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POWER AND RESONANCE

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Issue #25

"A LIGHTING MACHINE OF NOVEL PRINCIPLES"



"A machine built on novel and original lines is about to be placed on the market. It consists of a turbine and electric generator, both employing basically new principles in construction and operation, and intimately associated to constitute a unit. The former has been pronounced revolutionary in design and performance. It is simplicity itself..." Nikola Tesla

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CLEAN ENERGY NOW!

Issue #25

Dedicated to Tesla and his Prime Movers

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TEBA News is the official publication of the TESLA ENGINE BUILDERS ASSOCIATION (TEBA), an educational organization dedicated to Nikola Tesla and his Prime Movers. Research and dissemination of information on the history, theory, construction, and operation of Tesla Turbo Machinery, also referred to as the Tesla Engine or Tesla Turbine. Coverage is also given to Tesla's reciprocating engine referred to as the oscillating motor. Pumping applications are also considered.

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Faster Than Light — It may come as a shock, to | radio, television, power transmission, the inducmost students of science, to learn that there are | tion motor, and the robot, and the discoverer of

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ABOUT THE COVER

Featured on the cover is a rare photograph, previously unavailable, depicting Tesla's turbo alternator fully assembled. Photographs of this turbine disassembled have previously been published in TEBA News #20. This machine was originally intended to power the head lamp of a steam locomotive. The turbine contains a six inch runner turning at approximately 30,000 rpm and is direct connected to a high speed alternator rated at one kilowatt.

As the speed and therefore frequency of an alternator increases its physical size decreases, while at the same time output capability increases.

Power output of the turbine is a function of the volume of the applied working fluid and its pressure. As this turbine's working fluid would be the relatively low pressure of auxiliary steam from the locomotive boiler, approximately 80 psi, output power is limited to that necessary to illuminate the locomotive's head lamp.

A single stage Tesla turbine can be operated efficiently up to 185 psi, with working fluid volume limited only to the input nozzle diameter. A turbine of this nature could easily produce an output of several hundred horsepower. Tesla claimed that his turbine rated at 110 hp, containing a 9.75 inch diameter runner would easily produce over 1,000 hp if provided with sufficient steam pressure and volume. Shaft diameter increase would also be required.

Volvo used a conventional gas turbine direct connected to a Tesla high speed alternator in their experimental "Environmental Concept Car" E.C.C.

They proved the concept of this configuration as workable in a hybrid vehicle (see TEBA News #23). The vehicle was not practical, however, as the bladed turbine is expensive and dangerous. The Tesla turbine resolves the problems associated with a bladed turbine and would make practical this type of vehicle.

Tesla Motors has given us half of the Tesla concept using Tesla electric induction motors for propulsion, using batteries. Their vehicles may be the perfect test bed for the implementation of a high speed Tesla gas turbine placed in the auxiliary "trunk." The Tesla gas turbine could operate on any liquid fuel with the overwhelming advantage that half of its fuel volume can be contaminated water!

EVERYDAY SCIENCE AND MECHANICS

Tesla Engine Builders Association TeslaEngine.org Faster Than Light!

NOVEMBER 1931

By HUGO GERNSBACK

It may come as a shock, to most students of science, to learn that there are still in the world some scientists who believe that there are speeds greater than that of light.

Since the advent of Einstein, most scientists and physicists have taken it for granted that speeds greater than 186,000 miles per second are impossible in the universe. Indeed, one of the principal tenets of the relativity theory is that the mass of a body increases with its speed, and would become infinite at the velocity of light. Hence, a greater velocity is impossible.

Among those who deny that this is true, there is Nikola Tesla, well known for his hundreds of important inventions. The induction motor and the system of distributing alternating current are but a few of his great contributions to modern science. In 1892, he made his historic experiments in Colorado; Where he manufactured, for the first time, artificial lightning bolts 100 feet long, and where he was able, by means of high-frequency currents, to light electric lamps at a distance of three miles without the use of any wires whatsoever.

Talking to me about these experiments recently, Dr. Tesla revealed that he had made a number of surprising discoveries in the high-frequency electric field and that, in the course of these experiments, he had become convinced that he propagated frequencies at speeds higher than the speed of light.

In his patent No. 787,412, filed May 16, 1900, Tesla showed that the current of his transmitter passed over the earth's surface with a speed of 292,830 miles per second, while radio waves proceed with the velocity of light. Tesla holds, however, that our present "radio" waves are not true Hertzian waves, but really sound waves.

He informs me, further, that he knows of speeds several times greater than that of light, and that he has designed apparatus with which he expects to project so-called electrons with a speed equal to twice that of light.

Coming from so eminent a source, the statement should be given due consideration. After all, abstract mathematics is one thing, and actual experimentation is another. Not so many years ago, one of the world's greatest scientists of the time proved mathematically that it is impossible to fly a heavier-than-air machine. Yet we are flying plenty of airplanes today.

Tesla contradicts a part of the relativity theory emphatically, holding that mass is unalterable; otherwise, energy could be produced from nothing, since the kinetic energy acquired in the fall of a body would be greater than that necessary to lift it at a small velocity.

It is within the bounds of possibility that Einstein's mathematics of speeds greater than light may be wrong. Tesla has been right many times during the past, and he may be proven right in the future. In any event, the statement that there are speeds faster than light is a tremendous one, and opens up entirely new vistas to science.

While it is believed by many scientists, today, that the force of gravitation is merely another manifestation of electromagnetic waves, there have, as yet, been no proofs of this. There are, of course, many obscure things about gravitation that we have not, as yet, fathomed.

At one time, it was believed by many scientists that the speed of gravitation is instantaneous throughout the universe. This is simply another way of putting it that there are speeds greater than light.

Yet. from a strictly scientific viewpoint, no one today has any idea how fast gravitational waves—always providing that the force is in waves—travel. If the moon, for instance, were to explode at a given moment, how long would it be before the gravitational disturbance would be felt on earth? Would the gravitational impulse or waves travel at the speed of light —that is,186,000 miles per second—or would the effect be instantaneous? We do not know.

The entire subject will no doubt arouse a tremendous interest in scientific circles. It is hoped that other scientists will be encouraged to investigate Dr. Tesla's far-reaching assertions; either to definitely prove or to disprove them.

W.I.M.P.

Not name calling here, this according to the nightly news, stands for Weakly Interactive Massive Particle. These particles are larger than photons. If I have my facts straight these particles compose 90% of the known universe and are constantly passing through us and the planet. The particles in the opinion of researchers are "ghost like" in that they have little effect on matter. To achieve this (in my opinion) they would have to travel faster than light. It seems to me these particles are the cosmic rays Tesla spoke of. Since they are obiviously moving faster than the posted speed limit they should represent a massive amount of energy. Since they compose 90% of all matter, does this not strongly resemble the aether, which Tesla and others have postulated? Paul Eitson \odot

ELECTRICAL EXPERIMENTOR

TESLA'S LIGHTNING PROTECTION

Since the introduction of the lightning rod over one hundred years ago by Benjamin Franklin, its adoption as a means of protection against destructive atmospheric discharges such as lightning bolts, has been practically universal. In a recent discussion on the subject of lightning protection. Dr. Nikola Tesla of New York, brings out many interesting facts not generally known concerning the real efficacy of the ordinary lightning rod as installed on houses, barns and public buildings all over the world.

