TESLA TURBINE ENGINE

Nikola Tesla's Thermo Dynamic Converter

THE REAL ENERGY SOLUTION

Jeffery A Hayes

TeslaEngine.org

Journey back to the future and discover the fascinating secret behind the most powerful and economic combustion engine of our time: Tesla's whirl wind machine of natural harmony.

Experience the excitement of understanding as the vortex energy, of a perfectly controlled mechanical tornado, shatters the boundaries of our current mechanical standards.

Nikola Tesla

This amazing engine will improve all aspects of our mechanical life. Today's applications range from high mileage vehicles and supersonic aircraft to freon free air conditioning and virtually indestructible pumps.

Conventional pumps and engines pale in comparison. This jewel of mechanics has no equal. It stands alone above all others. No other pump or engine can match the longevity, economy, size, safety, silence and vibration free Herculean power of this truly elegant machine.

Tesla's Engine waits patiently, ready to solve the efficiency and pollution problems of today and will literally usher in

A New World

Fully Illustrated

TeslaEngine.org

"The success of my propulsion scheme is about as certain as the law of gravity"

NIKOLA TESLA

Copyright © 1993—2023, Jeffery A. Hayes All rights reserved.
No part of this book may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval devices or systems, without prior written permission from the publisher except that brief passages may be reproduced for review and technical papers.

Published by:

Tesla Engine Builders Association (TEBA)
A Membership Organization
TeslaEngine.org

PREPUB 1A

1.Turbines. 2.Geothermal power plants 3.Combustion engines.
4. Pumping machinery. 5. Electric vehicles. 6. Tesla, Nikola (1856-1943) Title.

About the Cover: Depicted in red is the spiraling vortex action of the propelling fluid in the Tesla Disc Turbine. Described as a Tornado in a Box.

Tesla's Thermal Dynamic Converter
THE REAL ENERGY SOLUTION

CONTENTS

CLASSIC WORKS

RARE ARTICLES

My Turbine Will Scrap All the Heat-Engines in the World !

Only the other day I had a disheartening experience when I met my friend and former assistant, Charles F. Scott, now professor of Electrical Engineering at Yale. I had not seen him for a long time and was glad to have an opportunity for a little chat at my office. Our conversation naturally enough drifted on my turbine and I became heated to a high degree. "Scott," I exclaimed, carried away by the vision of a glorious future, "my turbine will scrap all the heat-engines in the world." Scott stroked his chin and looked away thoughtfully, as though making a mental calculation. "That will make quite a pile of scrap," he said, and left without another word!

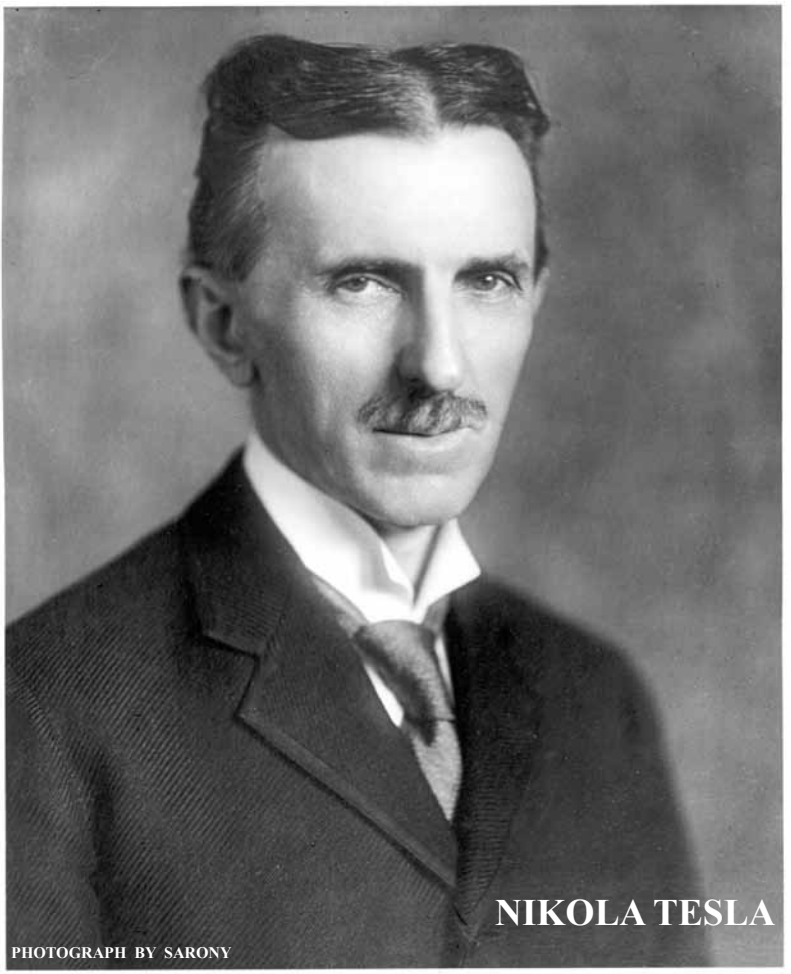
NIKOLA TESLA (1919)

Page **13** **AMERICAN MAGAZINE** April, 1921

MAKING YOUR IMAGINATION WORK FOR YOU

An interview with Nikola Tesla, great inventor, who tells the romantic story of his life. He also describes a method of work he has evolved, which will be of use to any imaginative man, whether he is an inventor, business man, or artist.

Interviewed by M.K. Wisehart



Born and educated in what was then Austria-Hungary, Tesla came to this country thirty-seven years ago when he was twenty-seven years old. His first invention, a telephone repeater, has been followed by other enormously valuable contributions to the science of telegraphy and telephony, especially in connection with the system of wireless transmission. He lives in New York City.

Page **1** **NEW YORK HERALD TRIBUNE** Oct. 15, 1911

WILL TESLA'S NEW MONARCH OF MACHINES REVOLUTIONIZE THE WORLD?

Noted Balkan Scientist claims to have perfected an engine that will develop ten horsepower to every pound of weight, and promises soon to give to the world a flying machine without wings, propeller, or gas bag. Characterizes aeroplanes of today as mere dangerous toys compared with the safe and stable appliance which will be used in a short time to dash through the air at a speed now unimagined.

Page **1** **NEW YORK HERALD TRIBUNE** Oct. 15, 1911

Latest Marvel of the Famous Inventor Nikola Tesla's Revolutionary Invention, *a Perfect Rotary Engine.*

By Frank Parker Stockbridge

Ten horse power from a tiny engine that a man could dangle from his little finger by a string!

