape is greatly facilitated by providing at the elevated end of the wire a conducting terminal of great surface, with many sharp edges or points. We are thus enabled to get a continuous supply of electrical energy by merely supporting a wire at a height, but, unfortunately, the amount of electricity which can be so obtained is small.

This is very close to describing St. Elmo's Fire which was mentioned earlier. What other ways do we have to facilitate the escape of electricity at the end of a wire? We could raise the potential gradient or making the air conductive by some means would help a lot.

The second fact which I have ascertained is that the upper air strata are permanently charged with electricity opposite to that of the earth. So, at least, I have interpreted my observations, from which it appears that the earth, with its adjacent insulating and outer conducting envelope, constitutes a highly charged electrical condenser containing, in all probability, a great amount of electrical energy which might be turned to the uses of man, if it were possible to reach with a wire to great altitudes.

Let's check this with some very rough estimates. If we assume a height of 70 Km for the ionosphere we can calculate the capacitance, being 65.226 mF. Assuming an electrical potential of 400 KV. Thus an estimate of the energy contained here is $5.218 \cdot 10^9$ J. The world energy consumption in 2008 was $1.64 \cdot 10^{13}$ W, so this energy can supply today's world's needs for about 0.3182 ms. Besides that we have no idea what natural disasters may follow if we would empty this capacitor.

It is possible, and even probable, that there will be, in time, other resources of energy opened up, of which we have no knowledge now. We may even find ways of applying forces such as magnetism or gravity for driving machinery without using any other means. Such realizations, though highly improbable, are not impossible. An example will best convey an idea of what we can hope to attain and what we can never attain. Imagine a disk of some homogeneous material turned perfectly true and arranged to turn in frictionless bearings on a horizontal shaft above the ground. This disk, being under the above conditions perfectly balanced, would rest in any position. Now, it is possible that we may learn how to make such a disk rotate continuously and perform work by the force of gravity without any further effort on our part; but it is perfectly impossible for the disk to turn and to do work without any force from the outside. If it could do so, it would be what is designated scientifically as a "perpetuum mobile," a machine creating its own motive power. To make the disk rotate by the force of gravity we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one half of the disk, and the rotation of the latter would follow. At least, we cannot deny such a possibility until we know exactly the nature of the force of gravity. Suppose that this force were due to a movement comparable to that of a stream of air passing from above toward the centre of the earth. The effect of such a stream upon both halves of the disk would be equal, and the latter would not rotate ordinarily; but if one half should be guarded by a plate arresting the movement, then it would turn.



This idea originates from Sir Isaac Newton's notebook in which he speculates that "gravity (heaviness) is caused by the descent of a subtle matter which strikes all bodies and carries them down. Whither ye rays of gravity may be stopped by reflecting or refracting ye, if so a perpetual motion may be made one of these two ways."

This is an interesting picture that Tesla presents here because we know that Tesla believed that the PCR are streams of particles. And if they are there, they may also play a role in gravitation.

This scheme is similar to what Tesla describes in his autobiography of 1919, chapter 3 "My later endeavours":

In the second year at that institution I became obsessed with the idea of producing continuous motion through steady air pressure. The pump incident, of which I have told, had set afire my youthful imagination and imprest me with the boundless abilities of a vacuum. I grew frantic in my desire to harness this inexhaustible energy but for a long time I was groping in the dark. Finally, however, my endeavours crystallized in an invention which was to enable me to achieve what no other mortal ever attempted.

Imagine a cylinder freely rotatable on two bearings and partly surrounded by a rectangular trough which fits it perfectly. The open side of the trough is closed by a partition so that the cylindrical segment within the enclosure divides the latter into two compartments entirely separated from each other by airtight sliding joints. One of these compartments being sealed and once for all exhausted, the other remaining open, a perpetual rotation of the cylinder would result, at least, I thought so.

A DEPARTURE FROM KNOWN METHODS

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

When I began the investigation of the subject under consideration, and when the preceding or similar ideas presented themselves to me for the first time, though I was then unacquainted with a number of the facts mentioned, a survey of the various ways of utilizing the energy of the medium convinced me, nevertheless, that to arrive at a thoroughly satisfactory practical solution a radical departure from the methods then known had to be made. The windmill, the solar engine, the engine driven by terrestrial heat, had their limitations in the amount of power obtainable. Some new way had to be discovered which would enable us to get more energy. There was enough heat-energy in the medium, but only a small part of it was available for the operation of an engine in the ways then known. Besides, the energy was obtainable only at a very slow rate. Clearly, then, the problem was to discover some new method which would make it possible both to utilize more of the heat-energy of the medium and also to draw it away from the same at a more rapid rate.

Here we have come to the core of the article: the "self-acting machine" that would derive power from the medium. This is the way of getting energy without burning fuels.

I was vainly endeavouring to form an idea of how this might be accomplished, when I read some statements from Carnot and Lord Kelvin (then Sir William Thomson) which meant virtually that it is impossible for an inanimate mechanism or self-acting machine to cool a portion of the medium below the temperature of the surrounding, and operate by the heat abstracted. These statements interested me intensely. Evidently a living being could do this very thing, and since the experiences of my early life which I have related had convinced me that a living being is only an automaton, or, otherwise stated, a "self-acting-engine," I came to the conclusion that it was possible to construct a machine which would do the same. As the first step toward this realization I conceived the following mechanism. Imagine a thermopile consisting of a number of bars of metal extending from the earth to the outer space beyond the atmosphere. The heat from below, conducted upward along these metal bars, would cool the earth or the sea or the air, according to the location of the lower parts of the bars, and the result, as is well known, would be an electric current circulating in these bars. The two terminals of the thermopile could now be joined through an electric motor, and, theoretically, this motor would run on and on, until the media below would be cooled down to the temperature of the 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.

Step 1: the thermopile. The first picture Tesla presents us is a machine that operates on the temperature difference between the Earth and outer space. Now remember that electricity in Tesla's view is caused by a gaseous medium. And a gas acts more or less conform the ideal gas law: $P \cdot V = N \cdot k_B \cdot T$. Pressure of a gas (P) relates to voltage, volume (V) to capacitance, quantity (N) to charge. And now Tesla is talking about what everybody seems to overlook: the Temperature of electricity.

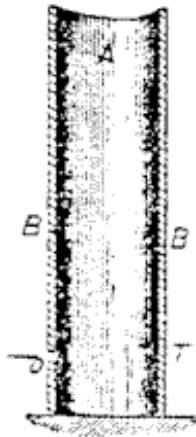
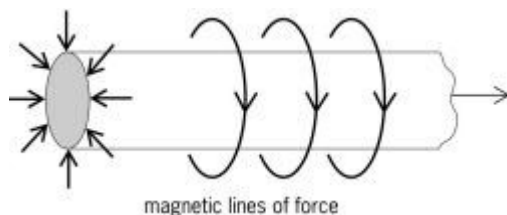


DIAGRAM b. OBTAINING ENERGY FROM THE AMBIENT MEDIUM

A, medium with little energy; B, ambient medium with much energy; O, path of the energy.

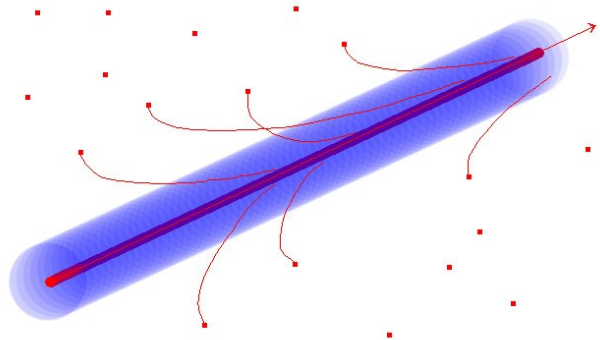
But was it not possible to realize a similar condition without necessarily going to a height? Conceive, for the sake of illustration, [a cylindrical] enclosure T, as illustrated in diagram b, such that energy could not be transferred across it except through a channel or path O, and that, by some means or other, in this enclosure 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. 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. The question was, Could such a condition be attained? Could we produce artificially such a "sink" for the energy of the ambient medium to flow in? Suppose that an extremely low temperature could be maintained by some process in a given space; the surrounding medium would then be compelled to give off heat, which could be converted into mechanical or other form of energy, and utilized. By realizing such a plan, we should be enabled to get at any point of the globe a continuous supply of energy, day and night. More than this, reasoning in the abstract, it would seem possible to cause a quick circulation of the medium, and thus draw the energy at a very rapid rate.

This is an interesting thought experiment. It looks like we are fooling Mother Nature, and the question then is: "Can Mother Nature be fooled?" Remember Tesla is talking about **electric temperature**.



magnetic lines of force

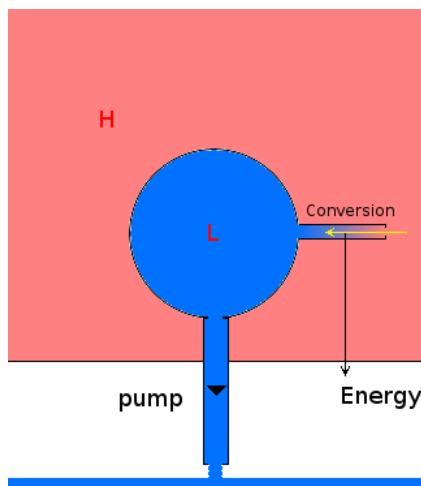
A current creates a magnetic field which constricts the current. This is called the pinch effect. With a very strong electric field we can create a movement in free charges, which is in fact a current, and because of the pinch effect, the current constricts itself creating a second suction effect.



So the current removes charges from its direct environment (it removes energy from our "cylinder"), which are replenished by the environment slightly further away (the medium outside our cylinder). But once they try to fill the void they get sucked into the current (converted into a different form and taken out). You can also look at it in this way: Temperature is a chaotic movement, the magnetic field caused by the current directs this chaotic movement in one direction and therefore the pressure (voltage) to the outside drops. This lack of outside pressure in the discharge makes that the surrounding charges, which still do have pressure, force themselves into the discharge, get converted into a current and enforce the magnetic field that is needed for this process.

Here, then, was an idea which, if realizable, afforded a happy solution of the problem of getting energy from the medium. But was it realizable? I convinced myself that it was so in a number of ways, of which one is the following. As regards heat, we are at a high level, which may be represented by the surface of a mountain lake considerably above the sea, the level of which may mark the absolute zero of temperature existing in the interstellar space. Heat, like water, flows from high to low level, and, consequently, just as we can let the water of the lake run down to the sea, so we are able to let heat from the earth's surface travel up into the cold region above. Heat, like water, can perform work in flowing down, and if we had any doubt as to whether we could derive energy from the medium by means of a thermopile, as before described, it would be dispelled by this analogue. But can we produce cold in a given portion of the space and cause the heat to flow in continually? To create such a "sink," or "cold hole," as we might say, in the medium, would be equivalent to producing in the lake a space either empty or 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. Consequently nothing could be gained in this double operation of first raising the water and then letting it fall down. This would mean that it is impossible to create such a sink in the medium. But let us reflect a moment. 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 a low level. To make our mechanical analogy complete and true, we must, therefore, 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. For example, if heat be represented in this analogue 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. If the process of heat transformation were absolutely perfect, no heat at all would arrive at the low level, since all of it would be converted into other forms of energy. Corresponding to this ideal case, all the water flowing into the tank would be decomposed into oxygen and hydrogen before reaching the bottom, 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 in, a condition enabling us to get any amount of energy without further effort. This would be an ideal way of obtaining motive power. We do not know of any such absolutely perfect process of heat-conversion, and consequently some heat will generally reach the low level, which means to say, in our mechanical analogue, that some water will arrive at the bottom of the tank, and a gradual and slow filling of the latter will take place, necessitating continuous pumping out. But evidently 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 fall, and this is to say that some energy will be gained from the medium. What is not converted in flowing down can just be raised up with its own energy, and what is converted is clear gain. Thus the virtue of the principle I have discovered resides wholly in the conversion of the energy on the downward flow.



This is exactly the same as the previous paragraph with a few additions. Again Tesla mentions "we are able to let heat (electric temperature) from the earth's surface travel up into the cold region above". Remember the first diagram on iron production where water is split into hydrogen and oxygen. Tesla uses the same analogy here, however, in this scheme the energy that is attracted is split into two components, while in the first diagram the energy that we start out with is split to be recombined with a component found in air.

FIRST EFFORTS TO PRODUCE THE SELF-ACTING ENGINE —THE MECHANICAL OSCILLATOR—WORK OF DEWAR AND LINDE—LIQUID AIR.