Says, Dr. Tesla, "The efficacy of the ordinary lightning rod is to a certain degree unquestionably

with that induced within a considerable terrestrial area, and of no moment whatever in the process of dissipation. But it is true that the negatively charged air in the vicinity of the rod, rendered conductive thru the influence of the same, facilities the passage of the bolt. Therefore it increases the probability of a lightning discharge in the vicinity. The fundamental facts underlying this type of lightning rod are: First, it attracts lightning, so that it will be struck oftener than would be the building if it were not present; second, it renders harmless most but not all, of the discharges which it receives; third, by rendering the

established thru statistical records. but there is generally prevalent, nevertheless. a singular theoretical fallacy as to its operation, and its construction is radically defective in one feature, namely its typical pointed terminal." In his new form o f



air conductive and for other reasons, it is sometimes the cause of damage to neighboring objects: and fourth, on the whole, its power of preventing injury predominates, more or less. over the hazards it invites.

By contrast, Tesla's new lightning

lightning protecting rod and terminal here illustrated, Tesla avoids all such points on the metal parts facing skyward, and uses an entirely different form and arrangement of terminals.

In permitting leakage into the air, the needleshaped lightning rod is popularly believed to perform two functions: one to drain the ground of its negative electricity, the other to neutralize the positive electricity of the clouds. To some degree it does both. But a systematic study of electrical disturbances in the earth has made it palpably evident that the action of Franklin's conductor, as commonly interpreted, is chiefly illusionary. Actual measurement proves the quantity of electricity escaping even from many points, to be entirely insignificant when compared protector is founded on principles diametrically opposite. Its terminal has a large surface. It secures a very low density and preserves the insulating qualities of the ambient medium thereby minimizing leakage, and thus acting as a quasi-repellant to increase enormously the safety factor.

An understanding of but part of the truths relative to electrical discharges, and their misapplication due to the want of fuller appreciation has doubtless been responsible for the Franklin lightning rod taking its conventional pointed form, but theoretical considerations, and the important discoveries that have been make in the course of investigations with a Tesla wireless transmitter of great activity by which arcs of a volume and tension actually comparable

1918

to those occurring in nature were obtained, at once establish the fallacy of the hitherto type of rod is based and show the distinctive novelty of this new lightning protector.

Practical estimates of the electrical quantities concerned in natural disturbances show, moreover, how absolutely impossible are the functions attributed to the pointed lightning conductor. A single cloud may contain several billion electric units, or more, inducing in the earth an equivalent amount, which a number of lightning rods could not neutralize in many years. Particularly to instance conditions that may have to be met, reference is made to an actual case (in 1904) wherein it appears that upon one occasion approximately 12,000 strokes occurred within two hours, all within a radius of less than 31 miles from the place of observation.

But altho the pointed lightning rod is quite ineffective in the one respect noted, it has the property of attracting lightning to a high degree—first, on account of its shape and secondly, because it ionizes and renders conductive the surrounding air. This has been unquestionably established in long continued tests with the Tesla wireless transmitter above-mentioned, the inventor claims, and in this feature lies the chief disadvantage of the Franklin type of protector.

In Fig. A and Fig. B, different forms of such low density terminals and the arrangement of the same are illustrated. In Fig. A, there is a cast or spun metal shell of ellipsoidal outline, having on its underside a sleeve with a bushing of porcelain or other insulating material, adapted to be slipt tightly on a metal rod, which may be an ordinary lightning conductor. Fig. B shows another form of terminal made up of rounded or flat metal bars radiating from a central hub, which is supported directly on a metal rod and in electrical contact with the

same. The special object of this type is to reduce the wind resistance, but it is essential that the bars have a sufficient area to insure small electrostatic density, and also that they are close enough to make the aggregate capacity nearly equal to that of a continuous shell of the same outside dimensions. The general view of the building shows a cupola-shaped and earthed metal dome carried by a chimney, serving in this way the twofold practical purpose of hood and protector.

From the foregoing it will be clear that in all cases the new Tesla terminal prevents leakage of electricity and attendant ionization of the air. It is immaterial to this end whether it is insulated or not. Should it be struck the current will pass readily to the ground either directly or, as in Fig. A, thru a small air-gap between. But such an accident is rendered extremely improbable owing to the fact that there are everywhere points and projections on which the terrestrial charge attains a high density and where the air is ionized. Thus being so, it is not necessary to support it at a great height, but the ground connection should be made with the usual care and the conductor leading to it must be of as small a self-induction and resistance as practicable. Tesla has taken out a patent on this new lightning protector. \odot

ELECTRIC VEHICLES IN NORWAY

Electric vehicles are now receiving considerable attention and encouragement in Norway for every form of mechanical propulsion. Heretofore gasoline cars have been practically the only machines in use in the country. For several months past no gasoline has been received, and as there are but few electric cars in Norway, automobiles have practically disappeared. (*Ed. 1918*)



Tesla Patent US 01266175 May 14, 1918

Photo Credit: Richard Fisk

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CANADIAN PATENT: CA 434827

MAY 21, 1946

GAS TURBINE

ARTHUR H. MATTHEWS

This invention relates to gas turbines and the object is to provide a simple and efficient gas turbine which may be constructed of ordinary inexpensive metals and in which provision is made for adequate cooling with minimum loss of power and efficiency.

The commercial development of cheap and efficient gas turbines, especially in the smaller sizes

required for general use, has been retarded by reason of the fact that the gas turbines heretofore proposed must be constructed of relatively rare and expensive heat resistant metals or alloys, in order to withstand, for any considerable period, the destructive action of the high operating temperatures characteristic of such turbines. Gasturbines constructed of ordinary metals and equipped with heat dissipating water jackets, in accordance with preproposals, vious do not have the operating

not have the operating speed, efficiency, low-cost characteristics and other essential requisites necessary to justify wide-scale commercial production thereof, especially in the smaller sizes, suitable for general use in various fields in which other types of relatively small power plants are now being used.

An important feature of the gas turbine provided in accordance with my invention is that the rotor is of simple design and is free of vanes, buckets, or other resistance increasing projections which, as employed in prior types of gas-turbines, tend to decrease both the operating speed and the power output.

Another feature of the invention consists in the provision of a generally improved gas turbine in use of water jets which serve both as a cooling medium and as a motive fluid.

A still further feature of the invention consists in the provision of a jet-propelled or reaction type gasturbine in which the rotor comprises a simple disk-

shaped element provided with a peripheral channel into which jet of motive fluid are directed from nozzles or jets carried by a stator casing in which the rotor operates, at least one side wall of said channel in the form of jets which impinge against stationary buckets or vanes carried by the stator casing.

Other characteristic features and advantages of my

invention will be made apparent by the following detailed description of the accompanying drawings, in which—

Figure 1 is a vertical sectional view taken substantially along the line1-1 of figure 2;

and

Figure 2 is a sectional view taken substantially along the line 2-2 of Figure 1.

In these drawings the rotor and the stator-casing elements of my improved gas-turbine are respectively indicated at 5 and 6.

- The rotor 5 is shown as a simple disk fixed

to a shaft 7 which rotates in bearings 8 carried by opposite side walls of the stator-casing 6. The periphery of the rotor is recessed to provide an annular channel 9 into which jets of fluid are directed from nozzles or jet passages 10, 11, and 12 formed in a removable section 6a of the stator casing 6. At least one side wall of the channel 9 is provided with discharge ports 14 through which jet of the motive fluid supplied to said channel are discharged against stationary vanes or buckets 15 of the stator casing 6 to thereby effect jet reaction operation of the rotor. The motive fluid is discharged from stator-casing 6 through the exhaust outlet 17.

Part of the motive fluid supplied to the channel 9 of rotor 5 comprises hot products of combustion resulting from ignition of a combustible fuel mixture with a combustion chamber 19 provided in the removable cylinder section 6a. The fuel mixture is supplied to chamber 19 through a "Tesla" valve 20 and is ignited by a spark plug 21 or other suitable ignitor.



The resulting products of combustion escape from | I Claim: chamber 19 through jet passages 10 and are directed into the rotor channel 9.