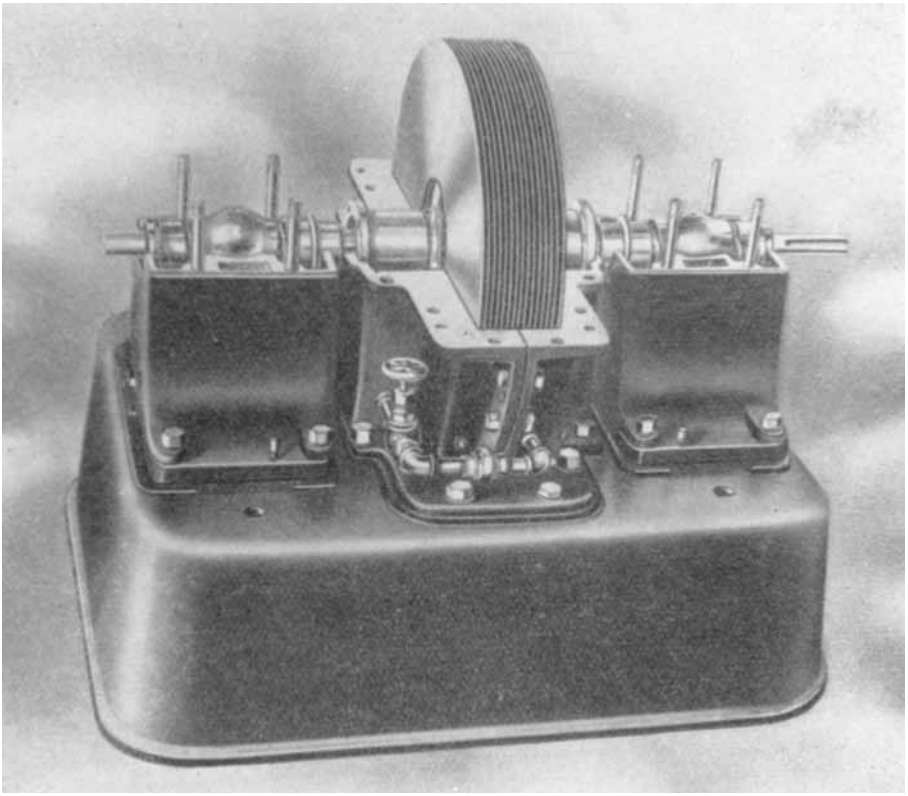
Five hundred horse power in a package that a man could lift easily in one hand!

A thousand horse power motor occupying hardly more space than the cardboard box in which your hatter sent your new derby home!

Marvelous? ***Wait until you hear the rest of it!***

Suppose some one should discover a new mechanical principle—something as fundamental as James Watt's discovery of the expansive power of steam—by the use of which it became possible to build a motor that would give ten horse power for every pound of the engine's weight, a motor so simple that the veriest novice in mechanics could construct it and so elemental that it could not possibly get out of repair. Then suppose that this motor could be run forward or backward at will, that it could be used as either an engine or a pump, that it cost almost nothing to build as compared with any other known form of engine, that it utilized a larger percentage of the available power than any existing machine, and, finally, that it would operate with gas, steam, compressed air or water, any one of them, as its driving power.

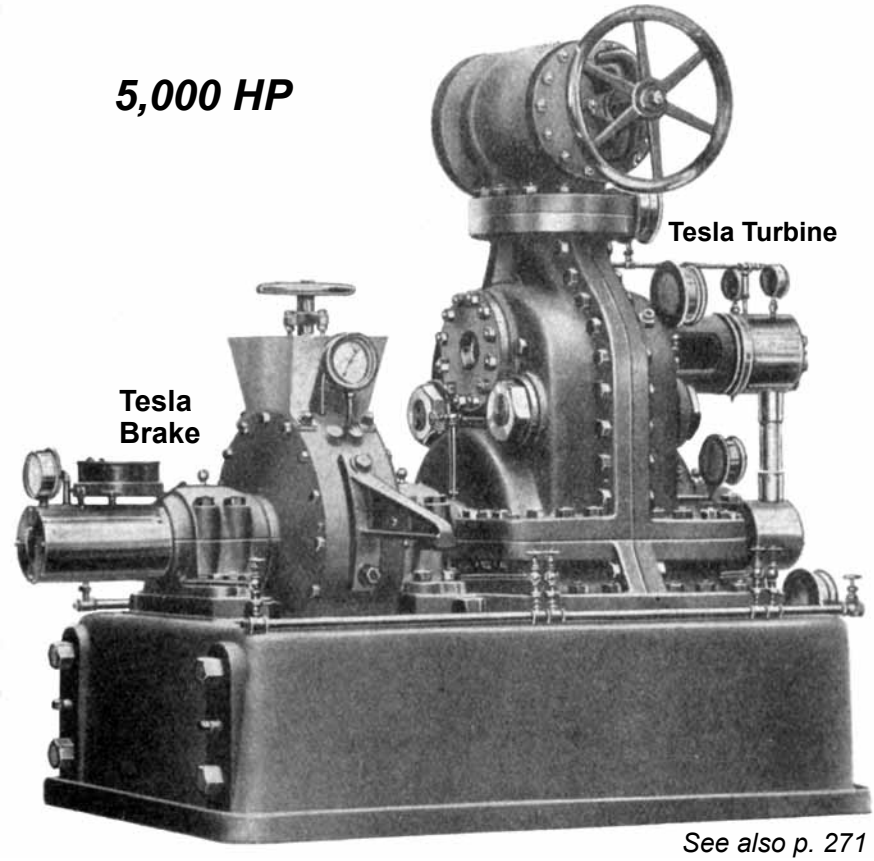
It does not take a mechanical expert to imagine the limitless possibilities of such an engine. It takes very little effort to conjure up a picture of a new world of industry and transportation made possible by the invention of such a device. "Revolutionary" seems a mild term to apply to it. That, however, is the word the inventor uses in describing it—Nikola Tesla, the scientist whose electrical discoveries underlie all modern electrical power development, whose experiments and deductions made the wireless telegraph possible, and who now, in the mechanical field, has achieved a triumph even more far reaching than anything he accomplished in electricity.



Tesla Engine with Upper Half of Casing Removed

This engine, whose rotor or "runner" consists simply of a set of flat disks 18 inches in diameter, developed a maximum of 330 brake horse-power on test. Because of safety considerations, involving the strength of the casing, it was conservatively rated at 200 HP. Half of the disks have been removed for better photographic resolution. See p. 34 for fully assembled unit, p. 94 for unit with all disks installed.

There is something of the romantic in this discovery of the famous explorer of the hidden realms of knowledge. The pursuit of an ideal is always romantic, and it was in the pursuit of an ideal which he has been seeking twenty years that Dr. Tesla made his great discovery. That ideal is the power to fly—to fly with certainty and absolute safety—not merely to go up in an aeroplane and take chances on weather conditions, "holes in the air," tornadoes, lightning and the thousand other perils the aviator of to-day faces, but to fly with the speed and certainty of a cannon ball, with power to overcome any of nature's aerial forces, to start when one pleases, go whither one pleases and alight where one pleases. That has been the aim



See also p. 271

of Dr. Tesla's life for nearly a quarter of a century. He believes that with the discovery of the principle of his new motor he has solved this problem and that incidentally he has laid the foundations for the most startling new achievements in other mechanical lines.