Having recognized this truth, I began to devise means for carrying out my idea, and, after long thought, I finally conceived a combination of apparatus which should make possible the obtaining of power from the medium by a process of continuous cooling of atmospheric air. This apparatus, by continually transforming heat into mechanical work, tended to become colder and colder, and if it only were practicable to reach a very low temperature in this manner, then a sink for the heat could be produced, and energy could be derived from the medium. This seemed to be contrary to the statements of Carnot and Lord Kelvin before referred to, but I concluded from the theory of the process that such a result could be attained. This conclusion I reached, I think, in the latter part of 1883, when I was in Paris, and it was at a time when my mind was being more and more dominated by an invention which I had evolved during the preceding year, and which has since become known under the name of the "rotating magnetic field." During the few years which followed I elaborated further the plan I had imagined, and studied the working conditions, but made little headway. The commercial introduction in this country of the invention before referred to required most of my energies until 1889, when I again took up the idea of the self-acting machine. A closer investigation of the principles involved, and calculation, now showed that the result I aimed at could not be reached in a practical manner by ordinary machinery, as I had in the beginning expected. This led me, as a next step, to the study of a type of engine generally designated as "turbine," which at first seemed to offer better chances for a realization of the idea. Soon I found, however, that the turbine, too, was unsuitable. But my conclusions showed that if an engine of a peculiar kind could be brought to a high degree of perfection, the plan I had conceived was realizable, and I resolved to proceed with the development of such an engine, the primary object of which was to secure the greatest economy of transformation of heat into mechanical energy. A characteristic feature of the engine was that the work-performing piston was not connected with anything

else, but was perfectly free to vibrate at an enormous rate. The mechanical difficulties encountered in the construction of this engine were greater than I had anticipated, and I made slow progress. This work was continued until early in 1892, when I went to London, where I saw Professor Dewar's admirable experiments with liquefied gases. Others had liquefied gases before, and notably Ozlewski¹⁵ and Pictet had performed creditable early experiments in this line, but there was such a vigour about the work of Dewar that even the old appeared new. His experiments showed, though in a way different from that I had imagined, that it was possible to reach a very low temperature by transforming heat into mechanical work, and I returned, deeply impressed with what I had seen, and more than ever convinced that my plan was practicable. The work temporarily interrupted was taken up anew, and soon I had in a fair state of perfection the engine which I have named "the mechanical oscillator." In this machine I succeeded in doing away with all packings, valves, and lubrication, and in producing so rapid a vibration of the piston that shafts of tough steel, fastened to the same and vibrated longitudinally, were torn asunder. By combining this engine with a dynamo of special design I produced a highly efficient electrical generator, invaluable in measurements and determinations of physical quantities on account of the unvarying rate of oscillation obtainable by its means. I exhibited several types of this machine, named "mechanical and electrical oscillator," before the Electrical Congress at the World's Fair in Chicago during the summer of 1893, in a lecture which, on account of other pressing work, I was unable to prepare for publication. 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.

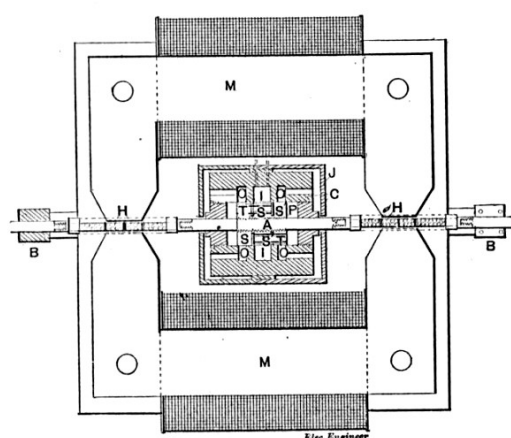


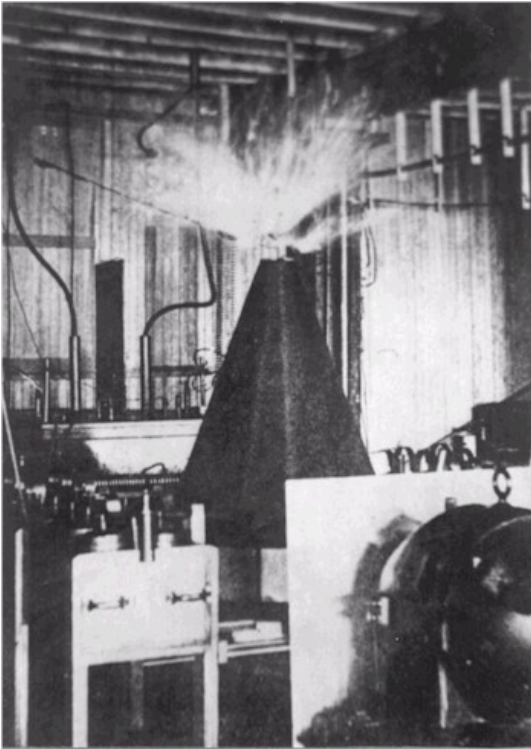
FIG. 2.—THE TESLA OSCILLATOR.—SECTIONAL VIEW.

Heat is converted into mechanical work, creating a cold sink. This attracts new heat which is consequently converted into mechanical work. This conversion is done by a "work-performing piston not connected with anything else, but perfectly free to vibrate at an enormous rate." A piston usually stands for a coil. Dewar's work is again mentioned, but his way is different from what Tesla envisioned. Dewar compresses a gas which brings out its internal heat, then by rapid expansion the gas goes back to its original state but now with less heat, in other words colder. The first part of the self-acting machine was Tesla's mechanical and electrical oscillator. A machine that produced a very constant high frequency alternating current. This oscillator was published in the *Electrical Engineer* of 1893-11-08.

In the process, as I had primarily conceived it, for the utilization of the energy of the ambient medium, there were five essential elements in combination, and each of these had to be newly designed and perfected, as no such machines existed. The mechanical oscillator was the first element of this combination, and having perfected this, I turned to the next, which was an air-compressor of a design in certain respects resembling that of the mechanical oscillator. Similar difficulties in the construction were again encountered, but the work was pushed vigorously, and at the close of 1894 I had completed these two elements of the combination, and thus produced an apparatus for compressing air, virtually to any desired pressure, incomparably simpler, smaller, and more efficient than the ordinary. I was just beginning work on the third element, which together with the first two would give a refrigerating machine of exceptional efficiency and simplicity, when a misfortune befell me in the burning of my laboratory, which crippled my labours and delayed me. Shortly afterwards Dr. Carl Linde announced the liquefaction of air by a self-cooling process, demonstrating that it was practicable to proceed with the cooling until liquefaction of the air took place. This was the only experimental proof which I was still wanting that energy was obtainable from the medium in the manner contemplated by me.

The self-acting machine consists of 5 elements. The oscillator is the first which maps to the motor of Dewar's system that drives a compressor which is the next element, most probably a Tesla coil as published in *Century Magazine*, April 1895 in an article named "Tesla's Oscillator and Other Inventions".

15 Karol Stanisław Olszewski (1846-1915)

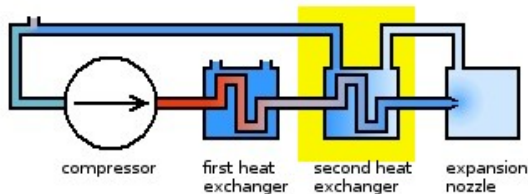


This picture comes from Tesla's laboratory at 35 South Fifth Avenue just before it was destroyed by fire. Quoting Tesla from his pre-hearing interview in 1916:

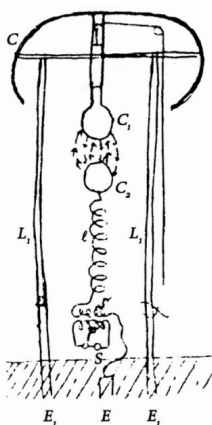
This coil, which I have subsequently shown in my patents Nos. 645,576 and 649,621, in the form of a spiral, was, as you see, in the form of a cone. The idea was to put the coil, with reference to the primary, in an inductive connection which was not close—we call it now a loose coupling—but free to permit a great resonant rise. That was the first single step, as I say, toward the evolution of an invention which I have called my "magnifying transmitter." That means, a circuit connected to ground and to the antenna, of a tremendous electromagnetic momentum and small damping factor, with all the conditions so determined that an immense accumulation of electrical energy can take place.

It was along this line that I finally arrived at the results described in my article in the Century Magazine of June 1900. This shows an alternator; not the alternator that was furnished for my laboratory on Houston Street—that was another one, [but] at 35 South Fifth Avenue [and] operated on the same principle. Here [lower left] are the condensers, primary, and all the rest.

From this we learn that the Magnifying Transmitter either is the self-acting machine or is a part of it. Theoretically it is possible that the Magnifying Transmitter is a spin-off development, but that does not match with what Tesla says about the Magnifying Transmitter in (for example) his autobiography in 1919. In the current article Tesla describes the development of his self-acting machine which took him at least 10 years of systematic research. In autobiography you will read how Tesla spend many years developing his Magnifying Transmitter. So this leaves us the two before mentioned options.



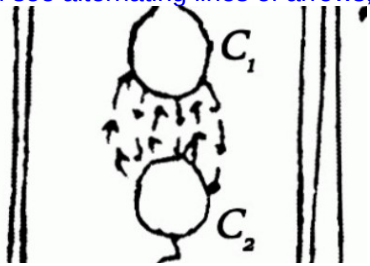
The 3rd element would make this into a refrigerating machine, so that is most probably some equivalent of the expansion nozzle. The final "experimental proof" was delivered by Carl Linde, so some regenerative feed-back loop, marked with yellow in this diagram, must be created with elements 4 and/or 5.



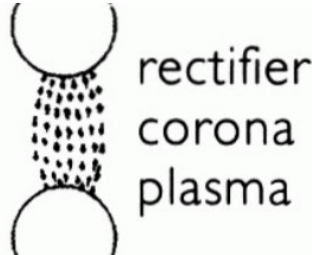
The diagram to the left is from the "Rare Notes" published in "Electric Spacecraft" of Apr/May/Jun 1997. It is not difficult to visualize charge being compressed to a high voltage in the lower top-load and escaping under high pressure exactly as would happen in an expansion nozzle. The greater top-load acts as the expansion chamber.

In our experiments we have seen a twice as high voltage on the greater top-load, which could also be explained by the inductive action of the extra coil combined with a diode-action of the discharge. Even at smaller scale and with relatively low voltages there seems to be a very significant voltage increase. More research is required.

There is a strange thing about this "rectifier"; if you look closely, you will see alternating lines of arrows,



up and down. So if electric charges are moving both ways, then where is the rectifying action? It is in "unifying heterogeneous elements".



This image could depict the extra charge being sucked in. This happens in both directions (left to right and right to left) hence the shape of the plasma, getting smaller in both directions.

Five additional quotes might help to understand this picture:

1917-05-18: Minutes of the Annual Meeting of the American Institute of Electrical Engineers, Held at the Engineering Societies Building, Friday Evening

One day as I was walking in the forest a storm gathered and I ran under a tree for shelter. The air was very heavy, and all at once there was a lightning flash, and immediately after a torrent of rain fell. That gave me the first idea. I realized that the sun was lifting the water vapour, and wind swept it over the regions where it accumulated and reached a condition when it was easily condensed and fell to earth again. This life-sustaining stream of water was entirely maintained by sun power, and lightning, or some other agency of this kind, simply came in a trigger-mechanism to release **the energy** at the proper moment. I started out and attacked the problem of constructing a machine which would enable us to precipitate this water whenever and wherever desired.

1919 autobiography

One day, as I was roaming in the mountains, I sought shelter from an approaching storm. The sky became overhung with heavy clouds but somehow the rain was delayed until, all of a sudden, there was a lightning flash and a few moments after a deluge. This observation set me thinking. It was manifest that the two phenomena were closely related, as cause and effect, and a little reflection led me to the conclusion that the electrical energy involved in the precipitation of the water was inconsiderable, the function of lightning being much like that of a sensitive trigger. Here was a stupendous possibility of achievement. If we could produce electric effects of the required quality, this whole planet and the conditions of existence on it could be transformed. The sun raises the water of the oceans and winds drive it to distant regions where it remains in a state of most delicate balance. If it were in our power to upset it when and wherever desired, this mighty life-sustaining stream could be at will controlled. We could irrigate arid deserts, create lakes and rivers and provide motive power in unlimited amounts. This would be the most efficient way of **harnessing the sun to the uses of man**. The consummation depended on our ability to develop electric forces of the order of those in nature.