Another part of the motive fluid supplied to the rotor consists of steam formed by vaporization of jets or water which are directed into the rotor channel 9 by the jet passages 11 and 12. The cooling action of the jets of water is sufficient to prevent heat destruction of ordinary metal used in the construction of the turbine. The water is preferably supplied to the jet passages 11 and 12 through "Tesla" type valves indicated at 22 and 23.

The peripheral wall of the stator casing 6 is provided with a series of expansion chambers 25 into which the steam resulting from vaporization of the water jets directed against the rotor is expanded to

increase the momentum imparted to the rotor.

The hot products of combustion directed into the rotor channel 9 by nozzle 10 constitute the main motive fluid which drives and heats the rotor. The water injected through the jet passages 11 an 12 serves primarilv as a cooling medium but, when converted into steam as described herein, also serves as a motive fluid and enables the turbine to be operated efficiently with a smaller amount of combustible fluid than would otherwise be required.

Combustion JUNE-23-1944 The chamber 19 is provided

with a removable cover or head 26 formed with a water jacket 27 by a suitable supply pipe (not shown) and passes from, thence through pipe 26 and valve 22 to water-jet passage 11. The valve 23 of waterjet passage 12 may be similarly connected to water jacket 27.

Having thus described what I now conceive to be the preferred embodiment of my invention it will be understood that various modifications may be resorted to within the scope and spirit of the invention as defined by the appended claims.

PRESENTATION OF THIS PATENT DOES NOT CONSTITUTE AN ENDORSEMENT **BY TESLAENGINE.ORG**

1. A gas-turbine comprising a rotor provided with a peripheral channel having discharge ports in one side wall thereof, a stationary casing enclosing said rotor and provided with jet-passages through which motive fluid is directed into said channel and stationary vanes or buckets in said casing located opposite the port side of said channel and positioned to receive the impact of jets of motive fluid discharged from said channel through said ports.

2. A gas-turbine as set forth in claim 1, including means for supplying hot products of combustion to at least one of said jet passages and means for supplying water to other side of said jet passages, said water serving primarily as a cooling medium which, when flashed into steam by contact with the rotor,



also serves as a motive fluid for driving the rotor.

3. A gas-turbine as set forth in claim 1, in which said rotor comprises a simple, substantially disk-shaped member having its periphery recessed to provide said channel.

4. A gas-turbine comprising a rotor provided with a peripheral channel having discharge ports in at least one side wall thereof, a stationary casing enclosing said rotor, the peripheral portion of said casing being provided with a withustonhaugh The series of jet passages and a series of expansion chambers, internal

stationary vanes or buckets carried by said casing and positioned to provide impact surfaces for jets of motive fluid discharged from said channel through said discharge ports, means, including at least one of said jet passages, for delivering to said channel a motive fluid consisting of hot products of combustion, means, including other of said jet passages, for delivering jets of cooling water to said channel, the arrangement being such that the cooling water delivered to said channel is flashed into steam which expands into said expansion chambers and assists in driving the rotor.

ATTORNEYS

5. A gas-turbine as set forth in claim 4, in which said hot products of combustion are produced in a combustion chamber forming part of said casing. \bigcirc

EVERYDAY SCIENCE AND MECHANICS

A MACHINE TO END WAR

A Famous Inventor, Picturing Life 100 Years from Now, Reveals an Astounding Scientific Venture Which He Believes Will Change the Course of History by NIKOLA TESLA

AS TOLD TO

George Sylvester Viereck

Nikola Tesla, now in his seventy eighth year, has been called the father of radio, television, power transmission, the induction motor, and the robot, and the discoverer of the cosmic ray. Recently he has announced a heretofore unknown source of energy present everywhere in unlimited amounts, and he is now working upon a device which he believes will

make war impracticable.

Tesla and Edison have often been represented as rivals. They were rivals, to a certain extent, in the battle between the alternating and direct current in which Tesla championed the former. He won: the great power plants at Niagara Falls and elsewhere are founded on the Tesla system. Otherwise the two men were merely opposites. Edison had a genius for practical inventions immediately applicable. Tesla, whose inventions were far ahead of the time, aroused antagonisms which delays the fruition of his ideas for years.

However, great physicists like Kelvin and Crookes spoke of his inventions as marvelous. "Tesla," said Professor A. E. Kennelly of Harvard University,

when the Edison medal was presented to the inventor, "set wheels going round all over the world.... What he showed was a revelation to science and art unto all time."

"Were we," remarks B. A. Behrend, distinguished author and engineer, "to seize and to eliminate the results of Mr. Tesla's work, the wheels of industry would cease to turn, our electric cars and trains would stop, our towns would be dark, our mills would be dead and idle. Forecasting is perilous. No man can look very far into the future. Progress and invention evolve in directions other than those anticipated. Such has been my experience, although I may flatter myself that many of the developments which I forecast have been verified by events in the first third of the twentieth century.



"It Seems That I Have Always Been Ahead Of My Time"

It seems that I I've always been ahead of my time. I had to wait nineteen years before Niagara was harnessed by my system, fifteen years before the basic inventions for wireless which I gave to the world in 1893 were applied universally. I announced the cosmic ray and my theory of radio activity in 1896. One of my most important discoveries -- terrestrial resonance -- which is the foundation of wireless power transmission and which I announced in 1899, is not understood even today. Nearly two years after I had flashed an electric current around the globe, Edison, Steinmetz, Marconi, and others declared that it would not be possible to transmit even signals by wireless across the Atlantic. Having anticipated so many important

developments, it is not without assurance that I attempt to predict what life is likely to be in the twentyfirst century.

Life is and will ever remain an equation incapable of solution, but it contains certain known factors. We may definitely say that it is a movement even if we do not fully understand its nature. Movement implies a body which is being moved and a force which propels it against resistance. Man, in the large, is a mass urged on by a force. Hence the general laws governing movement in the realm of mechanics are applicable to humanity.

There are three ways by which the energy, which determines human progress can be increased: First, we may increase the mass. This, in the case of humanity, would mean the improvement of living conditions, health, eugenics, etc. Second, we may reduce the frictional forces which impede progress, such as Ignorance, insanity, and religious fanaticism. Third, we may multiply the energy of the human mass by enchaining the forces of the universe, like those of the sun, the ocean, the winds and tides.

The first method increases food and well-being. The second tends to bring peace. The third enhances our ability to work and to achieve. There can be no progress that is not constantly directed toward increasing well-being, peace, and achievement. Here the mechanistic conception of life is one with the teachings of Buddha and Sermon on the Mount.

While I am not a believer in the orthodox sense, I commend religion, first, because every individual should have some ideal - religious, artistic, scientific, or humanitarian -- to give significance to his life. Second, because all the great religions contain wise prescriptions relating to the conduct of life, which hold good now as they did when they were promulgated.

There is no conflict between the ideal of religion and the ideal of science, but science is opposed to theological dogmas because science is founded on fact. To me, the universe is simply a great machine which never came into being and never will end. The human being is no exception to the natural order. Man, like the universe, is a machine. Nothing enters our minds or determines our actions which is not directly or indirectly a response to stimuli beating upon our sense organs from without. Owing to the similarity of our construction and the sameness of our environment, we respond in like manner to similar stimuli, and from the concordance of our reactions, understanding is born. In the course of ages, mechanisms of infinite complexity are developed, but what we call "soul" or "spirit," is nothing more than the sum of the functionings of the body. When this functioning ceases the "soul" or the "spirit" ceases likewise.

I expressed these ideas long before the behaviorists led by Pavlov in Russia and by Watson in the United States, proclaimed their new psychology. This apparently mechanistic conception is not antagonistic to an ethical conception of life. The acceptance by mankind at large of these tenants will not destroy religious ideals. Today Buddhism and Christianity are the greatest religions both in number of disciples and in importance. I believe that the essence of both will be the religion of the human race in the twenty-first century.