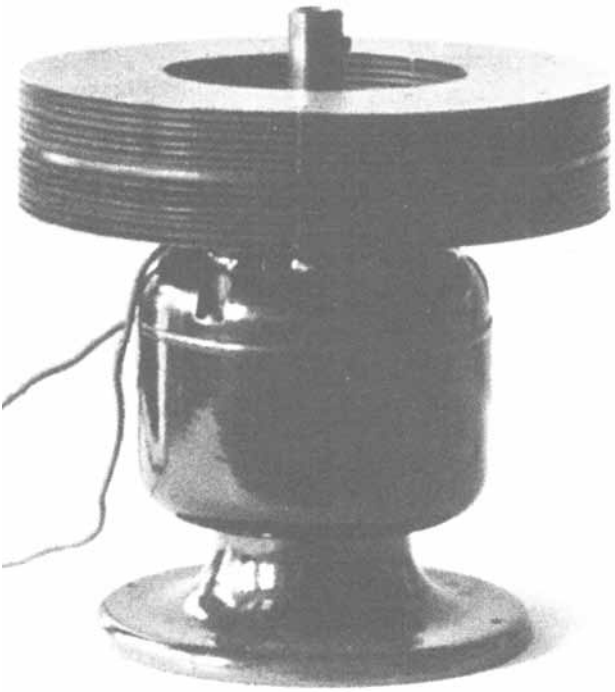
There was a time when men of science were skeptical—a time when they ridiculed the announcement of revolutionary discoveries. Those were the days when Nikola Tesla, the young scientist from the Balkans, was laughed at when he urged his theories on the engineering world. Times have changed since then, and the "practical" engineer is not so incredulous about "scientific" discoveries. The change came about when young Tesla showed the way by which the power of Niagara Falls could be utilized. The right to divert a portion of the waters of Niagara had been granted; then arose the question of how best to utilize the tremendous power thus made available—how to transmit it to the points where it could be commercially utilized. An international commission sat in London and listened to theories and practical plans for months.

Telling His Life Dream.

Up to that time the only means of utilizing electric power was the direct current motor, and direct current dynamos big enough to be of practical utility for such a gigantic power development were not feasible.

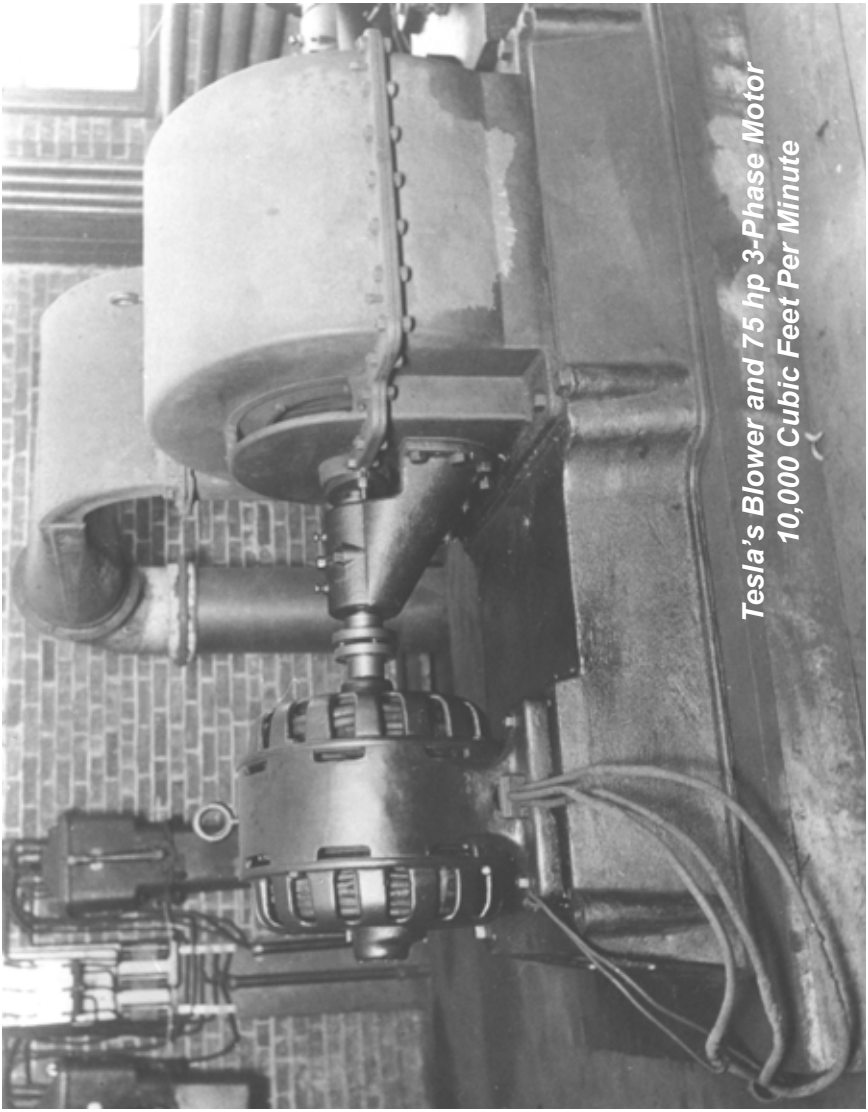
Then came the announcement of young Tesla's discovery of the principle of the alternating current motor. Practical tests showed that it could be built—that it would work.

That discovery, at that opportune time, decided the commission. Electricity was determined upon as the means for the transmission of Niagara's power to industry and commerce. To-day a million horse power is developed on the brink of the great cataract, turning the wheels of Buffalo, Rochester, Syracuse and the intervening cities and villages operating close at hand the great new electro-chemical industries that the existence of this immense source of power has made possible, while all around the world a thousand waterfalls are working in the service of mankind, sending the power of their "white coal" into remote and almost inaccessible corners of the globe, all because of Nikola Tesla's first great epoch making discovery.