1931 December: Our Future Motive Power

The sun raises the water to a height where it remains in a state of delicate suspension until a disturbance, of relatively insignificant energy, causes condensation at a place where the balance is most easily disturbed. The action, once started, spreads like a conflagration for a vacuum is formed and the air rushing in, **being cooled** by expansion, enhances further condensation in the surrounding masses of the cloud. All life on the globe is absolutely dependent on this gigantic trigger mechanism of nature and my extended observations have shown that the complex effects of lightning are, in most cases, the chief controlling agents. This theory, formulated by me in 1892, was borne out in some later experiments I made with artificial lightning bolts over 100 feet long, according to which it appears possible, by great power plants suitably distributed and operated at the proper times, to draw unlimited quantities of water from the oceans to the continents. The machines being driven by the waterfalls, all the work would be performed by the sun, while we would have merely to release the trigger.

1933 December: Breaking Up Tornadoes

One of the greatest possible achievements of the human race would be the control of the precipitation of rain. The sun raises the waters of the ocean and winds carry them to distant regions, where they remain in a state of delicate suspension until a relatively feeble impulse causes them to fall to earth. The terrestrial mechanism operates much like an apparatus releasing great energy through a trigger or priming cap.

If man could perform this relatively trifling work, he could direct the life-giving stream of water wherever he pleased, create lakes and rivers and transform the arid regions of the globe. Many means have been proposed to this end, but only one is operative. **It is lightning, but of a certain kind.**

We have here 4 times the same story, in the first one he makes a 'mistake' by talking about the precipitation

of energy instead of water, the second time he links this story to our current and main article by quoting its sub-title, the 3rd time he links it to the self-acting machine by mentioning the 'cooling by expansion' principle which we just covered and the 4th time he explains that it concerns a lightning discharge.

The last quote to shed light on this process also comes from his autobiography; chapter V about the Magnifying Transmitter:

One winter's day I managed to climb a steep mountain, in company with other boys. The snow was quite deep and a warm southerly wind made it just suitable for our purpose. We amused ourselves by throwing balls which would roll down a certain distance, gathering more or less snow, and we tried to outdo one another in this exciting sport. Suddenly a ball was seen to go beyond the limit, swelling to enormous proportions until it became as big as a house and plunged thundering into the valley below with a force that made the ground tremble. I looked on spellbound, incapable of understanding what had happened. For weeks afterwards the picture of the avalanche was before my eyes and I wondered how anything so small could grow to such an immense size. Ever since that time the magnification of feeble actions fascinated me, and when, years later, I took up the experimental study of mechanical and electrical resonance, I was keenly interested from the very start....

This is the very first thing he wants to say about his magnifying transmitter. And what does he tell us? He explains an avalanche effect, mentions magnification of feeble actions and says:

... Possibly, had it not been for that early powerful impression, I might not have followed up the little spark I obtained with my coil and never developed my best invention, the true history of which I'll tell here for the first time.

It does not get much clearer than this: The Sun creates energy of some sort in our atmosphere and with a discharge of the right properties we can create an avalanche effect and collect this energy.

Back to our main article.

The liquefaction of air by a self-cooling process was not, as popularly believed, an accidental discovery, but a scientific result which could not have been delayed much longer, and which, in all probability, could not have escaped Dewar. This fascinating advance, I believe, is largely due to the powerful work of this great Scotchman. Nevertheless, Linde's is an immortal achievement. The manufacture of liquid air has been carried on for four years in Germany, on a scale much larger than in any other country, and this strange product has been applied for a variety of purposes. Much was expected of it in the beginning, but so far it has been an industrial ignis fatuus. By the use of such machinery as I am perfecting, its cost will probably be greatly lessened, but even then its commercial success will be questionable. When, used as a refrigerant it is uneconomical, as its temperature is unnecessarily low. It is as expensive to maintain a body at a very low temperature as it is to keep it very hot; it takes coal to keep air cold. In oxygen manufacture it cannot yet compete with the electrolytic method. For use as an explosive it is unsuitable, because its low temperature again condemns it to a small efficiency, and for motive-power purposes its cost is still by far too high. It is of interest to note, however, that in driving an engine by liquid air a certain amount of energy may be gained from the engine, or, stated otherwise, from the ambient medium which keeps the engine warm, each two hundred pounds of iron-casting of the latter contributing energy at the rate of about one effective horsepower during one hour. But this gain of the consumer is offset by an equal loss of the producer.

Much of this task on which I have laboured so long remains to be done. A number of mechanical details are still to be perfected and some difficulties of a different nature to be mastered, and I cannot hope to produce a self-acting machine deriving energy from the ambient medium for a long time yet, even if all my expectations should materialize. Many circumstances have occurred which have retarded my work of late, but for several reasons the delay was beneficial.

Tesla was not ready? No, as we have already read, he could not create a controlling device (a 'mind') and the selective distribution of energy to receivers was not completely worked out as we can infer from his Long Island notes. Also there were "some difficulties of a different nature to be mastered". One of those difficulties may have something to do with the delays that he mentions, like the burning of his laboratory?

One of these reasons was that I had ample time to consider what the ultimate possibilities of this development might be. I worked for a long time fully convinced that the practical realization of this 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.

This new energy source will be of incalculable (industrial) value, but it may not be commercially profitable to the same degree. That certainly does make sense and may have something to do with the before mentioned delays.

DISCOVERY OF UNEXPECTED PROPERTIES OF THE ATMOSPHERE

—STRANGE EXPERIMENTS—TRANSMISSION OF ELECTRICAL ENERGY THROUGH ONE WIRE WITHOUT RETURN—TRANSMISSION THROUGH THE EARTH WITHOUT ANY WIRE.

Another of these reasons was that I was led to recognize 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 uses of man. For a long time I was convinced that such a transmission on an industrial scale, could never be realized, but a discovery which I made changed my view. I observed that under certain conditions the atmosphere, which is normally a high insulator, assumes conducting properties, and so becomes capable of conveying any amount of electrical energy. But the difficulties in the way of a practical utilization of this discovery for the purpose of transmitting electrical energy without wires were seemingly insuperable. Electrical pressures of many millions of volts had to be produced and handled; generating apparatus of a novel kind, capable of withstanding the immense electrical stresses, had to be invented and perfected, and a complete safety against the dangers of the high-tension currents had to be attained in the system before its practical introduction could be even thought of. All this could not be done in a few weeks or months, or even years. The work required patience and constant application, but the improvements came, though slowly. Other valuable results were, however, arrived at in the course of this long-continued work, of which I shall endeavour to give a brief account, enumerating the chief advances as they were successively effected.

There is a strange twist in this paragraph: "For a long time I was convinced that such a transmission on an industrial scale, could never be realized, but a discovery which I made changed my view." This I have already mentioned. That was the discovery of standing waves in the Earth. But now Tesla continues "I observed that under certain conditions the atmosphere, which is normally a high insulator, assumes conducting properties, and so becomes capable of conveying any amount of electrical energy." That would lead you to believe that Tesla intended to use the air as a distribution medium for electrical energy. But that is not the case. We read in this article of 1932-07-10: "Tesla Cosmic Ray Motor May Transmit Power 'Round Earth":

He at that time announced two principles which could be used in this project. In one the ionizing of the upper air would make it as good a conductor of electricity as a metal. In the other the power would be transmitted by creating "standing waves" in the earth by charging the earth with a giant electrical oscillator that would make the earth vibrate electrically in the same way a bell vibrates mechanically when it is struck with a hammer.

"I do not use the plan involving the conductivity of the upper strata of the air," he said, "but I use the conductivity of the earth itself, and in this I need no wires to send electrical energy to any part of the globe."

But this is confusing because in some other instances Tesla clearly states that he intends to use the conductivity of the air to convey electrical power to different places. Reading the pre-hearing interview, we find the solution:

Up to the end of 1896, I had been developing the wireless system along the lines set forth in my lecture which is in the Martin book, particularly in the chapter on Electrical Resonance, pages 340-349.

We look up that lecture of 1893-02-24 "On Light and Other High Frequency Phenomena":

We now know that electric vibration may be transmitted through a single conductor. Why then not try to avail ourselves of the earth for this purpose?

This is scheme A which Tesla was researching until the end of 1896, and apparently Tesla found this not suitable for transmission of power. Then the conductivity of air was discovered and Tesla changed to plan B, transmission through the conductive layers of the atmosphere. Later again, one night in Colorado Springs (July 3rd, 1899) Tesla discovered stationary waves in the Earth and changed to plan C, which was the final scheme for transmission of messages and energy.

The discovery of the conducting properties of the air, though unexpected, was only a natural result of experiments in a special field which I had carried on for some years before. It was, I believe, during 1889 that certain possibilities offered by extremely rapid electrical oscillations determined me to design a number of special machines adapted for their investigation. Owing to the peculiar requirements, the construction of these machines was very difficult, and consumed much time and effort; but my work on them was generously rewarded, for I reached by their means several novel and important results. One of the earliest observations I made with these new machines was that electrical oscillations of an extremely high rate act in an extraordinary manner upon the human organism. Thus, for instance, I demonstrated that powerful electrical discharges of several hundred thousand volts, which at that time were considered absolutely deadly, could be passed through the body without inconvenience or hurtful consequences. These oscillations produced

other specific physiological effects, which, upon my announcement, were eagerly taken up by skilled physicians and further investigated. This new field has proved itself fruitful beyond expectation, and in the few years which have passed since, it has been developed to such an extent that it now forms a legitimate and important department of medical science. Many results, thought impossible at that time, are now readily obtainable with these oscillations, and many experiments undreamed of then can now be readily performed by their means. I still remember with pleasure how, nine years ago, I passed the discharge of a powerful induction-coil through my body to demonstrate before a scientific society the comparative harmlessness of very rapidly vibrating electric currents, and I can still recall the astonishment of my audience. I would now undertake, with much less apprehension than I had in that experiment, to transmit through my body with such currents the entire electrical energy of the dynamos now working at Niagara—forty or fifty thousand horsepower. I have produced electrical oscillations which were of such intensity that when circulating through my arms and chest they have melted wires which joined my hands, and still I felt no inconvenience. I have energized with such oscillations a loop of heavy copper wire so powerfully that masses of metal, and even objects of an electrical resistance specifically greater than that of human tissue brought close to or placed within the loop, were heated to a high temperature and melted, often with the violence of an explosion, and yet into this very space in which this terribly-destructive turmoil was going on I have repeatedly thrust my head without feeling anything or experiencing injurious after-effects.

Another observation was that by means of such oscillations light could be produced in a novel and more economical manner, which promised to lead to an ideal system of electric illumination by vacuum-tubes, dispensing with the necessity of renewal of lamps or incandescent filaments, and possibly also with the use of wires in the interior of buildings. The efficiency of this light increases in proportion to the rate of the oscillations, and its commercial success is, therefore, dependent on the economical production of electrical vibrations of transcending rates. In this direction I have met with gratifying success of late, and the practical introduction of this new system of illumination is not far off.

The investigations led to many other valuable observations and results, one of the more important of which was the demonstration of the practicability of supplying electrical energy through one wire without return. At first I was able to transmit in this novel manner only very small amounts of electrical energy, but in this line also my efforts have been rewarded with similar success.

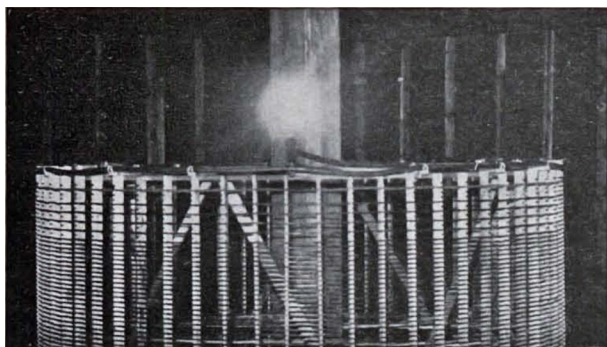


FIG. 3. EXPERIMENT TO ILLUSTRATE THE SUPPLYING OF ELECTRICAL ENERGY THROUGH A SINGLE WIRE WITHOUT RETURN

An ordinary incandescent lamp, connected with one or both of its terminals to the wire forming the upper free end of the coil shown in the photograph, is lighted by electrical vibrations conveyed to it through the coil from an electrical oscillator, which is worked only to one fifth of one per cent. of its full capacity.