The year 2100 will see eugenics universally estab-

lished. In past ages, the law governing the survival of the fittest roughly weeded out the less desirable strains. Then man's new sense of pity began to interfere with the ruthless workings of nature. As a result, we continue to keep alive and to breed the unfit. The only method compatible with our notions of civilization and the race is to prevent the breeding of the unfit by sterilization and the deliberate guidance of the mating instinct. Several European countries and a number of states of the American Union sterilize the criminal and the insane. This is not sufficient. The trend of opinion among eugenicists is that we must make marriage more difficult. Certainly no one who is not a desirable parent should be permitted to produce progeny. A century from now it will no more occur to a normal person to mate with a person eugenically unfit than to marry a habitual criminal.

Hygiene, physical culture will be recognized branches of education and government. The Secretary of Hygiene or Physical Culture will be far more important in the cabinet of the President of the United States who holds office in the year 2035 than the Secretary of War. The pollution of our beaches such as exists today around New York City will seem as unthinkable to our children and grandchildren as life without plumbing seems to us. Our water supply will be far more carefully supervised, and only a lunatic will drink unsterilized water.

More people die or grow sick from polluted water than from coffee, tea, tobacco, and other stimulants. I myself eschew all stimulants. I also practically abstain from meat. I am convinced that within a century coffee, tea, and tobacco will be no longer in voque. Alcohol, however, will still be used. It is not a stimulant but a veritable elixir of life. The abolition of stimulants will not come about forcibly. It will simply be no longer fashionable to poison the system with harmful ingredients. Bernarr Macfadden has shown how it is possible to provide palatable food based upon natural products such as milk, honey, and wheat. I believe that the food which is served today in his penny restaurants will be the basis of epicurean meals in the smartest banquet halls of the twenty-first century.

There will be enough wheat and wheat products to feed the entire world, including the teeming millions of China and India, now chronically on the verge of starvation. The earth is bountiful, and where her bounty fails, nitrogen drawn from the air will refertilize her womb. I developed a process for this purpose in 1900. It was perfected fourteen years later under the stress of war by German chemists.

Long before the next century dawns, systematic reforestation and the scientific management of natu-

ral resources will have made an end of all devastating droughts, forest fires, and floods. The universal utilization of water power and its long-distance transmission will supply every household with cheap power and will dispense with the necessity of burning fuel. The struggle for existence being lessened, there should be development along ideal rather than material lines.

Today the most civilized countries of the world spend a maximum of their income on war and a minimum on education. The twenty-first century will reverse this order. It will be more glorious to fight against ignorance than to die on the field of battle. The discovery of a new scientific truth will be more important than the squabbles of diplomats. Even the newspapers of our own day are beginning to treat scientific discoveries and the creation of fresh philosophical concepts as news. The newspapers of the twenty-first century will give a mere "stick" in the back pages to accounts of crime or political controversies, but will headline on the front pages the proclamation of a new scientific hypothesis.

Progress along such lines will be impossible while nations persist in the savage practice of killing each other off. I inherited from my father, an erudite man whe labored hard for peace, an ineradicable hatred of war. Like oher inventors, I believed at one time that war could be stopped by making it more destructive. But I found that I was mistaken. I underestimated man's combative instinct, which it will take more than a century to breed out. We cannot abolish war by outlawing it. We cannot end it by disarming the strong. War can be stopped, not by making the strong weak but by making every nation, weak or strong, able to defend itself.

Hitherto all devices that could be used for defense could also be utilized to serve aggression. This nullified the value of the improvement for purposes of peace. But I was fortunate enough to evolve a new idea and to perfect means which can be used chiefly for defense. If it is adopted, it will revolutionize the relations between nations. It will make any country, large or small, impregnable against armies, airplanes, and other means for attack. My invention requires a large plant, but once it is established it will be possible to destroy anything, men or machines, approaching within a radius of 200 miles. It will, so to speak, provide a wall of power offering an insuperable obstacle against any effective aggression.

If no country can be attacked successfully, there can be no purpose in war. My discovery ends the menace of airplanes or submaines, but it insures the supremacy of the battleship, because battleships may be provided with some of the required equipment. There might still be war at sea, but no warship could successfully attack the shore line, as the coast equipment will be superior to the armament of any battleship.

I want to state explicitly that this invention of mine does not contemplate the use of any so-called "death rays." Rays are not applicable because they cannot be produced in requisite quantities and diminish rapidly in intensity with distance. All the energy of New York City (approximately two million horsepower) transformed into rays and projected twenty miles, could not kill a human being, because, according to a well known law of physics, it would disperse to such an extent as to be ineffectual.

My apparatus projects particles which may be relatively large or of microscopic dimensions, enabling us to convey to a small area at a great distance trillions of times more energy than is possible with rays of any kind. Many thousands of horsepower can thus be transmitted by a stream thinner than a hair, so that nothing can resist. This wonderful feature will make it possible, among other things, to achieve undreamed-of results in television, for there will be almost no limit to the intensity of illumination, the size of the picture, or distance of projection.

I do not say that there may not be several destructive wars before the world accepts my gift. I may not live to see its acceptance. But I am convinced that a century from now every nation will render itself immune from attack by my device or by a device based upon a similar principle.

At present we suffer from the derangement of our civilization because we have not yet completely adjusted ourselves to the machine age. The solution of our probems does not lie in destroying but in mastering the machine.

Innumerable activities still performed by human hands today will be performed by automatons. At this very moment scientists working in the laboratories of American universities are attempting to create what has been described as a "thinking machine." I anticipated this development.

I actually constructed "robots." Today the robot is an accepted fact, but the principle has not been pushed far enough. In the twenty-first century the robot will take the place which slave labor occupied in ancient civilization. There is no reason at all why most of this should not come to pass in less than a century, freeing mankind to pursue its higher aspirations.

And unless mankind's attention is too violently diverted by external wars and internal revolutions, there is no reason why the electric millennium should not begin in a few decades.

Tesla Engine Builders Association TeslaEngine.org Mountain Sunshine - Colorado Springs and the Pikes Peak Region Vol.I. No. 1. A Quarterly

NIKOLA TESLA EXPERIMENTS IN THE MOUNTAINS

by Desire Stanton

"Familiar Science" were popular in certain of our institutions of learning, together with "Chronology," taught as a separate branch, disassociated from the head-waters of the Platte and Arkansas, began

ABOUT a quarter of a century past, books of | tain"-that "far blue cloud" which allured him over many a mile of wilderness march, and from his reports of discovery of Pikes's Peak and exploration at

events,-and Magnall's Questions. The exhaustive study of "Ancient Geography" was also commended and "a gage of dictionary" was the invariable spelling lesson. Waldfer was standard authority, and in his pages the present writer learned to spell music, "musick." and sundry extra "u's" and doubled consonants, which are fine old historical English, Isaac Pitman to the contrary notwithstanding. It was the special privilege of the book of "Familiar Science" to hurl disconnected facts at the scholars head-to pelt him with the arbitrary



processes of nature-"Why does dew fall?" Paraded arm in arm with "Why does a cat's fur emit sparks when you stroke here in the dark?"

But the chief glory of the "Book of Familiar Science" was a full-page wood-cut of placid Benjamin Franklin, in broad-brim and gaiters, flying his scientific kite, and bringing lightning down from the skies by the aid of a large door key. The experiment marked the beginning of electrical science in America. "The knowledge of this world passeth away, away."

In the first years of 1800, Lieutenant Pike camped at the foot of his great "Mexican mounthe exodus from the Missouri river-first over the Santa Fe trail direct-and then gradually diverted to the north, where "Pike's Peak or Bust!" became the motto of the "59er."