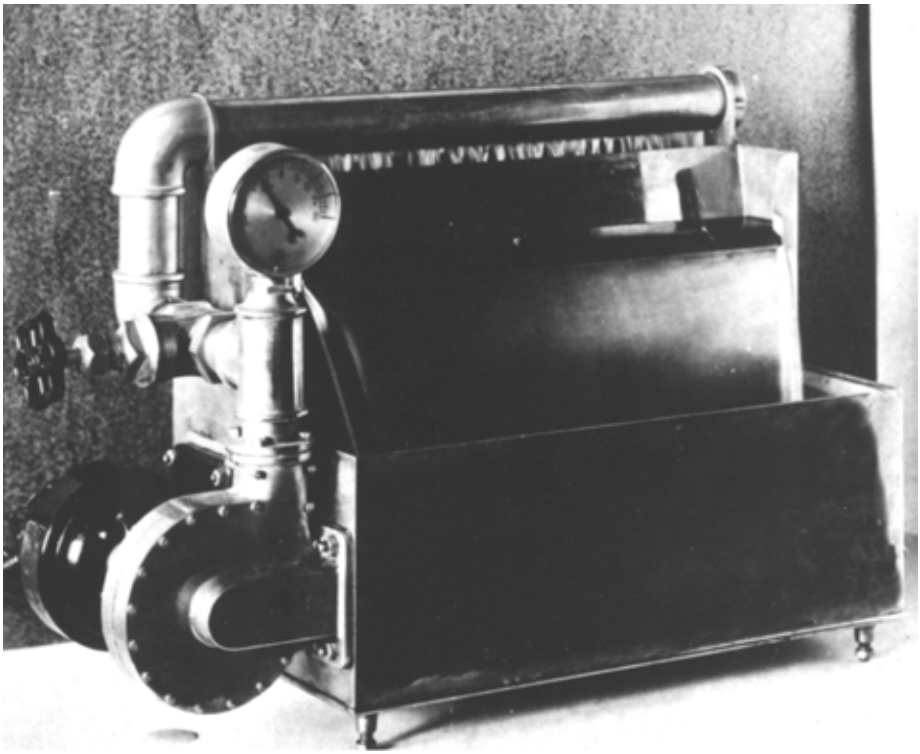
Tesla's Demonstration Blower Sat Upon His Desk

To-day the engineering world listens respectfully when Dr. Tesla speaks. The first announcement of the discovery of his new mechanical principle was made in a technical periodical in mid-September, 1911. Immediately it became the principal topic of discussions wherever engineers met.



"It is the greatest invention in a century," wrote one of the foremost American engineers, a man whose name stands close to the top of the list of those who have achieved scientific fame and greatness.

"No invention of such importance in the automobile trade has yet been made," declared the editor of one of the leading engineering publications. Experts in other engineering lines pointed out other applications of the new principle and letters asking for further information poured in on Dr. Tesla from the four quarters of the globe.

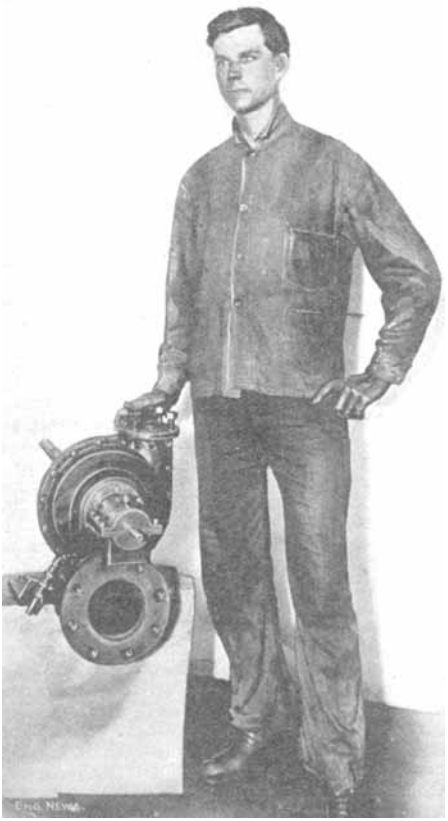


The Engine used as a Pump

This little pump, with a six inch volute housing, is driven by a motor of 1/12 horse-power (operated at 150% nameplate). It is shown here delivering 40 gallons of water per minute at a nine foot head.

"Oh, I've had too much publicity," he said, when I telephoned to him to ask for an interview in order to explain his new discovery to the non-technical public. It took a good deal of persuasion before he reluctantly fixed an hour when he would see me, and a good bit more after that before he talked at all freely. When he did speak, however, he opened up vistas of possible applications of the new engine that staggered the imagination of the interviewer.

Looking out over the city from the windows of his office, on the twentieth floor of the Metropolitan Tower, his face lit up as he told of his life dream and its approaching realization, and the listener's fancy could almost see the air full of strange flying craft, while huge steamships propelled at unheard of speeds ploughed the waters of the North River, automobiles climbed the very face of the Palisades, locomotives of incredible power whisked wheeled palaces many miles a minute and all the discomforts of summer heat vanished as marvelous refrigerating plants reduced the temperature of the whole city to a comfortable maximum—for these were only a few of



The Tesla 110 Horsepower Engine, Conveying an Idea of the Size of the Machine

The Runner of the 110 Horsepower Engine Measures 9 3/4" in diameter and Weighs Twenty Pounds.

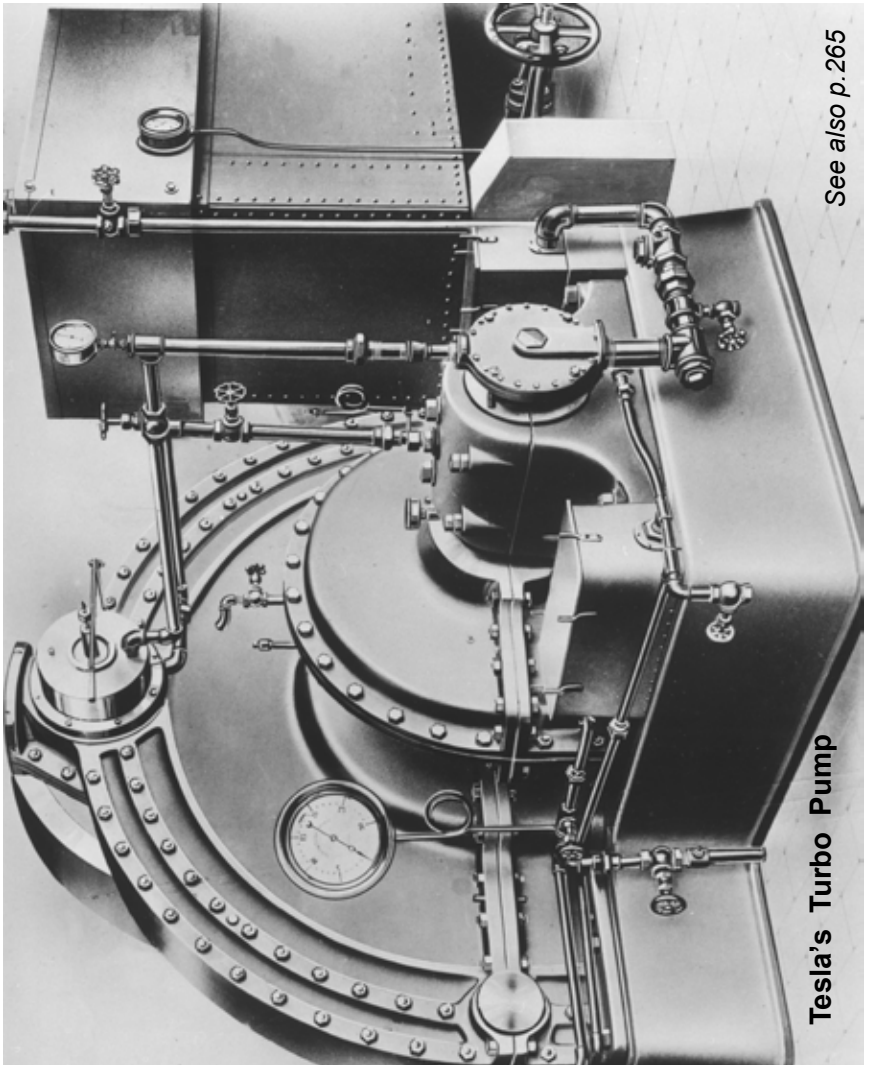
the suggestions of the limitless possibilities of the latest Tesla discovery.