The photograph shown in Fig. 3 illustrates, as its title explains, an actual transmission of this kind effected with apparatus used in other experiments here described. To what a degree the appliances have been perfected since my first demonstrations early in 1891 before a scientific society, when my apparatus was barely capable of lighting one lamp (which result was considered wonderful), will appear when I state that I have now no difficulty in lighting in this manner four or five hundred lamps, and could light many more. In fact, there is no limit to the amount of energy which may in this way be supplied to operate any kind of electrical device.

So Tesla tells us of some discoveries: the conductivity of air which led to researching transmission of power, the effect of high frequency currents on living beings, the production of light with electrodeless tubes and

finally the transmission of electrical power in a novel way where there seems to be no limit in the amount of energy that can be supplied. This is explained in the pre-hearing interview:

I have an idea that [you] will get the best picture of the process in my system of transmission if you will imagine that the earth is a reservoir, say, of fluid under pressure -- that is the potential energy -- and at my plant, operating a distant tuned circuit, I must open a valve and enable that energy to flow in. It is exactly that way. The energy is all conserved, whether it is vibrating or purely potential. Whatever the transmitter does in the receiver, the effect is simply to open a valve, as it were, and permit energy to flow in.

Here we read about another important feature of this scheme; the transmitted energy is not used directly but it is used to collect energy and it is this energy that is being used. Very much like in the diagram of iron production, only instead of water power, we now use the vibrational energy in the Earth's electricity.

After demonstrating the practicability of this method of transmission, the thought naturally occurred to me to use the earth as a conductor, thus dispensing with all wires. Whatever electricity may be, it is a fact that it

behaves like an incompressible fluid, and the earth may be looked upon as an immense reservoir of electricity, which, I thought, could be disturbed effectively by a properly designed electrical machine. Accordingly, my next efforts were directed toward perfecting a special apparatus which would be highly effective in creating a disturbance of electricity in the earth. The progress in this new direction was necessarily very slow and the work discouraging, until I finally succeeded in perfecting a novel kind of transformer or induction-coil, particularly suited for this special purpose. That it is practicable, in this manner, not only to transmit minute amounts of electrical energy for operating delicate electrical devices, as I contemplated at first, but also electrical energy in appreciable quantities, will appear from an inspection of Fig. 4, which illustrates an actual experiment of this kind performed with the same apparatus. The result obtained was all the more remarkable as the top end of the coil was not connected to a wire or plate for magnifying the effect.

"WIRELESS" TELEGRAPHY

—THE SECRET OF TUNING—ERRORS IN THE HERTZIAN INVESTIGATIONS—A RECEIVER OF WONDERFUL SENSITIVENESS.

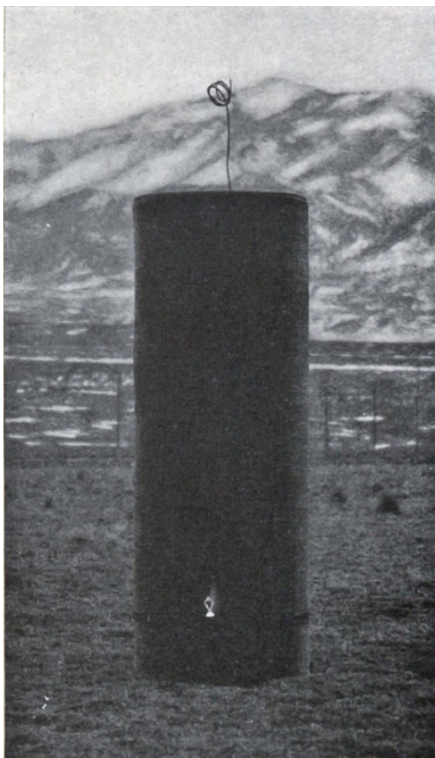


FIG. 4. EXPERIMENT TO ILLUSTRATE THE TRANSMISSION OF ELECTRICAL ENERGY THROUGH THE EARTH WITHOUT WIRE.

The coil shown in the photograph has its lower end or terminal connected to the ground, and is exactly attuned to the vibrations of a distant electrical oscillator. The lamp lighted is in an independent wire loop, energized by induction from the coil excited by the electrical vibrations transmitted to it through the ground from the oscillator, which is worked only to five per cent. of its full capacity.

As the first valuable result of my experiments in this latter line a system of telegraphy without wires resulted, which I described in two scientific lectures in February and March, 1893. It is mechanically illustrated in diagram c, the upper part of which shows the electrical arrangement as I described it then, while the lower part illustrates its mechanical analogue. The system is extremely simple in principle. Imagine two tuning-forks F , F_1 , one at the sending- and the other at the receiving-station respectively, each having attached to its lower prong a minute piston p , fitting in a cylinder. Both the cylinders communicate with a large reservoir R , with elastic walls, which is supposed to be closed and filled with a light and incompressible fluid. By striking repeatedly one of the prongs of the tuning-fork F , the small piston p below would be vibrated, and its vibrations, transmitted through the fluid, would reach the distant fork F_1 , which is "tuned" to the fork F , or, stated otherwise, of exactly the same note as the latter. The fork F_1 would now be set vibrating, and its vibration would be intensified by the continued action of the distant

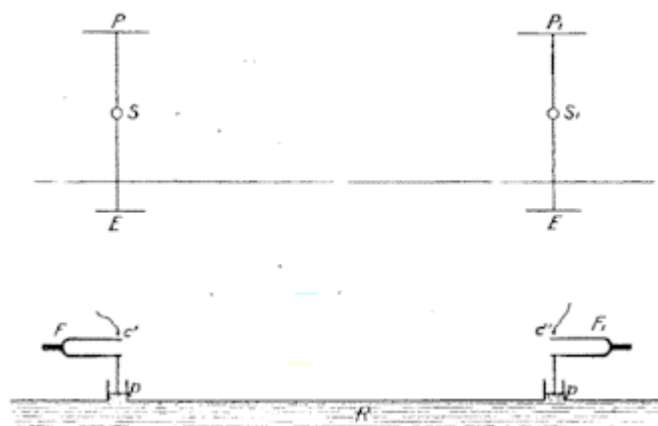


DIAGRAM c. "WIRELESS" TELEGRAPHY MECHANICALLY ILLUSTRATED.

fork F until its upper prong, swinging far out, would make an electrical connection with a stationary contact c'' , starting in this manner some electrical or other appliances which may be used for recording the signals. In this simple way messages could be exchanged between the two stations, a similar contact c' being provided for this purpose, close to the upper prong of the fork F , so that the apparatus at each station could be employed in turn as receiver and transmitter.

The electrical system illustrated in the upper figure of diagram c is exactly the same in principle, the two wires or circuits ESP and $E_1S_1P_1$, which extend vertically to a height, representing the two tuning-forks with the pistons attached to them. These circuits are connected with the ground by plates E , E_1 , and to two

elevated metal sheets P, P_1 , which store electricity and thus magnify considerably the effect. The closed reservoir R , with elastic walls, is in this case replaced by the earth, and the fluid by electricity. Both of these circuits are "tuned" and operate just like the two tuning-forks. Instead of striking the fork F at the sending-station, electrical oscillations are produced in the vertical sending- or transmitting-wire ESP , as by the action of a source S , included in this wire, which spread through the ground and reach the distant vertical receiving-wire $E_1S_1P_1$, exciting corresponding electrical oscillations in the same. In the latter wire or circuit is included a sensitive device or receiver S_1 , which is thus set in action and made to operate a relay or other appliance. Each station is, of course, provided both with a source of electrical oscillations S and a sensitive receiver S_1 , and a simple provision is made for using each of the two wires alternately to send and to receive the messages.

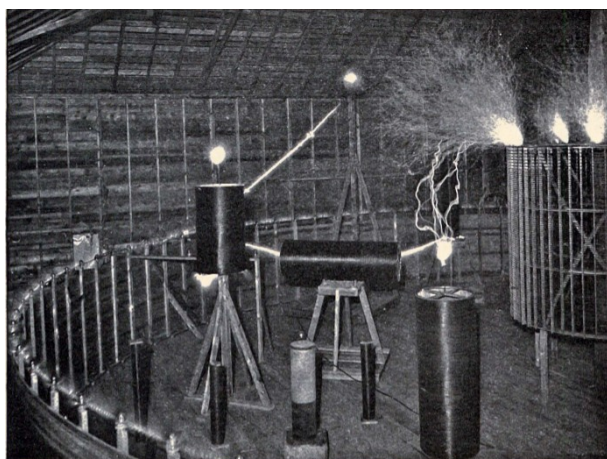


FIG. 5. PHOTOGRAPHIC VIEW OF THE COILS RESPONDING TO ELECTRICAL OSCILLATIONS.

The picture shows a number of coils, differently attuned and responding to the vibrations transmitted to them through the earth from an electrical oscillator. The large coil on the right, discharging strongly, is tuned to the fundamental vibration, which is fifty thousand per second; the two larger vertical coils to twice that number; the smaller white wire coil to four times that number, and the remaining small coils to higher tones. The vibrations produced by the oscillator were so intense that they affected perceptibly a small coil tuned to the twenty-sixth higher tone.

The exact attunement of the two circuits secures great advantages, and, in fact, it is essential in the practical use of the system. In this respect many popular errors exist, and, as a rule, in the technical reports on this subject circuits and appliances are described as affording these advantages when from their very nature it is evident that this is impossible. In order to attain the best results it is essential that the length of each wire or circuit, from the ground connection to the top, should be equal to one quarter of the wave-length of the electrical vibration in the wire, or else equal to that length multiplied by an odd number. Without the observation of this rule it is virtually impossible to prevent the interference and insure the privacy of messages. Therein lies the secret of tuning. To obtain the most satisfactory results it is, however, necessary to resort to electrical vibrations of low pitch. The Hertzian spark apparatus, used generally by experimenters, which produces oscillations of a very high rate, permits no effective tuning, and slight disturbances are sufficient to render an exchange of messages impracticable. But scientifically designed, efficient appliances allow nearly perfect adjustment.

An experiment performed with the improved apparatus repeatedly referred to, and intended to convey an idea of this feature, is illustrated in Fig. 5, which is sufficiently explained by its note.

These few paragraphs and pictures are all about resonance, tuning and the importance of the wire length.

Since I described these simple principles of telegraphy without wires I have had frequent occasion to note that the identical features and elements have been used, in the evident belief that the signals are being transmitted to considerable distance by "Hertzian" radiations. This is only one of many misapprehensions to which the investigations of the lamented physicist have given rise. About thirty-three years ago Maxwell, following up a suggestive experiment made by Faraday in 1845, evolved an ideally simple theory which intimately connected light, radiant heat, and electrical phenomena, interpreting them as being all due to vibrations of a hypothetical fluid of inconceivable tenuity, called the ether. No experimental verification was arrived at until Hertz, at the suggestion of Helmholtz, undertook a series of experiments to this effect. Hertz proceeded with extraordinary ingenuity and insight, but devoted little energy to the perfection of his old-fashioned apparatus. The consequence was that he failed to observe the important function which the air played in his experiments, and which I subsequently discovered. Repeating his experiments and reaching different results, I ventured to point out this oversight. The strength of the proofs brought forward by Hertz in support of Maxwell's theory resided in the correct estimate of the rates of vibration of the circuits he used. But I ascertained that he could not have obtained the rates he thought he was getting. The vibrations with identical apparatus he employed are, as a rule, much slower, this being due to the presence of air, which produces a dampening effect upon a rapidly vibrating electric circuit of high pressure, as a fluid does upon a vibrating tuning-fork. I have, however, discovered since that time other causes of error, and I have long ago ceased to look upon his results as being an experimental verification of the poetical conceptions of Maxwell. The work of the great German physicist has acted as an immense stimulus to contemporary electrical research, but it has likewise, in a measure, by its fascination, paralysed the scientific mind, and thus hampered independent inquiry. Every new phenomenon which was discovered was made to fit the theory, and so very often the truth has been unconsciously distorted.

Tesla is very careful in saying that Maxwell's theory is probably wrong. But in later articles (already quoted)

he says so more directly. The most important fact that Maxwell got wrong, according to Tesla, is that Maxwell says that electric (and magnetic) effects are caused by an ether that behaves like an incompressible fluid, while Tesla says these are caused by a gaseous medium, and also that Maxwellian radiations are transverse while Tesla believes them to be longitudinal. As the top of a resonating HV coil rapidly changes polarity, it alternatively attracts and repels electric charges in the air. To understand this is important for anyone who would like to understand the TMT and that is why Tesla stresses this phenomenon, which of course results in "sound waves of electrified air" as he calls it in his article of Dec 21st, 1892.