The years to be dated 1800 are fast drawing to a close. and in spanning them in thought, with all their stirring happenings and marvelous achievements, not a hundred years later than Zebulon Pike. we find another discoverer camped at the foot of Pike's Peak, armed with a more mighty key to electrical science than that of Poor Richard.

Nikola Tesla, the Serbian scientist,

whose electrical discoveries are not of one nation, but the pride of the world, has taken up his abode in Colorado Springs, where he will remain for some time conducting experiments in the medium of light air, and perpetual sunshine.

On East Pike's Peak avenue, with limitless plains stretching to the eastward, and a panorama of mighty mountains sweeping away north and south, to the west-Tesla has caused to be constructed a station for scientific research. It is a building, which, when complete, will cover an area of from 50 to 60 feet, with an extension with two windows and a large door. The structure is about 18 feet high,

and crowned with a large platform. The center of the building remains unroofed to permit the scientific apparatus to project above, and to be inspected and regulated from the surrounding balcony. The structure has been built according to Mr. Tesla's own plans, and in telegraphing without wires from plain to mountain, or from mountain to plain, it would occupy an equally central situation

It is said that Mr. Tesla's experiments will take this direction, though he is, naturally, reticent upon these points, until he is assured, by the success of his experiments, that the results are prepared to meet the demands of the scientific world.

With Tesla's wireless telegraph oscillator, he affirms he could talk to the inhabitants of the planet

Mars, and will talk to the people of this earth, at any distance away, without the assistance of wires. Into the great oscillator Tesla will turn an ordinary current of electricity. The oscillator instantly transforms this electric current, by a series of coils. into electromotive force, vibrating at the rate of 2,000,000 to 4,000,000 times a second. This starts electric waves

through the air and earth, which vibrate almost as fast as the waves that produce light, and travel with the same speed. These waves, like X-rays, pass through any dense substances, and, according to Tesla, there is nothing to prevent the transmission of messages by their aid directly through the earth. Tesla's plan for cabling across the Atlantic is to erect two terminal stations, one in London and one in New York, with the oscillators placed at the top of high towers, communicating thence with great disks suspended in captive balloons floating 5,000 feet above the earth to catch the strata of rarefied air through which electrical waves travel most easily. A message could be flashed instantly by these lightning rays from the oscillator to the disk in the balloon, and across the thousands of miles of intervening space to the second disk. Cable tolls would be reduced to a minimum and messages flashed around the world a little more than letter postage rates. Mr. Tesla says he is ready to put his wireless system into operation as soon as the practical

details can be arranged.

In inter-planetary communication, however, it would be necessary to have a receiver upon the objective star, and it is also a pre-requisite that the inhabitant of Venus or Mars (if there he be) should unlike some who wear the uniform in this sublunary sphere—"know enough to take a message."

The oscillator, charged, seems like a vivid sphere, fairly radiating light and glorious possibilities. Who that has looked into the soft green depths of light, in the heart of which lies hidden the X-ray (to which matter is no longer opaque and impenetrable), has not felt that under the touch of electric light and force, power is limitless and the future boundless?

In Bulwer-Lytton's novel of the "The Coming



Race" the heroine was a "perfect woman, nobly planned" on a superhuman scale. She and her sisters took the initiative in all good and wise achievement, while the men of the coming race somewhat lagged in the rear. By means of the "vril" staff, power was transmitted or arrested, in an incredible degree. The labor of the coming race was

performed by automata, vivifies and directed by the action of "vril," according to the woman who wished that "posterity was here—right now." The employer of the present, longs upon attempt of direction by the guiding mind, do the thing that is not wanted, in just the way that is not desirable or right.

Colorado, with here enfranchised women, opens a future for the sisterhood of the coming race. Tesla, in an interview with a representative of the Denver Republican, indicates that the day of "vril power" is not far distant.

"I would," said Tesla, "light whole cities and give to mere machines all the motions of intelligence. I have given demonstrations of this discovery of mine before bodies of men of science many times, but they have found it difficult to believe me. I gave a demonstration of one experiment, which I think is the most beautiful I have ever tried. I think if I live a long life and work all the time I shall never have a more beautiful experiment than that. I had a boat without crew or captain, which I controlled

merely by the force of my intelligence. I would will 'turn,' and it would turn, 'go to the right,' and it would go to the right, 'to the left,' it would go to the left. The beautiful thing about it was that it seemed to be instinct with life, and, as a dog obeys the commands of his master, so this machine obeyed mind. And yet, it was governed simply by electrical waves striking upon a receiver. And so with any machine.



form all the motions of a man, except wherein the fact of its not being an organic being would make a difference. All this theory is developed from my idea that the actions of all animate beings are governed by impressions of outside objects received upon the eye.

"My idea is that people are simply automata, governed by the transmission of circumstances surrounding them upon the eye. "This," said Nikola Tesla, solemnly, and with the greatest simplicity, "is the greatest idea of the age. The relations of nations will be affected by it. It will revolutionize thought. It may take years, but it will gradually come abut. Men of science find it difficult to accept this idea. They cannot comprehend it. It is stupendous, and yet it is very simple."

Colorado may be the theater of the first exhibition of "vril."

Mr. Tesla announces that he is at Colorado Springs, simply collecting experimental data. His instruments will shortly be mounted, and scientific work will begin. He has made similar experiments at different atmospheric levels, and the work here will be comparative.

Nikola Tesla is from the mountains of Serbia, and his native tongue is Montenegrin. To those familiar with foreign types, he suggests the Pole the grave and gentle temperament illumined by the flash of fire. He is very tall and slight, with thin and delicate features, black hair and mustache, and clear gray eyes. He speaks of himself and his



work with simple modesty and reticence, in perfect English, with a slight foreign accent.

Mr. Leonard E.Curtis, a well-known member of the bar, who has been Tesla's legal adviser, gave a banquet to the famous electrician at the El Paso Club, where twenty gentlemen of Colorado Springs were invited to meet him, including Governor Thomas, of Colorado. Tesla was in his happiest vein and spoke of his life and work. When first he heard of the great Niagara of the western hemisphere, he was impressed with its power—mightily, resistless force! Some day he would turn it to account. Years after he went to Buffalo, and in the great power plant at Niagara, he saw machinery bearing the name of Tesla.

All who were present at the banquet felt, if it may be so stated without bathos, that they had "soared toward the empyrean," for a glimpse of the glory that excelleth; the man in the midst of the fire; the controlling power, "Half spirit and half bird. And all a wonder and a wild desire."

> "Now shine your very brightest." Said Dame Nature to the Sun;
> "Appear, ye flowers and leaflets, for winter's course is run;
> Let every rugged mountain peak in added grandeur rear;
> Let everything look pleasant for the tourist season's near." ('Gazette.' Colorado Springs.)

The New York Times

September 30 1894

often equals 15 percent more - or 50

percent, in all, used

up in the working of

the engine itself, and in the transfer of the

energy which it com-

municates to a piece

of shafting. Even

should that shaft be

directly connected with

an electric dynamo of

good construction, for adjustment, there will

be a further waste of

certainly 10 percent in

the dynamo itself. If

the dynamo be worked

in connection with an

arc-lighting system,

NIKOLA TESLA AND HIS WORK

by John Foord

ADVANCING WITH CERTAINTY TO **GREATEST TRIUMPH**

Amazing Force Wasted in Making Electric Light — Economical Conversion of Available Energy — The Oscillator, Which Will Give to Most Machines the Value of Old Metal Only -Power of the Medium in Motion Around Us.

"Of the energy that goes to the making of electric light over 90 percent is wasted."