"Just what is your new invention?" I asked.

"I have accomplished what mechanical engineers have been dreaming about ever since the invention of steam power," replied Dr. Tesla. "That is the perfect rotary engine. It happens that I have also produced an engine which will give at least twenty-five times as much power to a pound of weight as the lightest weight engine of any kind that has yet been produced.

"In doing this I have made use of two properties which have always been known to be possessed by all fluids, but which have not heretofore been utilized. These properties are adhesion and viscosity.

"Put a drop of water on a metal plate. The drop will roll off, but a certain amount of the water will remain on the plate until it evaporates or is removed



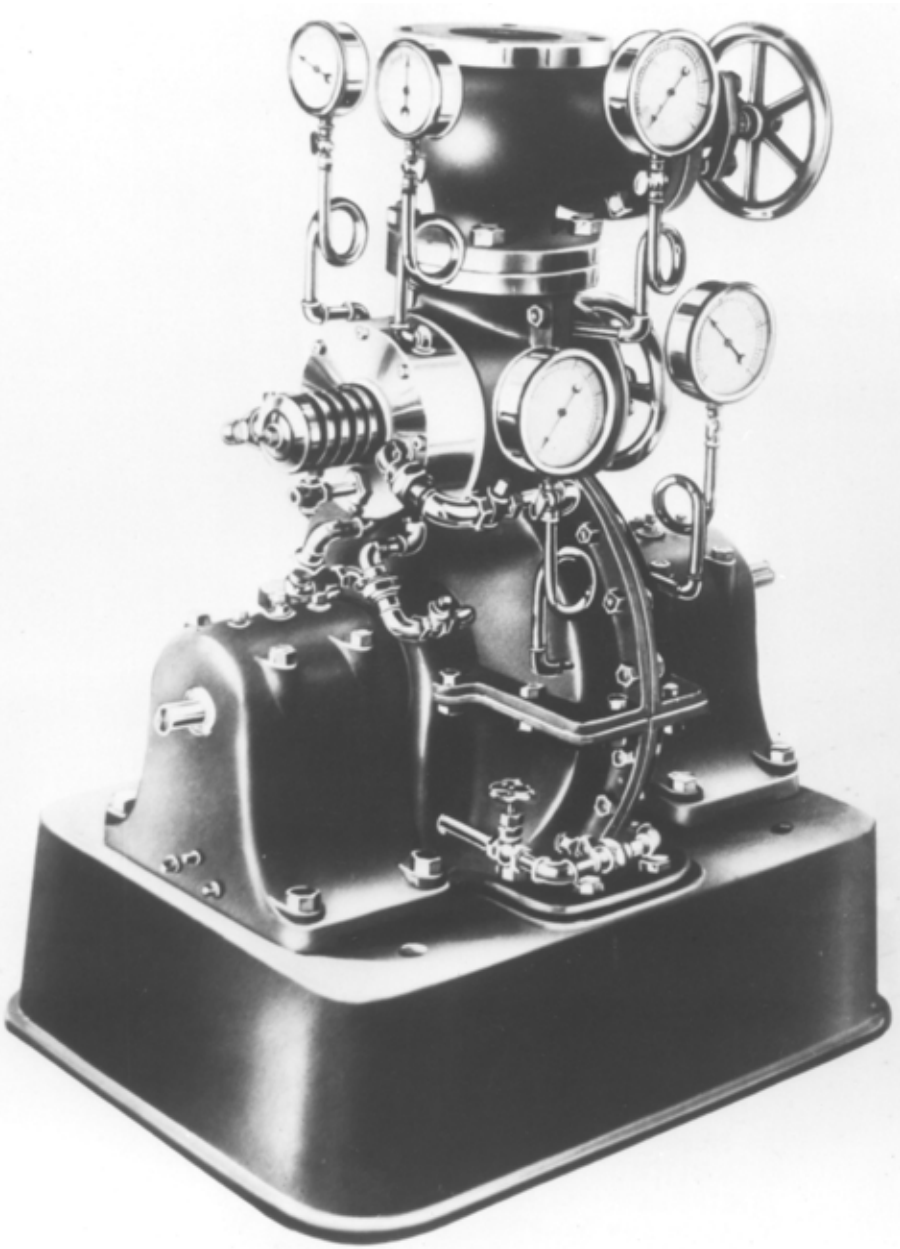
See also p.265

Tesla's Turbo Pump

by some absorptive means. The metal does not absorb any of the water, but the water adheres to it.

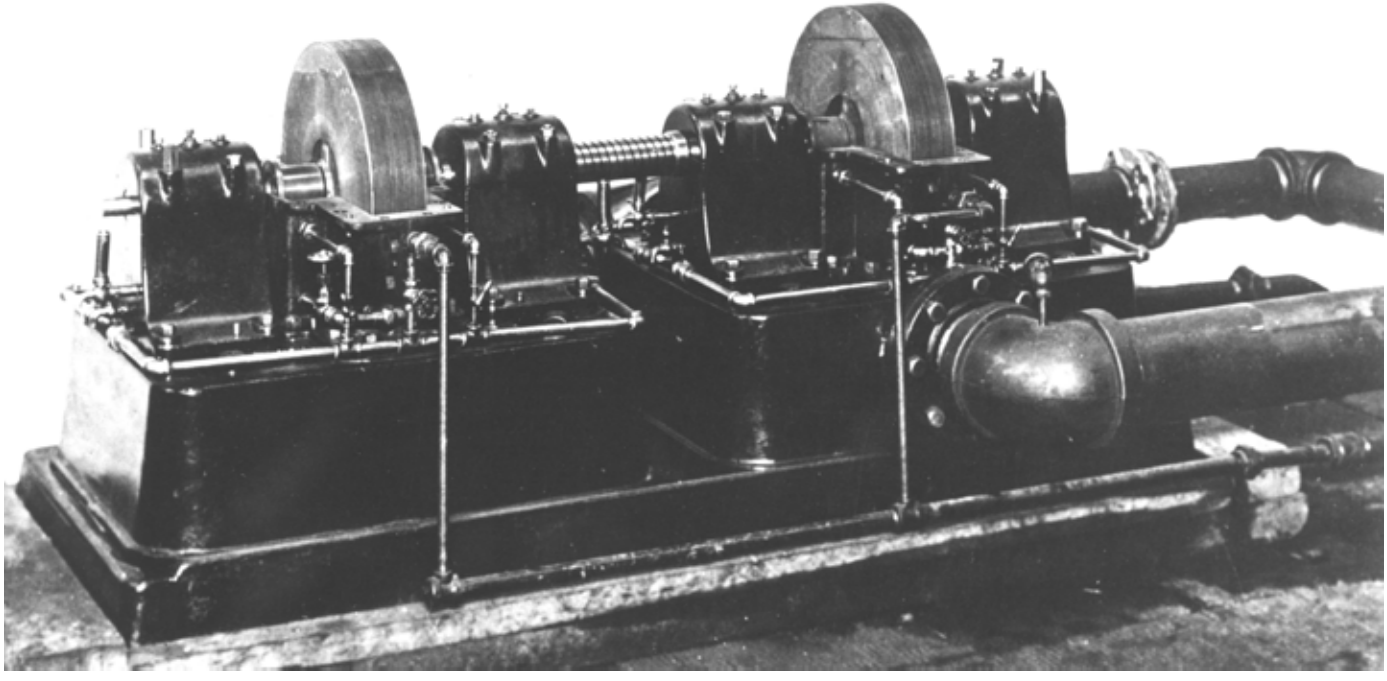
"The drop of water may change its shape, but until its particles are separated by some external power it remains intact. This tendency of all fluids to resist molecular separation is viscosity. It is especially noticeable in the heavier oils.