When I advanced this system of telegraphy, my mind was dominated by the idea of effecting communication to any distance through the earth or environing medium, the practical consummation of which I considered of transcendent importance, chiefly on account of the moral effect which it could not fail to produce universally. As the first effort to this end I proposed at that time, to employ relay-stations with tuned circuits, in the hope of making thus practicable signalling over vast distances, even with apparatus of very moderate power then at my command. I was confident, however, that with properly designed machinery signals could be transmitted to any point of the globe, no matter what the distance, without the necessity of using such intermediate stations. I gained this conviction through the discovery of a singular electrical phenomenon, which I described early in 1892, in lectures I delivered before some scientific societies abroad, and which I have called a "rotating brush." This is a bundle of light which is formed, under certain conditions, in a vacuum-bulb, and which is of a sensitiveness to magnetic and electric influences bordering, so to speak, on the supernatural. This light-bundle is rapidly rotated by the earth's magnetism as many as twenty thousand times per second, the rotation in these parts being opposite to what it would be in the southern hemisphere, while in the region of the magnetic equator it should not rotate at all. In its most sensitive state, which is difficult to obtain, it is responsive to electric or magnetic influences to an incredible degree. The mere stiffening of the muscles of the arm and consequent slight electrical change in the body of an observer standing at some distance from it, will perceptibly affect it. When in this highly sensitive state it is capable of indicating the slightest magnetic and electric changes taking place in the earth. The observation of this wonderful phenomenon impressed me strongly that communication at any distance could be easily effected by its means, provided that apparatus could be perfected capable of producing an electric or magnetic change of state, however small, in the terrestrial globe or environing medium.

The question that comes to mind is this: if the device is so sensitive that the stiffening of a muscle disturbs it, how do you prevent all the disturbing influences and pick up only those that you desire? Maybe Tesla wants to tell us something about the Earth's magnetism rotating it 20,000 times per second (how did Tesla measure this?). But what it is, I am not sure. This remains an obscure passage, but fortunately the only one.

DEVELOPMENT OF A NEW PRINCIPLE

—THE ELECTRICAL OSCILLATOR—PRODUCTION OF IMMENSE ELECTRICAL MOVEMENTS— THE EARTH RESPONDS TO MAN—INTERPLANETARY COMMUNICATION NOW PROBABLE.

I resolved to concentrate my efforts upon this venturesome task, though it involved great sacrifice, for the difficulties to be mastered were such that I could hope to consummate it only after years of labour. It meant delay of other work to which I would have preferred to devote myself, but I gained the conviction that my energies could not be more usefully employed; for I recognized that an efficient apparatus for the production of powerful electrical oscillations, as was needed for that specific purpose, was the key to the solution of other most important **electrical and, in fact, human problems**. Not only was communication, to any distance, without wires possible by its means, but, likewise, the transmission of energy in great amounts, the burning of the atmospheric nitrogen, the production of an efficient illuminant, and many other results of inestimable scientific and industrial value. Finally, however, I had the satisfaction of accomplishing the task undertaken by the use of a new principle, the virtue of which is based on the marvellous properties of the electrical

Here Tesla relates *electrical to human problems*, which is a key to understand the title of this article: "The Problem of increasing Human Energy". "The Problem of increasing Electrical Energy"

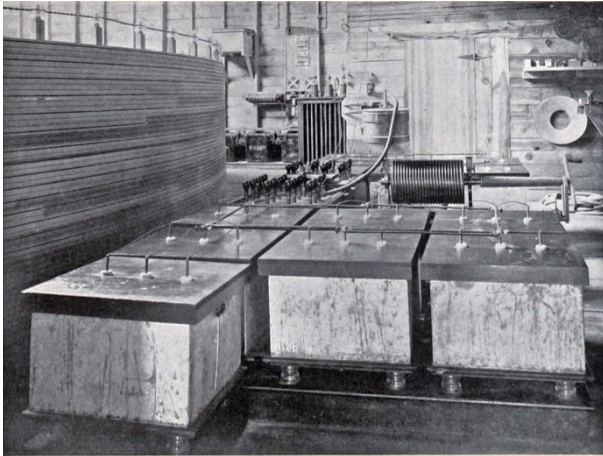


FIG. 6. PHOTOGRAPHIC VIEW OF THE ESSENTIAL PARTS OF THE ELECTRICAL OSCILLATOR USED IN THE EXPERIMENTS DESCRIBED



FIG. 7. EXPERIMENT TO ILLUSTRATE AN INDUCTIVE EFFECT OF AN ELECTRICAL OSCILLATOR OF GREAT POWER.

The photograph shows three ordinary incandescent lamps lighted to full candle-power by currents induced in a local loop consisting of a single wire forming a square of fifty feet each side, which includes the lamps, and which is at a distance of one hundred feet from the primary circuit energized by the oscillator. The loop likewise includes an electrical condenser, and is exactly attuned to the vibrations of the oscillator, which is worked at less than five percent of its total capacity.

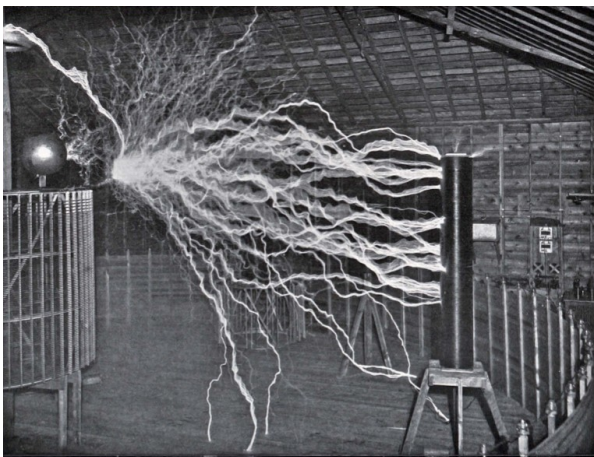


FIG. 8. EXPERIMENT TO ILLUSTRATE THE CAPACITY OF THE OSCILLATOR FOR PRODUCING ELECTRICAL EXPLOSIONS OF GREAT POWER.

Note to Fig. 8.—The coil, partly shown in the photograph, creates an alternative movement of electricity from the earth into a large reservoir and back at a rate of one hundred thousand alternations per second. The adjustments are such that the reservoir is filled full and bursts at each alternation just at the moment when the electrical pressure reaches the maximum. The discharge escapes with a deafening noise, striking an unconnected coil twenty-two feet away, and creating such a commotion of electricity in the earth that sparks an inch long can be drawn from a water main at a distance of three hundred feet from the laboratory.

condenser. One of these is that it can discharge or explode its stored energy in an inconceivably short time. Owing to this it is unequalled in explosive violence. The explosion of dynamite is only the breath of a consumptive compared with its discharge. It is the means of producing the strongest current, the highest electrical pressure, the greatest commotion in the medium. Another of its properties, equally valuable, is that its discharge may vibrate at any rate desired up to many millions per second.

I had arrived at the limit of rates obtainable in other ways when the happy idea presented itself to me to resort to the condenser. I arranged such an instrument so as to be charged and discharged alternately in rapid succession through a coil with a few turns of stout wire, forming the primary of a transformer or induction-coil. Each time the condenser was discharged the current would quiver in the primary wire and induce corresponding oscillations in the secondary. Thus a transformer or induction-coil on new principles was evolved, which I have called "the electrical oscillator," partaking of those unique qualities which characterize the condenser, and enabling results to be attained impossible by other means. Electrical effects of any desired character and of intensities undreamed of before are now easily producible by perfected apparatus of this kind, to which frequent reference has been made, and the essential parts of which are shown in Fig. 6. For certain purposes a strong inductive effect is required; for others the greatest possible suddenness; for others again, an exceptionally high rate of vibration or extreme pressure; while for certain other objects immense electrical movements are necessary. The photographs in Figs. 7, 8, 9, and 10, of experiments performed with such an oscillator, may serve to illustrate some of these features and convey an idea of the magnitude of the effects actually produced. The completeness of the titles of the figures referred to makes a further description of them unnecessary.

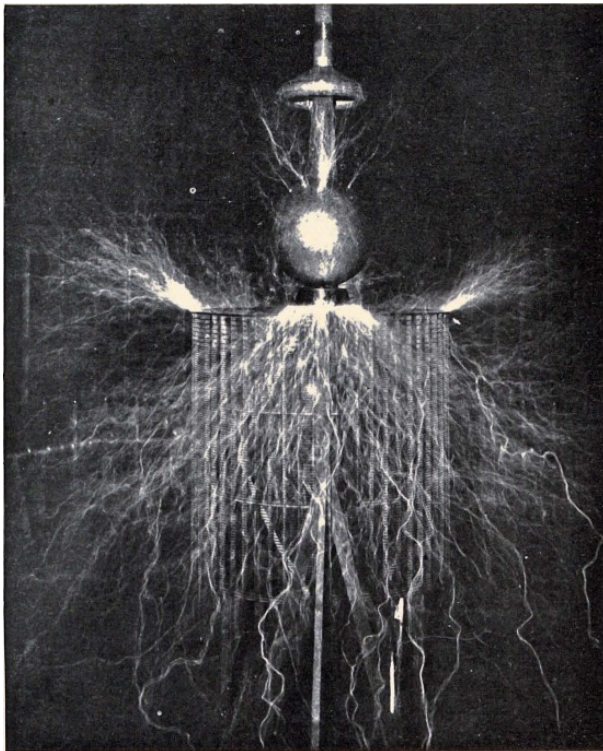


FIG. 9. EXPERIMENT TO ILLUSTRATE THE CAPACITY ON THE OSCILLATOR FOR CREATING A GREAT ELECTRICAL MOVEMENT.

The ball shown in the photograph, covered with a polished metallic coating of twenty square feet of surface, represents a large reservoir of electricity, and the inverted tin pan underneath, with a sharp rim, a big opening through which the electricity can escape before filling the reservoir. The quantity of electricity set in movement is so great that, although most of it escapes through the rim of the pan or opening provided, the ball or reservoir is nevertheless alternately emptied and filled to over-flowing (as is evident from the discharge escaping on the top of the ball) one hundred and fifty thousand times per second.

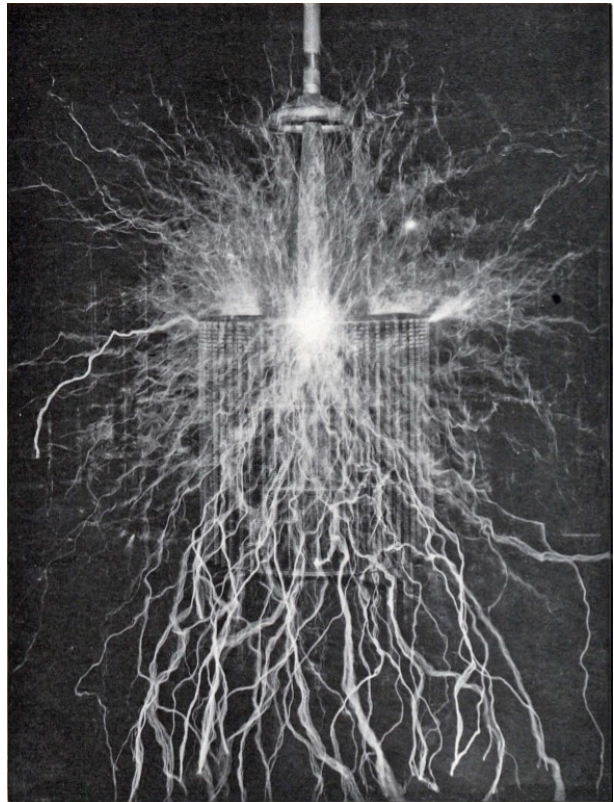


FIG. 10. PHOTOGRAPHIC VIEW OF AN EXPERIMENT TO ILLUSTRATE AN EFFECT OF AN ELECTRICAL OSCILLATOR DELIVERING ENERGY AT A RATE OF SEVENTY-FIVE THOUSAND HORSE-POWER.

The discharge, creating a strong draft owing to the heating of the air, is carried upward through the open roof of the building. The greatest width across is nearly seventy feet. The pressure is over twelve million volts, and the current alternates one hundred and thirty thousand times per second.

Here Tesla tells us what can be done with capacitors and high voltage discharges of the same and illustrates it with some pictures. The explanation below Fig 9 is particularly interesting as it helps us understanding how Tesla sees electricity.