The statement is made on the authority of Nikola Tesla, and will be disputed by few competent electricians. To explain the grounds on which it is made would be to elucidate some of the most elusive probborn common places of mechanical engineering that a practical engine does not utilize more than 16 percent, and sometimes not even as much as 5 percent of the heat energy employed to operate it. Besides there is loss by mechanical friction, in most cases equal to 35 percent on an average load on the engine, and

lems in physics, and to mark out the path of success for some of the most daring achievements of applied science. For, be it noted, it is electrical energy only of which Mr. Tesla speaks. No account is taken of the waste incurred in the steps of the process preceding the transformation of caloric into mechanical and mechanical into electrical energy.

Accepting Mr. Tesla's startling assertion in all it's preposterous disposition there must be of the energy stored in a lump of coal between its first liberation by combustion and its final emergence in the form of electric light! The waste of heat energy begins

The New Standard Encyclopedia University Society Inc. New York 1907 Up until 1894 the most economical method of producing electricity was through the dynamo, a steam engine to drive it, a boiler to supply the engine with steam, and the furnace to heat the boiler. Nikola Tesla, the inventor of the engine dynamo, retained the furnace and the boiler, but constructed an apparatus which combined an engine and dynamo. This engine dynamo has hardly one of the features breadth, what a which distinguish an engine. There are no fly wheels, pistons, crank as 30 percent because shaft, belts, or the heavy iron form visible. In fact, the machine has the appearance of a dynamo with a steam pipe directly connected

to it. Tesla's own explanation of this device is that the steam is used to create a vibrating motion of certain mechanism (in cylinder) which separates so as to cut the lines of magnetic force of the large field magnets in the apparatus, thus creating electricity. It is pointed bon filament, or pencil, out that by this method important advantages are gained, viz., the absence of a costly engine; and what is of much higher importance, the generation of electricity at about one-half the cost of former methods. These claims have been verified by the operation of machines that have been built and tested.

in the furnace, and is continued at every step of the | process of generation, transmission, and conversion of the steam, so it is one of the oldest and most stub-

it of at least 90 percent. To speak of the finality of scientific achievement in presence of waste on a scale like this is more than absurd.

the loss will be as high of the unsteadiness of the regulating mechanism. And, between the dynamo and carwhich is made the center, of an electric light, there ensues, as has been said, a loss of the potential energy which is conveyed to

Science and Invention to Save Energy

In point of fact, science and her handmaiden invention are advancing by deliberate but perfectly confident strides toward a much more economical conversion of available energy.

In the case of electric light, one may accept the correctness of the statement that it is not probable that the incandescent lamp can be much improved, and yet be forced to acknowledge that by a single stroke of purely mechanical adaptation, the cost of producing the light may be reduced by one-half or even more. Suppose the steam engine and the electric generator or dynamo, instead of being separate should be combined into one. Suppose that the average 35 percent of loss by mechanical friction in the working of the engine should be saved, likewise the 15 percent of loss by belt friction and the 10 percent wasted in the dynamo, there would clearly be an addition of 60 percent to the available energy obtained from the steam for the purpose of producing electricity. Suppose, further, that the consolidated machine is much simpler, smaller, and lighter than the mechanisms it is to replace; suppose it is to be absolutely constant in its action, automatically regulated, and therefore subject to the least possible amount of wear and tear, its advent would certainly mark a revolution, not only in the equipment of electric-light stations, but in many other fields of applied energy. These requirements Mr. Tesla seems to have met in the invention of the "oscillator." The essential characteristics of this very remarkable appliance may be briefly described as the application of the pressure of steam to produce an extremely rapid vibration of a bar of steel or piston, which, in turn, is so adapted to a set of magnets that the mechanical energy of the vibration is converted into electricity. Moreover, under certain conditions, the electrical vibrations entirely governs the motion of the bar or piston, and, finally by means of this appliance, the extraordinary result is reached, that to all intents and purposes, an absolutely constant vibration is established.

For reasons difficult to make plain without recourse to technical language, the great rapidity of this piston action admits to the use of steam at very high pressure, indeed, and lends itself to the development in this simply and economically constructed machine, of power much beyond that obtainable in the most costly expansion engines, using a similar amount of steam. The primary purpose of the "oscillator" is to convert by a process as direct as possible the energy of steam into that of electricity. It has no rotary motion, because for its purpose rotary motion is not only unnecessary, but wasteful. If it be a question of generating electricity for the production of light, all rotary motion in the mechanism is merely so much dissipation of energy. For that and other reasons there can be no doubt about the impression which the "oscillator" will make in the lighting business. But if the machine does all that its inventor believes it can and will, it is also destined to have a very profound influence indeed on all the great agencies of production and transportation. The fact is already recognized by all progressive men that the cheapest way of distributing power is by means of electricity. To say nothing about the enormous frictional losses due to the employment of extended systems of shafting and belting, must be taken of the power wasted in moving long lines of shafting for the purpose of operating the small part which may be actually in use. When the distribution of power is made by electric energy, it is used only when and where it is needed.

Now, since it is recognized that it is most economical to convert the energy of the steam first into electricity, and then reconvert it into any form of motion that may be required, it must be clear that the most successful apparatus of power production adapted to modern needs will be the one best suited for the simple, direct, and economical generation of electricity. Mr. Tesla has taken what may be called the core of the steam engine and the core of an electrical dynamo, given them a harmonious mechanical adjustment, and produced a machine which has in it the potentiality of reducing to the rank of old metal half the machinery at present moving on the face of the globe. It may come to do the work of the engines of an ocean steam ship within a small part of the space they occupy and at a fraction of their cost, both of construction and operation. It will do the work, if at all, without jar or pounding, and will reduce to a minimum the risk of derangement or breakage. There is nothing in the whole range of mechanical construction, from railway locomotives to stamp mills, which such an invention may not revolutionize.

PARADOXES TESLA'S MACHINE INVOLVES

It will be perceived that what has been outlined in regard to the construction of the "oscillator" involves some paradoxes in mechanics. If it is not to wear out, it must be destitute of friction, and must, therefore, present the anomaly of a steam cylinder and piston without packing, and yet admitting of no escape of steam. Still further, to bear out the claim of practical impermeability, the motion of the piston must be such as to preclude molecular change in the metal calculated to weaken it, and the whole machine must be extremely simple in its adjustments and mode of operation in comparison with the highly complicated engines of today. There are engineers who will pronounce the attainment of these conditions to be impossible. But science men are becoming very cautious about the use of the word "impossible." It is less than twenty five years since an electrical engineer of some reputation, then engaged in the construction of the present fire alarm system of New York, said to the writer that

it would pay to use electricity as a motive power when we could afford to feed steam boiler furnaces with piano frames. A steel rod vibrating without friction, and without loss directly transforming the energy of its vibrations into electrical energy, may appear to be as much of a dream to hum drum machinist of today, even on the eve of its realization. But when the genius of a scientific investigator of the first rate is combined with the genius of the inventor, hum drum people must prepare to be startled. They doubtless will be when Mr. Tesla's machine is sufficiently perfected to be introduced to the public, and it may surprise people who are not hum drum to learn that this very beautiful piece of mechanical adaptation derives its chief value in the eyes of its inventor from the fact that it will enable him to pursue with new confidence some very far-reaching scientific investigations. It has given him a new tool, which possesses certain

indispensable qualities of certainty and uniformity of action hithheretofore lacking. This is by no means the only case in Tesla's scientific career in which he has demonstrated that practical achievement comes directly in the line of speculative advances. At the very onset of the path of investigation which has already led him to a position of distinguished eminence, he showed how the principles of the rotating magnetic field could be so applied. as to reduce to a far simpler expression. the cumbersome and costly armature employed in the construction of motors. Scores of patents have been taken out by other men on inventions based on suggestions of his, which he has freely made for the guidance of his fellow-workers. But, brilliant as have been the practical achievements which directly or indirectly stand to Tesla's credit, he is only at the beginning of these, because he aimed so extremely high. Electricians have an enormous respect for the man who applied the alternating current to motors, dispensed with brushes and commentators, and made an efficient armature, formerly about as big as a cart wheel, not much larger than its hub. But these seem relevantly small things for the man whose goal of effort can be thus outlined: "We are whirling through space at an inconceivable speed; all around us everything is spinning, everything is moving, everything 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." This was said before the American Institute of Electrical Engineers at Columbia college in 1891. It was only the other day that Tesla repeated the same idea to the writer in a more confident form. "I expect to live to be able to set a machine in the middle of

this room and move it by no other agency than the energy of the medium in motion around us." The three years which have elapsed, since the delivery of the lecture, have served only to deepen his conviction that the consummation which he outlined then is neither impractical nor visionary.