"It is these properties of adhesion and viscosity that cause the 'skin friction' that impedes a ship in its progress through the water or an aeroplane in going through the air. All fluids have these qualities—and you must keep in mind



The 200-Horsepower, High-Pressure, Steam Engine

This view shows one complete high pressure unit with the steam throttle above, and below it the reversing valve and the compact engine. It stands on a base 20 by 35 inches and measures only five feet from the Floor to the top of the steam inlet on the throttle housing. Note the many gages used in the tests.



The Tesla Steam Engine Testing Plant at the Esison Waterside Station, New York

The top halfs of the casings are removed, showing two rotors. Each rotor consists of 25 disks 1/16 - inch thick by 18 inch diameter. The rotor measures 3 1/8 inches across the face. The steam enters at the top periphery, and flows in spiral paths to exhaust at the center of the disks. The driving engine is on one side with the brake engine on the other. Between them is a torsion spring. The steam inlets are on opposite sides of the removed upper housings and are fully reversible; the driving and driven engines can be reversed during operation The torsion of the spring is automatically shown by beams of light and mirrors and the horse-power is read from the reflected light position on a scale. At 9,000 revolutions per minute, with 125 pounds at the throttle and free exhaust, this turbine develops 200 horse-power. It weighs two pounds per horse-power.

(see photos and drawing featured on pages 25, 35, 43,,149, 128,151, 185 and 203)

Page **277** **THE ELECTRICAL EXPERIMENTER** July, 1920

The Tesla Gasoline Turbine

A Revolutionary Gas Engine That Requires No Spark Plug, No Carburetor, No Valves and No Pistons.

By Joseph H. Kraus

An immense amount of work has been done during the past fifteen or twenty years by engineers who have endeavored to produce a simple and practical explosive gas turbine, but the mechanical and thermal hindrances have been so great that up to the present time no signal success has been achieved. The turbine is an ideal prime mover; simple in principle, but the accessory apparatus for operating it explosively is very complex and liable to great wear. Thus the products of an explosion must affect the rotor, during which time a number of operations have to be performed.

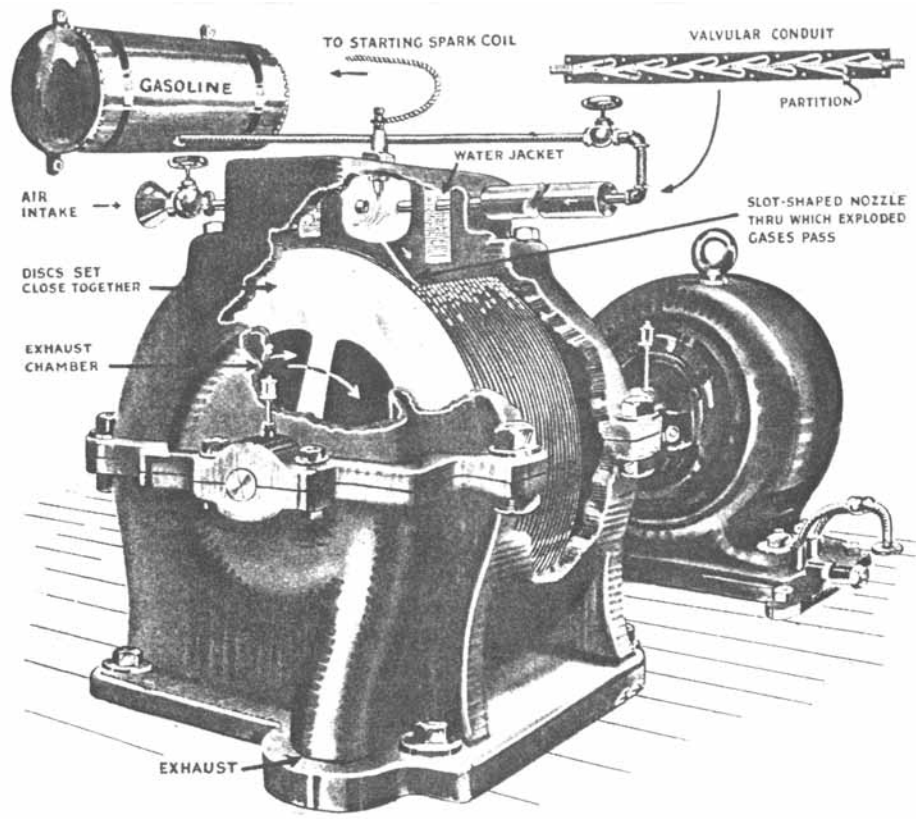
Fuel and air must first be admitted thru separate channels into a combustion chamber; the mixture is then ignited, all inlets and outlets closed. The compressed gases thus exploded must be directed thru a nozzle to the rotor plates or buckets and the chamber cleaned and made ready for the admission of a fresh mixture.

All these operations are controlled by valves which must be opened and closed at precise moments and therefore are generally controlled by the motion of the turbine rotor itself. Irrespective of the difficulty of keeping the valves in good order at high temperatures, at which they must operate the apparatus taken as a whole, is so complicated that the ordinary form or reciprocating type gasoline engine more preferable.

Doctor Nikola Tesla, whom the readers of this publication know very well and whose amazing work in the various scientific fields is also universally recognized, again comes into the limelight with a very remarkable explosive gasoline turbine perfected by him recently which he describes in detail in a patent just granted. This remarkable turbine does away with all the troubles and complexity of the former attempted types. Stated briefly, the invention consists in the production of a peculiar shape conduit, thru which the gases are admitted into the turbine, and which has the singular property of permitting their passage in that direction only; in other words, uni-directionally.