However extraordinary the results shown may appear, they are but trifling compared with those which are attainable by apparatus designed on these same principles. I have produced electrical discharges the actual path of which, from end to end, was probably more than one hundred feet long; but it would not be difficult to reach lengths one hundred times as great. I have produced electrical movements occurring at the rate of approximately one hundred thousand horse-power, but rates of one, five, or ten million horse-power are easily practicable. In these experiments effects were developed incomparably greater than any ever produced by human agencies, and yet these results are but an embryo of what is to be.

One should keep in mind that power here is energy per time interval. This means that one can increase the power either by using more energy or by reducing the time interval.

That communication without wires to any point of the globe is practicable with such apparatus would need no demonstration, but through a discovery which I made I obtained absolute certitude. Popularly explained, it is exactly this: When we raise the voice and hear an echo in reply, we know that the sound of the voice must have reached a distant wall, or boundary, and must have been reflected from the same. Exactly as the sound, so an electrical wave is reflected, and the same evidence which is afforded by an echo is offered by an electrical phenomenon known as a "stationary" wave—that is, a wave with fixed nodal and ventral regions. Instead of sending sound-vibrations toward a distant wall, I have sent electrical vibrations toward the remote boundaries of the earth, and instead of the wall the earth has replied. In place of an echo I have obtained a stationary electrical wave, a wave reflected from afar.

This was in 1899 when plan B was abandoned for plan C, as explained earlier.

Stationary waves in the earth mean something more than mere telegraphy without wires to any distance. They will enable us to attain many important specific results impossible otherwise. For instance, by their use we may produce at will, from a sending-station, an electrical effect in any particular region of the globe; we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, or its speed; or we may send over the earth a wave of electricity travelling at any rate we desire, from the pace of a turtle up to lightning speed.

With these developments we have every reason to anticipate that in a time not very distant most telegraphic messages across the oceans will be transmitted without cables. For short distances we need a "wireless" telephone, which requires no expert operators. The greater the spaces to be bridged, the more rational becomes communication without wires. The cable is not only an easily damaged and costly instrument, but it limits us in the speed of transmission by reason of a certain electrical property inseparable from its construction. A properly designed plant for effecting communication without wires ought to have many times the working capacity of a cable, while it will involve incomparably less expense. Not a long time will pass, I believe, before communication by cable will become obsolete, for not only will signalling by this new method be quicker and cheaper, but also much safer. By using some new means for isolating the messages which I have contrived, an almost perfect privacy can be secured.

I have observed the above effects so far only up to a limited distance of about six hundred miles, but inasmuch as there is virtually no limit to the power of the vibrations producible with such an oscillator, I feel quite confident of the success of such a plant for effecting transoceanic communication. Nor is this all. My measurements and calculations have shown that it is perfectly practicable to produce on our globe, by the use of these principles, an electrical movement of such magnitude that, without the slightest doubt, its effect will be perceptible on some of our nearer planets, as Venus and Mars. Thus from mere possibility interplanetary communication has entered the stage of probability. In fact, that we can produce a distinct effect on one of these planets in this novel manner, namely, by disturbing the electrical condition of the earth, is beyond any doubt. This way of effecting such communication is, however, essentially different from all others which have so far been proposed by scientific men. In all the previous instances only a minute fraction of the total energy reaching the planet—as much as it would be possible to concentrate in a reflector—could be utilized by the supposed observer in his instrument. But by the means I have developed he would be enabled to concentrate the larger portion of the entire energy transmitted to the planet in his instrument, and the chances of affecting the latter are thereby increased many millionfold.

The most probable explanation here, is that Tesla intended to use the z-pinch effect to emit a thin ray of electrified particles, such as he describes later as his 'peace ray', dubbed 'death ray' by the media.

Besides machinery for producing vibrations of the required power, we must have delicate means capable of revealing the effects of feeble influences exerted upon the earth. For such purposes, too, I have perfected new methods. By their use we shall likewise be able, among other things, to detect at considerable distance the presence of an iceberg or other object at sea. By their use, also, I have discovered some terrestrial phenomena still unexplained. That we can send a message to a planet is certain, that we can get an answer is probable: man is not the only being in the Infinite gifted with a mind.

**TRANSMISSION OF ELECTRICAL ENERGY TO ANY DISTANCE WITHOUT WIRES
—NOW PRACTICABLE—THE BEST MEANS OF INCREASING THE FORCE ACCELERATING
THE HUMAN MASS.**

The most valuable observation made in the course of these investigations was the extraordinary behaviour of the atmosphere toward electric impulses of excessive electromotive force. The experiments showed that the air at the ordinary pressure became distinctly conducting, and this opened up the wonderful prospect of transmitting large amounts of electrical energy for industrial purposes to great distances without wires, a possibility which, up to that time, was thought of only as a scientific dream. Further investigation revealed the important fact that the conductivity imparted to the air by these electrical impulses of many millions of volts increased very rapidly with the degree of rarefaction, so that air strata at very moderate altitudes, which are easily accessible, offer, to all experimental evidence, a perfect conducting path, better than a copper wire, for currents of this character.

Thus the discovery of these new properties of the atmosphere not only opened up the possibility of transmitting, without wires, energy in large amounts, but, what was still more significant, it afforded the certitude that energy could be transmitted in this manner economically. In this new system it matters little—in fact, almost nothing—whether the transmission is effected at a distance of a few miles or of a few thousand miles.

While I have not, as yet, actually effected a transmission of a considerable amount of energy, such as would be of industrial importance, to a great distance by this new method, I have operated several model plants under exactly the same conditions which will exist in a large plant of this kind, and the practicability of the system is thoroughly demonstrated. The experiments have shown conclusively that, with two terminals maintained at an elevation of not more than thirty thousand to thirty-five thousand feet above sea-level, and with an electrical pressure of fifteen to twenty million volts, the energy of thousands of horse-power can be transmitted over distances which may be hundreds and, if necessary, thousands of miles. I am hopeful, however, that I may be able to reduce very considerably the elevation of the terminals now required, and with this object I am following up an idea which promises such a realization. There is, of course, a popular prejudice against using an electrical pressure of millions of volts, which may cause sparks to fly at distances of hundreds of feet, but, paradoxical as it may seem, the system, as I have described it in a technical publication, offers greater personal safety than most of the ordinary distribution circuits now used in the cities. This is, in a measure, borne out by the fact that, although I have carried on such experiments for a number of years, no injury has been sustained either by me or any of my assistants.

But to enable a practical introduction of the system, a number of essential requirements are still to be fulfilled. It is not enough to develop appliances by means of which such a transmission can be effected. The machinery must be such as to allow the transformation and transmission, of electrical energy under highly economic and practical conditions. Furthermore, an inducement must be offered to those who are engaged in the industrial exploitation of natural sources of power, as waterfalls, by guaranteeing greater returns on the capital invested than they can secure by local development of the property.

[Someone who just invested in the AC-distribution network, might not be over-joyous about the prospect of his investment turning to dust.](#)

From that moment when it was observed that, contrary to the established opinion, low and easily accessible strata of the atmosphere are capable of conducting electricity, the transmission of electrical energy without wires has become a rational task of the engineer, and one surpassing all others in importance. Its practical consummation would mean that energy would be available for the uses of man at any point of the globe, not in small amounts such as might be derived from the ambient medium by suitable machinery, but in quantities virtually unlimited, from waterfalls. Export of power would then become the chief source of income for many happily situated countries, as the United States, Canada, Central and South America, Switzerland, and Sweden. Men could settle down everywhere, fertilize and irrigate the soil with little effort, and convert barren deserts into gardens, and thus the entire globe could be transformed and made a fitter abode for mankind. It is highly probable that if there are intelligent beings on Mars they have long ago realized this very idea, which would explain the changes on its surface noted by astronomers. The atmosphere on that planet, being of considerably smaller density than that of the earth, would make the task much more easy.

[Mars may refer to the future. \(and Venus to the past\) See 1909-05-23: How to Signal to Mars:](#)

In the solar system Venus, the Earth, and Mars represent respectively, youth, full growth, and old age. Venus, with its mountains rising dozens of miles into the atmosphere, is probably as yet unfitted for such existence as ours, but Mars must have passed through all terrestrial states and conditions.

It is probable that we shall soon have a self-acting heat-engine capable of deriving moderate amounts of energy from the ambient medium. There is also a possibility—though a small one—that we may obtain

electrical energy direct from the sun. This might be the case if the Maxwellian theory is true, according to which electrical vibrations of all rates should emanate from the sun. I am still investigating this subject. Sir William Crookes has shown in his beautiful invention known as the "radiometer" that rays may produce by impact a mechanical effect, and this may lead to some important revelation as to the utilization of the sun's rays in novel ways. Other sources of energy may be opened up, and new methods of deriving energy from the sun discovered, but none of these or similar achievements would equal in importance the transmission of power to any distance through the medium. I can conceive of no technical advance which would tend to unite the various elements of humanity more effectively than this one, or of one which would more add to and more economize human energy. It would be the best means of increasing the force accelerating the human mass. The mere moral influence of such a radical departure would be incalculable. On the other hand if at any point of the globe energy can be obtained in limited quantities from the ambient medium by means of a self-acting heat-engine or otherwise, the conditions will remain the same as before. Human performance will be increased, but men will remain strangers as they were.

I anticipate that any, unprepared for these results, which, through long familiarity, appear to me simple and obvious, will consider them still far from practical application. Such reserve, and even opposition, of some is as useful a quality and as necessary an element in human progress as the quick receptivity and enthusiasm of others. Thus, a mass which resists the force at first, once set in movement, adds to the energy. The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of the planter—for the future. His duty is to lay the foundation for those who are to come, and point the way. He lives and labours and hopes with the poet who says:

Schaff' das Tagwerk meiner Hände,
Hohes Glück, dass ich's vollende!
Lass, o lass mich nicht ermatten!
Nein, es sind nicht leere Träume:
Jetzt nur Stangen, diese Bäume
Geben einst noch Frucht und Schatten.

Daily work—my hands' employment,
To complete is pure enjoyment!
Let, oh, let me never falter!
No! there is no empty dreaming:
Lo! these trees, but bare poles seeming,
Yet will yield both food and shelter!

Goethe's "Hope"

Translated by William Gibson, Com. U. S. N.

Voltage and Temperature

Georg Ohm, in his theories, treated electricity the same way heat was treated and thus derived his famous equation.

Maxwell too compared electricity to heat, most notably in his Treatise of Electricity and Magnetism Volume 1, Chapter 10, Conduction in Dielectrics, parts 331, 332, and 333.

Lord Kelvin and possibly J.J. Thompson also believed that there was an analogy, but most (save Ohm, which you will read about in part 333) knew that the analogy wasn't perfect.

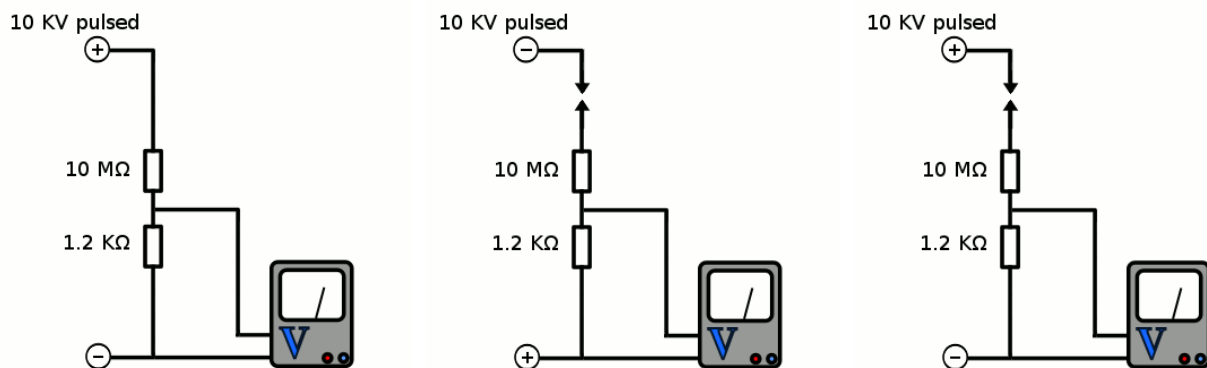
Tesla draws this very same analogy, but it looks as if Tesla believed there was some reality in it. Perhaps, in his view, 'the medium' surrounding atoms had this temperature, which is actually very close to our current understanding of electrons circling there.

How close are temperature and voltage related? We did some experiments with a IR-thermometer and a Tesla-coil and found some quite remarkable results. When the coil is switched on the IR-thermometer will indicate a temperature rise and when switching it off it will indicate a temperature drop.