Oscillator A Tool Of Larger Problems

When the key is found to the elimination of the 99 percent of waste incidental to the production of electric light, then that consummation will not be far from our grasp.

But, let it be noted, that however the machine referred to may prove to be in reducing the cost of generating the electricity that goes to the production of light, it marks only the first step toward the solution of the larger problems in the working out in which it is to serve as a tool. The scientific as distinguished from the commercial value of the new machine, consists, as its inventor has pointed out, in its capacity to produce very rapidly alternating currents of electricity whose frequency, i.e. rate of oscillation, weather high or low, is absolutely constant. Further progress in the direction wither Mr. Tesla's experiments are leading was all but impossible while the latter requirement was lacking. Some of the factors of the problem which Tesla has set out to solve elude popular definition, and some, indeed, almost transcend comprehension. But when it is stated that light is the result of etheric vibration of a very high pitch and of a definite kind, much higher than the heat producing vibration, we get some grasp of the idea, that light production must be wasteful when it continues to be impossible to obtain the higher light vibrations without passing through the lower heat vibrations. No apparatus yet devised for the production of light by conversion from any source of energy, weather the process be electrical, chemi-

cal, or other, has been able to avoid that necessity. Escape from it seems to be as impossible as from that of imparting to a body a certain velocity without passing through all lower velocities.

But we shall not be able to follow very far in the path which the advance guard of modern science is treading if the laws of what we have been accustomed to call matter are regarded as the measure of the universe. Matter is a term whose significance has greatly enlarged. It has become a scientific postulate that what is commonly called the void of space is filled with a medium which, though, imperceptible to any human sense, has yet material properties. That is to say, the all-enveloping, all-pervading, ether-the eternal ocean without a shore. In whose immensity suns and planets are but bubbles of varying size and hue—is the carrier and transmitter of all primary forms of energy, and perhaps is the material from which the tangible and visible universe has come. The question of the school books is relevant here: "If light is motion, what moves it?" Beyond that thin envelope that we call the earth's atmosphere there are the depths of interplanetary space, through which must be communicated to us the form of energy known as light. But as the science primer again remark, "Empty space can neither receive nor communicate motion." And so we come to the only hypothesis that accords with the facts, that of the etheric atoms, namely, in the sublime expectations to which that theory has given birth. The inconceivably minute atom." The ulterior element of the universes structure, is "posted about," as Tesla puts it, "in space eternally, at play to external influences, like a boat in a troubled sea." It moves, it vibrates, and that with the most marvelous rapidity, and by the very necessity of its existence, for matter at rest would be dead matter-quite an inconceivable thing, in spite of the popular impression to the contrary.

POSSIBILITIES AND APPALLING FIGURES

Science says that light must travel at the rate of 186,000 miles per second, and that light is the property of an etheric vibration whose rate is about 500,000,000,000 a second, but science has hardly stopped to consider what profound possibilities there are in the forces which such appalling figures convey. Even now we know very little of what electricity is, but it has been one of the triumphs of modern investigation to identify electromagnetic manifestations of energy with those of light and heat. Out of this identification has been born a desire to reach the very source of all the transformed, the accumulated, and stored-up supplies of this energy-such as coal, gas, and oilwhich there is so much waste in liberating from their mundane environment, and to take a lead directly from the inexhaustible fountain of it all. It is toward such an ideal that Tesla is continuously striving. There can be nothing more exact, more severely scientific, than

his methods of investigation; his experiments lead him from point to point along a solid path of ascertained fact. But he never fails to remember that speculation is the basis of investigation, and thus it is that, in following his experiments, the impression of wonder and admiration received from the immediate achievement quickly gives place to a feeling akinded to awe at the grandger of the conception, which is the end of ultimate attainment.

For example, in his London lecture of two years ago, Tesla demonstrated not only the fallacy of the idea that an electric motor could be operated only with a double connection between it and the generator-that is, with a wire for the return. as well as a wire for the transmission of the current-but He showed that the motor could be operated with one wire only, or without any connecting wire at all. In his own words: "It is not necessary to have even a single connection between the motor and the generator, except, perhaps, through the ground; for not only is an insulated plate capable of giving off energy into space, but it is likewise capable of deriving it from an alternating electrostatic field, so in the latter cases the available energy is much smaller." Now, from this demonstration of the possibility of working a motor without connecting wires by currents passed through the earth or air, a far-reaching possibility is revealed. For, "alternate currents, especially of high frequencies, pass with astonishing freedom through even slightly rarefied gases. To reach a number of miles into space requires the overcoming of difficulties of a merely mechanical nature. There is no doubt that with the enormous potentials obtained by the use of high frequencies and oil insulation, luminous discharges might be passed through many miles of rarefied air, and that, by thus directing the energy of many hundreds of thousands of horse power, motors or lamps might be operated at considerable distances from the stationary sources."

NO NEED OF TRANSMITTING POWER AT ALL

This is a sufficiently impressive perspective, but it is referred to by Tesla as only a possibility, for, dipping into the future further than most human eyes can see, he asserts that we shall have no need to transmit power in this or any other way. "We shall have no need to transmit power at all. Ere many generations past, our machinery will be driven by a power obtainable at any point of the universe. Throughout space there is energy. Is this energy static or kinetic? If static, our hopes are in vain; if kinetic-and this we know it is for certain-then it is a mere question of time when man will succeed in attaching their machinery to the very wheel work of nature." To state this in ordinary language, if we live amid a medium through which there is no continuous flow of energy, this realization would appear to be impossible, but if everything around us is in constant motion, then human ingenuity must find

a means of converting that energy to productive uses.

Here we have indeed the fairy tales of science, but, rightly considered, no more marvelous than many things we have long ceased to wonder at, because they are so familiar. It is, after all, in the interpretation of the familiar phenomenon that science reaches a higher range of achievement, and it is only when science accepts the familiar phenomenon without interrogating them that it fails to advance. "Lighting the gas" is a common everyday operation which nobody stops to wonder at, and so to, has become the act, of touching a button and seeing a carbon filament become luminous inside of an air tight glass bulb. But if science had the power to discern more clearly the hidden processes of nature and revealed to us the secret of the forces which are brought into action by either of these two simple proceedings, it would be able to resolve a great many of the riddles of the universe which remain unread. One does not advance very far towards the comprehension of what takes place during the incandescence of a gas at the ordinary pressure of the atmosphere by calling it a form of radiant energy. But we do come a step nearer to an intelligent grasp of the facts when we find that the luminosity is due to the shocks or impacts of the gaseous molecules. To quote from Tesla again: "Just as molecules or atoms impinging upon a solid body excite phosphorescence in it or render it incandescent, so in colliding among themselves they produce similar phenomenon." But, as our authority adds, "This is a very insufficient explanation and concerns only the crude mechanism."