This device when used in connection with his bucketless turbine produces an engine which may be explosively operated by gasoline, alcohol or other fuels and is absolutely devoid of all valves. It is the simplest internal

THE ELECTRICAL EXPERIMENTER



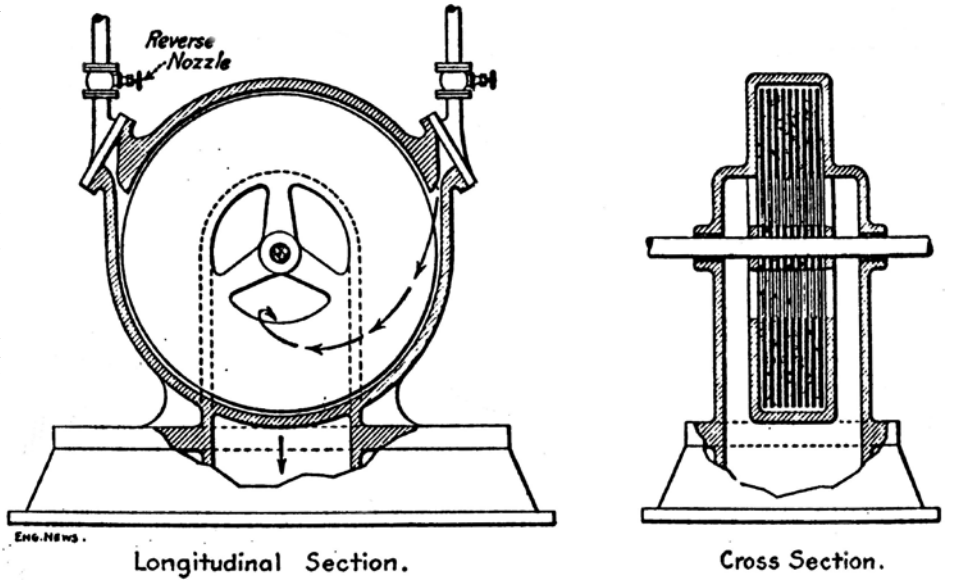
The Very Latest Invention In the Gasoline Engine Field Is the New *TESLA* "Valveless and Bucketless Gasoline Turbine," Here Illustrated. Two of the Main Features of This Remarkable Invention Are That the Usual Carburetor or Vaporizer is Done Away With and, Secondly, No Buckets Are Necessary on the Turbine Blades, the Latter Simply Comprising a Series of Flat Steel Discs, Placed a Short Distance Apart. The Successive Explosions of the Gaseous Vapor Are Projected Thru a Nozzle on to the Blades, Thus Causing the Rotation of the Blade Members and the Shaft to Which They Are Connected. A Dynamo Is Shown Connected to the Turbine at the Right of the Picture Herewith. This Article Was Prepared in Collaboration with Dr. Tesla.

combustion motor conceivable. Owing to the tremendous output of the Tesla turbine, one single disc being practically equivalent in performance to a whole bucket-wheel, a very small machine of this kind is capable of developing an astonishing amount of power. The principle of the operation will be clearly understood by the aid of the accompanying diagram.

Referring to the detailed view of the conduit, we first note a casing of metal or other suitable material which may be milled or pressed from sheet metal into the desired form. From its side walls extend alternately projections terminating in buckets which in order to facilitate manufacture are congruent and spaced at equal distances.

In addition to these there are independent partitions, the purpose of which will presently be made clear. There is a nipple at each end provided for pipe connections. The bottom is solid and the upper or open side is closed by a close-fitting plate. When desired any number of such pieces may be joined in series, thus making up a valvular conduit of such length as the circumstances may require.

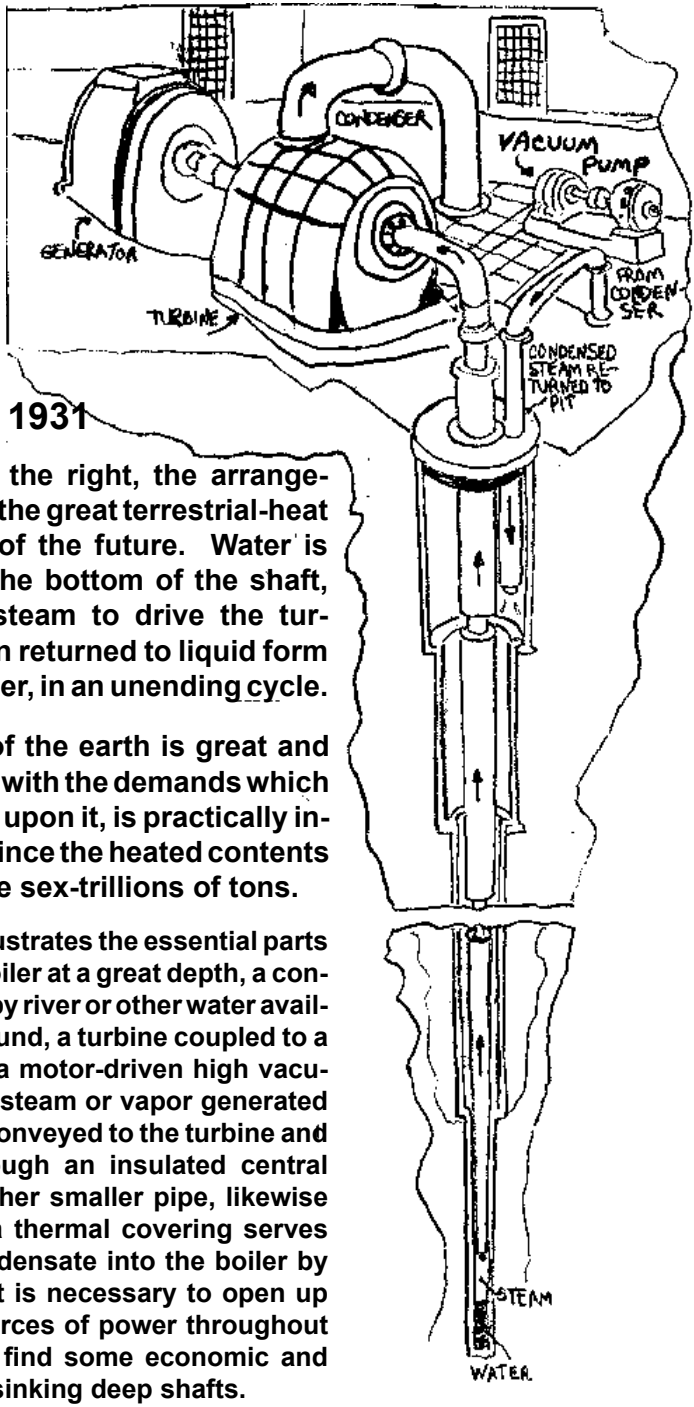
In elucidation of the mode of operation let it be assumed that the medium under pressure be admitted at the right. Evidently its approximate path will be as indicated by the dotted line, which is nearly straight, that is to say, if the channel be of adequate cross-section the fluid will encounter a very small resistance and pass thru, freely and undisturbed, at least to a degree.