With good static shielding of the thermometer, this effect gets less, but it remains and always shows the same pattern.



An IR-thermometer measures black-body radiation which is supposedly produced by photon-gas. This concept of photon-gas shows interesting similarities with Tesla's 'medium'.



reference: 12 KV

negative arcing: 126 KV(!)

positive arcing: 9.6 KV

Measuring the voltage on both sides of a discharge also shows something very much similar to evaporation processes; we see a voltage drop on the side where electrons leave and a sharp voltage rise on the electron receiving end. This reminds of evaporation where fast molecules go first, leaving slower molecules behind.

Some additional quotes 'n stuff

Most of what needed being said has been said in the previous chapters. Below just some interesting facts that I was afraid they would get lost....

On the Magnifying Transmitter construction

1904-01-01

This is, essentially, **a circuit of very high self-induction and small resistance** which in its arrangement, mode of excitation and action, may be said to be the diametrical opposite of a transmitting circuit typical of telegraphy by Hertzian or electromagnetic radiations.

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The electromagnetic radiations being reduced to an insignificant quantity, and proper conditions of resonance maintained, the circuit acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses and impressing upon the earth and its conducting atmosphere uniform harmonic oscillations of intensities which, as actual tests have shown, may be pushed so far as to surpass those attained in the natural displays of static electricity.

1905-01-07

It is, essentially, a freely vibrating secondary circuit of definite length, **very high self-induction and small resistance**, which has one of its terminals in intimate direct or inductive connection with the ground and the other with an elevated conductor, and upon which the electrical oscillations of a primary or exciting circuit are impressed under conditions of resonance.

1916

This [conical coil] shows the first single step I made toward the evolution of an apparatus which, given primary oscillations, will transform them into oscillations capable of penetrating the medium.

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This coil, which I have subsequently shown in my patents Nos. 645,576 and 649,621, in the form of a spiral, was, as you see, [earlier] in the form of a cone. The idea was to put the coil, with reference to the primary, in an inductive connection which was not close—we call it now a loose coupling—but free to permit a great resonant rise. That was the first single step, as I say, toward the evolution of an invention which I have called my "magnifying transmitter." That means, a circuit connected to ground and to the antenna, of **a tremendous electromagnetic momentum and small damping factor**, with all the conditions so determined that an immense accumulation of electrical energy can take place.

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Counsel

Mr. Tesla, at that point, what did you mean by electro-magnetic momentum?

Tesla

I mean that you have to have in the circuit, inertia. You have to have a large self-inductance in order that you may accomplish two things: First, a comparatively low frequency, which will reduce the radiation of the electromagnetic waves to a comparatively small value, and second, a great resonant effect. That is not possible in an antenna, for instance, of large capacity and small self-inductance. A large capacity and small self-inductance is the poorest kind of circuit which can be constructed; it gives a very small resonant effect. That was the reason why in my experiments in Colorado the energies were 1,000 times greater than in the present antennae.

Counsel

You say the energy was 1,000 times greater. Do you mean that the voltage was increased, or the current, or both?

Tesla

Yes [both]. To be more explicit, I take a very large self-inductance and a comparatively small capacity, which I have constructed in a certain way so that the electricity cannot leak out. I thus obtain a low frequency; but, as you know, the electromagnetic radiation is proportionate to the square root of the capacity divided by the self-induction. I do not permit the energy to go out; I accumulate in that circuit a tremendous energy. When the high potential is attained, if I want to give off electromagnetic waves, I do so, but I prefer to reduce those waves in quantity and pass a current into the earth, because electromagnetic wave energy is not recoverable while that [earth] current is entirely recoverable, being the energy stored in an elastic system¹⁶.

Counsel

What elastic system do you refer to?

Tesla

¹⁶ Note that Tesla refers to the Earth as an elastic system

I mean this: If you pass a current into a circuit with large self-induction¹⁷, and no radiation takes place, and you have a low resistance, there is no possibility of this energy getting out into space; therefore, the impressed impulses accumulate.

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But I knew also that even with a big capacity, if I connected it to the ground, through a generator, there still would be a frequency high enough to cause a considerable loss of energy in the production of the Hertz or electromagnetic waves; consequently, I had to employ also a very large inductance. Thus, my system was based on the proposition that I employ a very large inductance and a very large capacity and, furthermore, that I raise the potential of the source so high, by resonance, as to displace a quantity of electricity big enough to affect sensibly not only the near portions of the globe, a distance of 100 miles or so, but the whole globe.

In [my] Houston Street laboratory, I had already satisfied myself that it could be done. But in experimenting with these high potential discharges which I was always producing, I discovered a wonderful thing. I found, namely, that the air, which had been behaving before like an insulator, suddenly became like a conductor; that is, when subjected to these great electrical stresses, it broke down and I obtained discharges which were not accountable for by the theory that the air was an insulator. When I calculated the effects, I concluded that this must be due to the potential gradient at a distance from the electrified body, and subsequently I came to the conviction that it would be ultimately possible, without any elevated antenna -- with very small elevation -- to break down the upper stratum of the air and transmit the current by conduction.

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I should say so, and electricity, whatever it is, certainly it is incompressible because all our experiments show that.

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1919

Here was a stupendous possibility of achievement. If we could produce electric effects of the required quality, this whole planet and the conditions of existence on it could be transformed. The sun raises the water of the oceans and winds drive it to distant regions where it remains in a state of most delicate balance. If it were in our power to upset it when and wherever desired, this mighty life-sustaining stream could be at will controlled. We could irrigate arid deserts, create lakes and rivers and provide motive power in unlimited amounts. This would be the most efficient way of harnessing the sun to the uses of man. The consummation depended on our ability to develop electric forces of the order of those in nature. It seemed a hopeless undertaking, but I made up my mind to try it and immediately on my return to the United States, in the Summer of 1892, work was begun which was to me all the more attractive, because a means of the same kind was necessary for the successful transmission of energy without wires.

The first gratifying result was obtained in the spring of the succeeding year when I reached tensions of about 1,000,000 volts with my conical coil. That was not much in the light of the present art, but it was then considered a feat. Steady progress was made until the destruction of my laboratory by fire in 1895,

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*Profiting from this observation I resorted to the use of a high tension conductor with turns of considerable diameter sufficiently separated to keep down the distributed capacity, while at the same time preventing undue accumulation of the charge at any point. The application of this principle enabled me to produce pressures of 4,000,000 volts, which was about the limit obtainable in my new laboratory at Houston Street, as the discharges extended through a distance of 16 feet. **A photograph of this transmitter was published in the Electrical Review of November, 1898.**¹⁸*

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Well, then, in the first place, it is a resonant transformer with a secondary in which the parts, charged to a high potential, are of considerable area and arranged in space along ideal enveloping surfaces of very large radii of curvature, and at proper distances from one another thereby insuring a small electric surface density everywhere so that no leak can occur even if the conductor is bare. It is suitable for any frequency, from a few to many thousands of cycles per second, and can be used in the production of currents of tremendous volume and moderate pressure, or of smaller amperage and immense electromotive force. The maximum electric tension is merely dependent on the curvature of the surfaces on which the charged elements are situated and the area of the latter.

Judging from my past experience, as much as 100,000,000 volts are perfectly practicable. On the other hand currents of many thousands of amperes may be obtained in the antenna. A plant of but very moderate dimensions is required for such performances. Theoretically, a terminal of less than 90 feet in diameter is sufficient to develop an electromotive force of that magnitude while for antenna currents of from 2,000-4,000 amperes at the usual frequencies it need not be larger than 30 feet in diameter.

¹⁷ So the Earth is this large self induction with a low resistance.

¹⁸ Picture can not be found.

In a more restricted meaning this wireless transmitter is one in which the Hertz-wave radiation is an entirely negligible quantity as compared with the whole energy, under which condition the damping factor is extremely small and an enormous charge is stored in the elevated capacity. Such a circuit may then be excited with impulses of any kind, even of low frequency and it will yield sinusoidal and continuous oscillations like those of an alternator.

Patent 1,119,732; APPARATUS FOR TRANSMITTING ELECTRICAL ENERGY.

Claims:

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5. The means for producing excessive electric potentials consisting of a primary exciting circuit and a resonant secondary having its outer conducting elements which are subject to high tension arranged in proximity to each other and in surfaces of large radii of curvature so as to prevent leakage of the charge and attendant lowering of potential, substantially as described.

6. A circuit comprising a part upon which oscillations are impressed and another part for raising the tension by resonance, the latter part being supported on places of low electric density and having its outermost conducting boundaries arranged in surfaces of large radii of curvature, as set forth.

7. In apparatus for the transmission of electrical energy without wires a grounded circuit the outer conducting elements of which have a great aggregate area and are arranged in surfaces of large radii of curvature so as to permit the storing of a high charge at a small electric density and prevent loss through leakage, substantially as described.

Key points:

- a freely vibrating secondary circuit of definite length, very high self-induction and small resistance
- electromagnetic radiations are reduced to an insignificant quantity
- one of its terminals in intimate direct or inductive connection with the ground and the other with an elevated conductor of comparatively small capacity, constructed in a certain way so that the electricity cannot leak out
- the secondary circuit acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses
- an apparatus which, given primary oscillations (impulses of any kind and of any frequency), will transform them into sinusoidal and continuous oscillations capable of penetrating the earth and its conducting atmosphere

Note 1:

- A so called "extra coil" is not an essential part of this system. A Magnifying Transmitter can be built with a conical coil or a flat spiral without "extra coil"¹⁹.

Note 2:

"a freely vibrating secondary circuit" refers to "a work performing piston not connected to anything else" (1900 century magazine). But it vibrates at an enormous rate, so it can not include a huge induction?²⁰

Note 3:

Tesla writes "secondary circuit" not "secondary coil". This is easily overlooked.

Note 4:

- Tesla states that this "secondary circuit" has a "very high self-induction", but the coils he uses can not have a really high self-induction. This makes me think that Tesla is talking about the Earth which does have "a very high self-induction and small resistance" as he explains later on. However the addition "which has one of its terminals in intimate direct or inductive connection with the ground and the other with an elevated conductor" is hard to match with this assumption. In his Colorado Springs Notes and in the Long Island Notes you can see that the fourth coil (the one matching the above addition) has a very small inductance; not even 1 mH.

There are three possible ways out:

- Tesla thinks of a few mH (or there about) as a very high self-induction
- He is incomplete as it should read: "a freely vibrating secondary circuit of definite length, very high self-induction and small resistance (i.e. the Earth), *including a coil* which has one of its terminals in intimate direct or inductive connection with the ground and the other with an elevated conductor", or something similar.
- This circuit is not built using a conductor in the common sense. In an article of March 1934 Tesla gives us a hint that this may be the case. As we are unfamiliar with this phenomenon we can not estimate its inductance.

The final solution will have to be the second option.

A standard resonant transformer can only be excited by using certain very specific frequencies and it will produce a high voltage at exactly that same frequency. Here however, Tesla states that that the exciting

¹⁹ As is shown in the "Rare Notes"

²⁰ It produces a high frequency standing wave in the Earth (= high inductance)

impulses may be of a widely different character while the output will be a pure harmonic wave. This is a key difference with an ordinary Tesla coil.

How can this be accomplished?

This is because of the secondary circuit, which is free to vibrate in its natural rhythm. It is excited by the primary circuit, much like we do with a 50 Hz AC in the primary circuit of an ordinary Tesla-coil.

On Earth conductivity

1916:

When you think of resistance you imagine, naturally, that you have a long, thin conductor; but remember that while resistance is directly proportionate to length, it is inversely proportionate to the section. It is a quality that depends on a ratio. If you take a small sphere of the same size of a pea, and compare its length with its section, you would find a certain resistance. Now you extend this pea to the size of the earth, and what is going to happen? While the length increases, say a thousand times or a million times, the section increases with the square of the linear dimensions, so that the bigger this thing is the less resistance it has.

At first earth does not seem to be a very good conductor for electrical currents. Typical values range from 10 to 1000 Ωm , but this concerns just the upper layer. A large part of this upper layer is covered with sea water, which has a typical resistivity of 0.2 Ωm and at a depth of 100-200 Km the earth resistivity is 40 Ωm or less. A study of basaltic rock melts shows specific resistivities of 0.5 Ωm . Finally in the upper part of the lower crust there appears to be a highly conductive layer, the lower half of the lower crust seems to be moderately resistive, while the Earth mantle seems to be moderately conductive.