Take the problem of the incandescence of the filament in the bulb, which, if not more complicated, is at least more elusive, than that of the incandescence of the gas in an ordinary burner. Here atmospheric air has been exhausted, not by any means perfectly, it is true, but as near an approach to what is called a vacuum has been made as is usual in commercial appliances. A "vacuum" is, however, merely a relative term. In addition to a certain residue of atmospheric air, the etheric medium remains, for, as the text-books put the case, "an attempt to pump it out of space would be like trying to pump water with a sieve for a piston," and a sieve, it may be added, with very wide meshes indeed. When the electric vibrations passed along the wire are communicated to the filament within the bulb, they cause a disturbance of its molecules so violent as to produce both heat and light, but, to the despair of the man of science, unfortunately, very little of the latter. Light comes as the filament gives out an incandescent glow, but the light would be a much more economical one if the molecules or atoms of the surrounding gas or ether could be made to glow, too. And here we encounter one of the most instructive of the Tesla paradoxes, which can be best expressed in his own words: "Anyone who begins a study of the problem will be apt to think that what is wanted, in a lamp with an electrode, is a very high degree of incandescence of the electrode. There he will be mistaken. The high incandescence of the button is a necessary evil, but what is really wanted is the high incandescence of the gas surrounding the button. In other words, the problem in such a lamp is to bring a mass of gas to the highest possible incandescence."

WHAT IS TO BE THE LIGHT OF THE FUTURE?

To follow this idea further, it is necessary to distinguish between the origins of the incandescence of the filament and that of the mere button at the end of the conducting wire or lamp. In the case of the filament, the luminosity is due partly to the action of its component molecule on each other, one excited by the electric current, and partly to the bombardment or impact of the etheric particles, which have also received their electric charge and are being attracted, repelled, and agitated with tremendous velocity. The incandescence of the button, on the other hand, is caused almost solely by its very active bombardment by these inconceivably minute electrified atoms of the gas or ether. And here we begin to see why Mr. Tesla believes that the production of a small electrode (or terminal button) capable of withstanding enormous temperature is of the greatest importance in the manufacture of light. Or as he explains it, "The intensity of the light emitted depends principally on the frequency and potential of the impulses and on the electric density on the surface of the electrodes. It is of the greatest of importance to employ the smallest possible button, in order to push the density very far. Under the violent impact of the molecules of the gas surrounding it, the small electrode is, of course, brought to an extremely high temperature, but around it is a mass of highly-incandescent gas, a flame photo-sphere many hundreds times the volume of the electrode."

So far. the problems of practical adaptation, which, however important and interesting, appeal less powerfully to the imagination from the higher lights of the Tesla experiments. But Tesla never flys so high as to forget the "One and only desire" which he shares with all lovers of science and of progress, "To reach a result of utility to man in any direction to which throughout or experiment may lead." So, when he shows how a hollow glass tube, from which the air has been exhausted, before being sealed at each end, can be made to glow with light throughout its entire length by the mere act of holding it in the hand in a room in which electrostatic forces of sufficient strength have been made to act, he is thinking how such experiments may lead to the production of an efficient illuminating device. Or, as he puts it, "Every thinker, when considering the barbarous methods employed, the deplorable losses incurred in our best system of light production, must have asked himself; What is likely to

be the light of the future? Is it to be an incandescent solid, as in the present lamp, or an incandescent gas, or a phosphorescent body, or something like a burner, but incomparably more efficient?"

EXPLANATION OF ELECTROSTATIC FORCE

In such a quest one may, however, score very high. Take the very striking and beautiful vacuum-tube experiment to participate in which makes one feel as if the veritable scepter of the world of light were put in ones hand, what does the experimenter mean when he says that his conviction has grown strong that "To what ever kind of motion light may be due, it is produced by tremendous electrostatic stresses vibrating with extreme rapidity?" That raises the further question of what is electrostatic forces and here let Tesla speak for himself: "It is the force which governs the motion of the atoms, which causes them to collide and develop the life sustaining energy of heat and light, and which causes them to aggregate in an indefinite variety of ways, according to nature's fanciful designs, and form all these wondrous structures we see around us; it is, in fact, if our present views be true, the most important force for us to consider in nature." To establish what is called an electrostatic alternating field. acting through the whole extent of the room, requires an adjustment of electrical apparatus whose description belongs to technical, not to popular, study. Let it suffice to say that when two conducting bodies are insulated and electrified an electrostatic force is said to be acting between them. "This force manifests itself in attractions, repulsion's, and stresses in the bodies and space or medium without. So great may be the strain exerted in the air, or whatever separate the two conducting bodies, that may break down, and we observe sparks or bundles of light or streamers. as they are called." To demonstrate the potency of such a force, the experimenter, standing within an electrostatic field in his creation of the familiar induction coil plays an important part, brings a piece of metal which he hold in his hand in touch with the end of the secondary wire of the coil. His arm is then traversed by a powerful electric current, vibrating at about the rate of 1,000.000 times a second.

All around the electrostatic force makes itself felt and the air molecules and particles of dust flying around are acted upon and are hammered violently against his body. So great is this agitation of the particles that when the lights are turned out streams of feeble light may be seen to appear on some parts of the body. When such a "streamer" breaks out it produces a sensation like the pricking of a needle. For the potentials, or pressures, sufficiently high, and the frequency of the vibration, or rapidity, rather low, the skin would probably be ruptured under the tremendous strain and the blood would rush out with great force in the form of fine spray or jets so thin as to be invisible. The streams of light which are the most frequently sited, and overstated, of the Tesla marvels are due to a potential of about 200,000 volts, alternating in rather irregular intervals, but as already stated at something like 1,000,000 times a second. According to his own statement: "A vibration of the same amplitude, but four times as fast, to maintain with over 3,000,000 volts would be required, would be more than sufficient to envelop my body in a complete sheet of flame. But this flame would not burn me up; quite contrarily, the probability is that I would not be injured in the least." For the benefit of the adventurous amateurs of either sex desirous of experimenting, and for the information of artists desirous of illustrating, this novel effect, it should be stated that the body can not very well be enveloped in a complete sheet of electromagnetic flame with the clothes on.

TESLA, SCIENTIST, INVENTOR, AND SEER

But such an experiment, however well calculated could dazzle and amaze, as the significance much less profound than the production inside of an exhausted glass tube of a luminous thread possessing rigidity. This is one of Tesla's most beautiful and most significant demonstrations, and it appeals very powerfully to the scientific imagination, because it touches some of the most occult processes of the arcanum of nature. As Mr. Tesla puts it, "the demonstration of the fact that a vibrating, gaseous column possess rigidity must, greatly modify the view of thinkers. When with low frequencies and insignificant potentials indications of that property may be noted, how must a gaseous medium behave under the influence of enormous electrostatic stresses, which may be active in the interstellar space, and which may alternate with inconceivable rapidity? The existence of such an electrostatic. rhythmically-throbbing force-of a vibrating, electrostatic field-would show a possible way how solids might have formed from the ultra-gaseous uterus, and how transverse and all kinds of vibrations may be transmitted through a gaseous medium filling all space."

Slo itur ad astra! And thus we reach celestial heights of contemplation, even as we search for higher forms of incandescence, to light the murky nights of this little planet withal. This is to have the insight of the poet joined to the tireless patience of the seeker after exact truth, to have a philosophic mind guickened by imagination, and a penetrating intelligence directed by the enthusiasm of humanity. This it is to be advancing without haste, but without rest, with a serene and modest certainty toward the goal of achievements which will give the next century its characteristic distinction, as surely as the triumphs of steam have stamped their influence on the one now drawing to a close. This it is to be a scientist, inventor, and seer in one, to be one of the most remarkable men of this or any other time-to be Nikola Tesla. \odot