If we assume an average of $\rho=10 \Omega\text{m}$ and consider the Earth as a wire of varying thickness, then to get an

idea, the average conductive surface $\frac{\frac{4}{3}\pi r^3}{2r} = \frac{2}{3}\pi r^2 = 8.48826 \times 10^{13} \text{m}^2$ while the length is $2r =$

12,732,395 m. If we use $C = 2\pi r = 40,000,000 \text{m}$ for circumference, we get an electrical resistance of

$$\frac{2r}{\frac{2}{3}\pi r^2} \times \rho = \frac{3}{\pi r} \times \rho = \frac{6\rho}{C} = 1.5 \mu\Omega.$$

This is about the same as a copper wire of 1 m length and 12 cm thick. From this we may conclude that the Earth is an exceptionally good conductor for electrical currents due to its size.

This is of course an over-simplification, for in reality the resistance is given by:

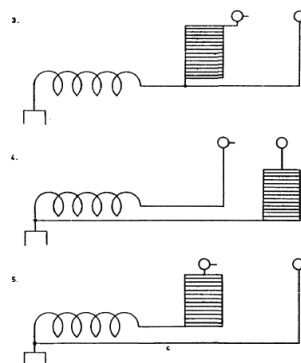
$$\int_{-r}^r \frac{\rho}{\pi(r^2 - x^2)} dx \quad \text{or} \quad 2 \frac{\rho}{\pi r^2} \int_0^r \frac{1}{\left(1 - \left(\frac{x}{r}\right)^2\right)} dx$$

From this we can only conclude that the resistance of the Earth is mostly determined by the resistance of the entry and exit points, exactly as Tesla says.

On Tesla's Magnifying Transmitter Diagrams

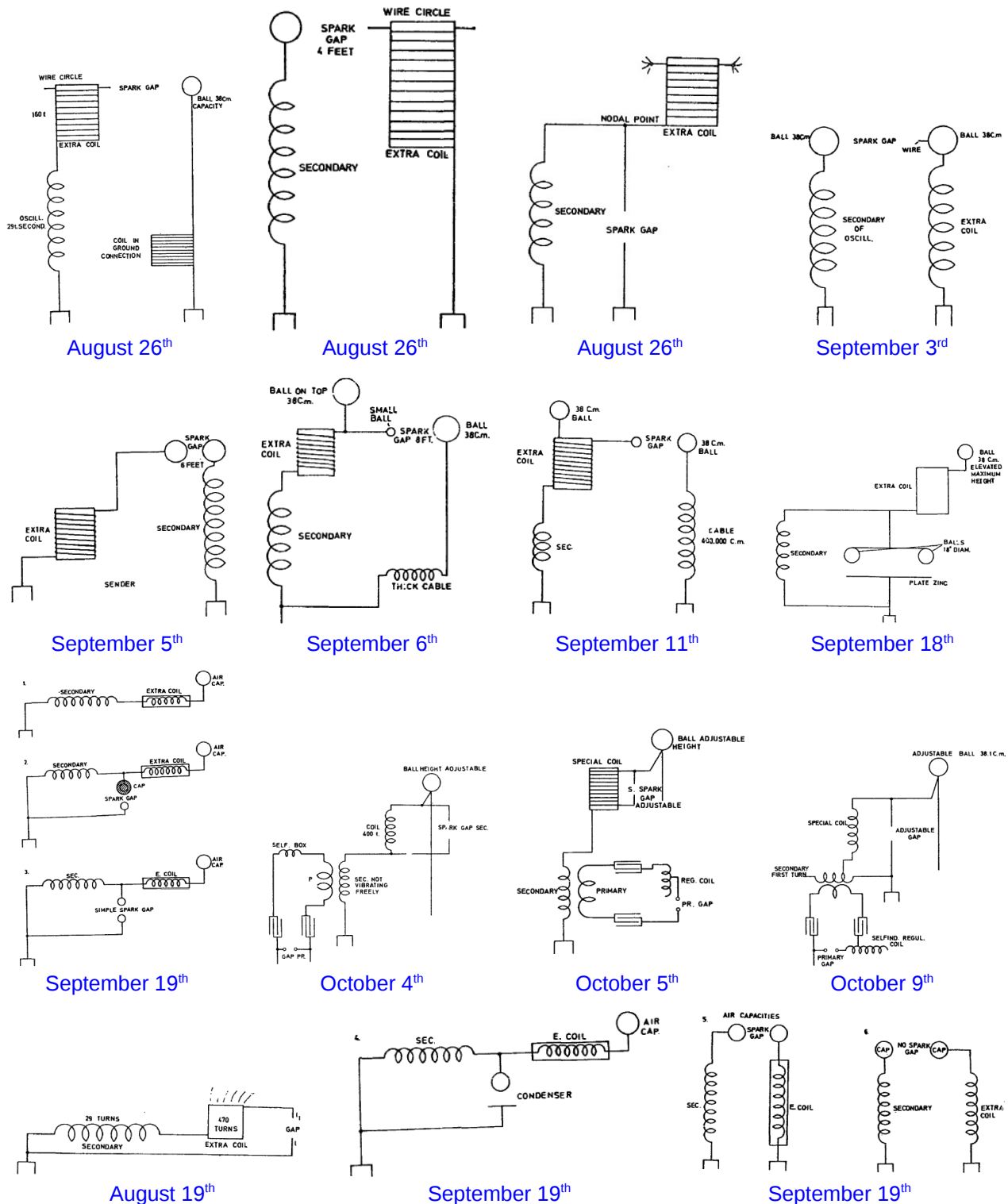
Apart from the diagrams shown thus far there is another source that we have barely touched upon; the Colorado Springs Notes and of course the Long Island Notes.

In the CSN of 30 July 1899 Tesla compares the following three set-ups:

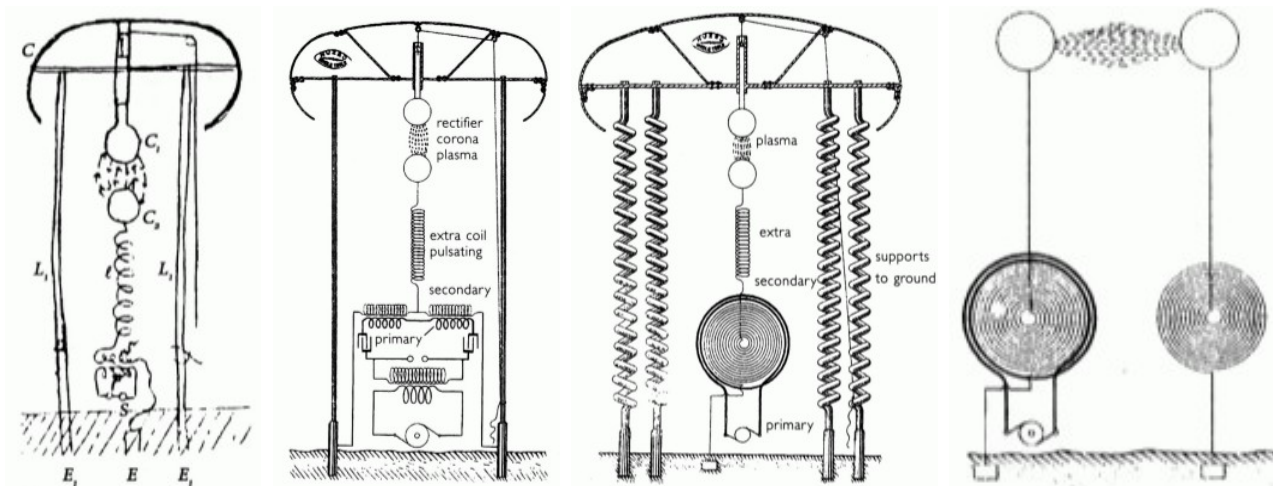


and concludes that the last one is by far the best to excite the Earth's electric charge.

The Colorado Spring Notes are most important because here the final circuit was decided upon. In these notes we find numerous diagrams to verify the working principles and find the exact parameters. Such as these:



It is easy to recognize the main theme from these diagrams, and this also matches with the "Rare Notes". The most clear examples are from August 19th and September 6th.



From all previous quotes it has become obvious that the main purpose of this scheme is to create a standing wave in the Earth's electrical charge.

The most clear is probably this quote from the 1916 Pre-hearing interview:

I have an idea that [you] will get the best picture of the process in my system of transmission if you will imagine that the earth is a reservoir, say, of fluid under pressure -- that is the potential energy -- and at my plant, operating a distant tuned circuit, I must open a valve and enable that energy to flow in. It is exactly that way. The energy is all conserved, whether it is vibrating or purely potential. Whatever the transmitter does in the receiver, the effect is simply to open a valve, as it were, and permit energy to flow in.

Conclusions on Tesla's Magnifying Transmitter

Time to wrap things up.

Electrical effects are caused by a gaseous medium and so the gas laws must apply. This means that electricity has a pressure (voltage), quantity (charge), volume (capacitance) and temperature. The last property seems to be completely overlooked by modern science. These properties should follow the same laws for electricity as for gasses, so:

$$P \cdot V = N \cdot k_B \cdot T$$

or in electrical terms:

$$V \cdot C = Q \cdot k_x \cdot T$$

(the Boltzman constant should be adjusted to the electrical units)

Notice that the unit of $P \cdot V$ is Joule (or Nm), so to make the match better we need to multiply the lower equation by V making it $V^2 \cdot C = Q \cdot k_x \cdot T$, then... C can be measured in m, so to compare it with a volume it should be multiplied by an area which we can borrow from V , changing it to field strength and to make Q dimensionless we divide it by the elementary charge as in:

$$\left(\frac{V^2}{d^2}\right) \cdot C \cdot A = \left(\frac{Q}{q_e}\right) \cdot k_x \cdot T$$

Now we see that V^2 compares to force (EMF). Meditating over this may result in a better understanding of the underlying mechanism, but it is beyond the scope of this paper.

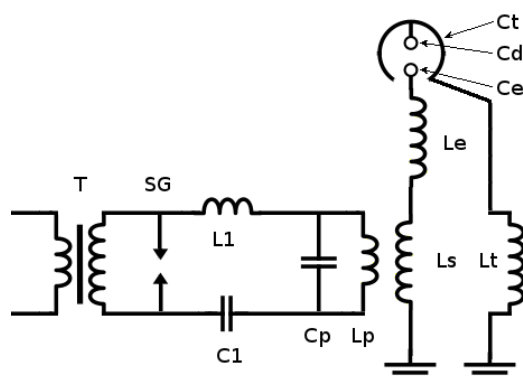
In space this electron temperature is low.

Every star can be seen as an electrode under a very high electrical pressure in a vacuum and thus it emits PCR's.

In space these rays interact with all kind of matter producing bremsstrahlung (SCR).

On Earth these PCR's heat the Earth and cause radioactive decay. This heat starts out as a rise in electron temperature. The electron temperature on Earth is determined by the intensity of PCR's and the properties of the Earth (size and mass) and is therefore fairly constant.

This results in a temperature difference across our atmosphere, a high electron temperature near the Earth (which we see as a negative potential) and a low electron temperature at high altitudes (seen as a positive potential), and heat being conducted upward. This flow of electron heat we see as an electric current (of 1800 Ampere worldwide) but it does not involve charge movement. If the Earth actually lost 1.8 KC of negative charge every second, its potential should rise more than 1 MV every hour. This is clearly not the case.



The above diagram shows a Tesla coil with a few peculiarities. First the spark gap is taken out of the resonating circuit $C_p L_p$. This is not an absolute necessity, it depends on the ratio BPM/f_{res} .

Second an extra coil L_e is used to further increase the voltage. As William Beaty noted, this will result in a relatively slow rise in potential. This slow rise helps the overall process, by producing less heat.

The discharge between C_e and C_d acts as an expansion nozzle, cooling the electricity.

This discharge has little outside pressure (read potential) because the charges move in 1 direction, while in

the surrounding medium the electron temperature (chaotic movement) causes an electrical pressure. Thus the charges outside the discharge force themselves into the discharge. Once inside they get drawn along by the magnetic and electric fields. Thus they do not increase the electron temperature of the discharge, but instead support the magnetic field and the discharge keeps attracting more charge from the surrounding medium.

So the PCR provides electron-heat to the Earth, the Earth provides electron-heat to our atmosphere and this heat is collected by Tesla's Magnifying Transmitter.

In all probability the PCR will maintain a constant electron temperature for the Earth, no matter how much of this heat we consume. And thus we have found a way to hook up our machinery to the wheelwork of Nature.

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