THE TESLA DISK WHEEL IN A STEAM TURBINE

Our Future Motive Power

By
Nikola Tesla



December 1931

Above and to the right, the arrangement of one of the great terrestrial-heat power plants of the future. Water is circulated to the bottom of the shaft, returning as steam to drive the turbines, and then returned to liquid form in the condenser, in an unending cycle.

Internal heat of the earth is great and in comparison with the demands which man can make upon it, is practically inexhaustible: since the heated contents of the earth are sex-trillions of tons.

This drawing illustrates the essential parts comprising a boiler at a great depth, a condenser, cooled by river or other water available, on the ground, a turbine coupled to a generator, and a motor-driven high vacuum pump. The steam or vapor generated in the boiler is conveyed to the turbine and condenser through an insulated central pipe while another smaller pipe, likewise provided with a thermal covering serves to feed the condensate into the boiler by gravity. All that is necessary to open up unlimited resources of power throughout the world is to find some economic and speedy way of sinking deep shafts.

Everyday Science and Mechanics

December, 1931

Our Future Motive Power

"In this instructive article, the great scientist and inventor who revolutionized industry and communication with his alternating current motors and distributing system, and opened the way for radio with his high-frequency researches, analyzes the problem of obtaining power to replace our wasted fuel, and indicates the method of tapping the earth's hidden resources which will support the industry of

The material as well as intellectual progress of Man is becoming ever more dependent on the natural forces and energies he is putting to his service. While not exactly a true measure of well being and enlightenment, the amount of power used is reliable indication of the degree of safety, comfort and convenience, without which the human race would be subject to increasing suffering and want and civilization might perish.

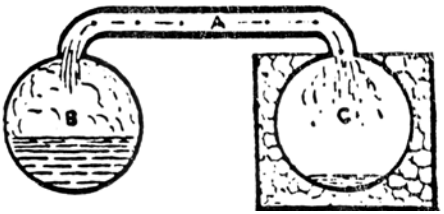


Figure 1
The "cryophoros" is well known as a scientific toy, exemplifying also the principle of refrigerating machinery.

Virtually all our energies are derived from the sun, and the greatest triumph we have achieved in the utilization of its undying fire is the harnessing of waterfalls. The hydroelectric process, now universally employed, enables us to obtain as much as eighty-five per cent of the solar energy with machines of elementary simplicity which, by resorting to the latest improvements in the technical arts, might be made capable of enduring for centuries. These advantages are entirely exceptional, very serious handicaps and great, unavoidable losses confronting us in all other transformations of the forces of nature. It is, therefore, desirable in the interest of the world as a whole, that this precious resource should be exploited to the limit. Judging from the average height of the water discharged annually from the clouds, and the mean fall over the aggregate land surface, the total terrestrial water power may be theoretically estimated at ten billions of horse power. Of course, only a part of that is suited for practical development and relatively little is actually utilized- twenty-five per cent, perhaps, in the most advanced countries, less in others, and there are some in which not even the ground has been broken. Great waterfalls exist in many inaccessible regions of the globe and new ones are being discovered, all of which well be eventually harnessed when the wireless transmission of energy is commercialized. There is foundation for hope, however, that our present limitations in the amount

of the available power may be removed in the future. Three-quarters of the earth's surface are covered by the oceans and the rainfall over all this vast area is useless for our purpose. Much thought has been given to artificial production of rain, but none of the means proposed offers the slightest chance of success. Besides, so far only the precipitation in a limited region was contemplated, leaving the total quantity of moisture for the entire land unchanged except as modified through the natural tendency of the oceans to divert more and more water from the continents. The real and important problem for us to solve is not to bring about precipitation in any chosen locality, but to reverse this natural process, draw the vapors from the seas and thereby increase, at will, the rainfall on the land. Can this be done?

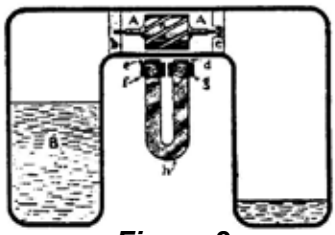


Figure 2
Fundamental plan of a system whereby the transfer of vapor between two vessels at different temperatures drives the armature of an electrical generator.

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 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 waterfalls, all the work would be performed by the sun, while we would have merely to release the trigger. In this manner we might obtain sufficient energy from falling water to provide for all our necessities. More than this, we could create new lakes and rivers, induce a luxuriant flora and fauna and convert even the arid sands of deserts into rich, fertile soil.

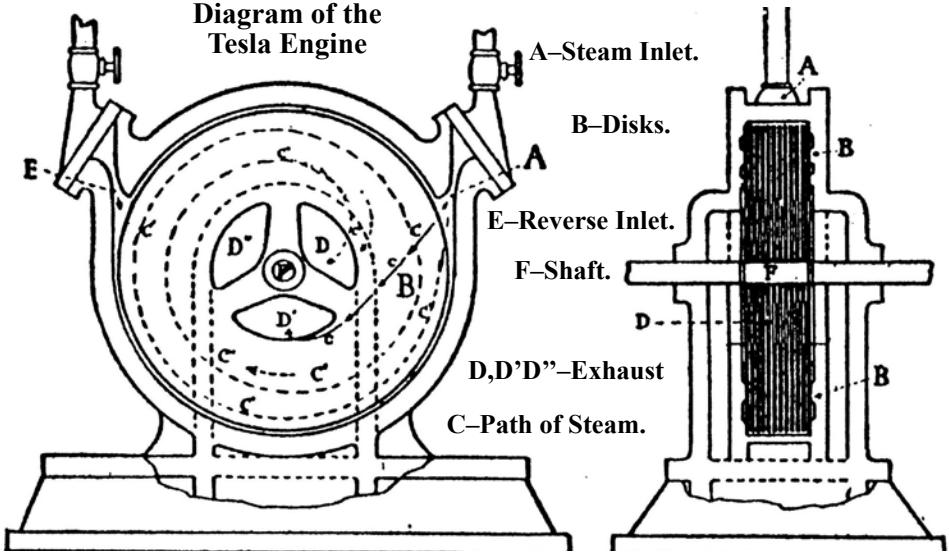
But the full realization of this idea is very remote. The hard fact is that unless new resources are opened up, energy derived from fuel will remain our chief reliance. The thermodynamic process is wasteful and barbarous, especially when burning coal, the mining of which, despite of modern im-

***** *"To look for noon around 2 o'clock."*

provements, still involves untold hardships and dangers to the unfortunates who are condemned to toil deep in the bowels of the earth. Oil and natural gas are immensely superior in this and other respects and their use is rapidity extending. It is quite evident, though, that this squandering cannot go on indefinitely, for geological investigations prove our fuel stores to be limited. So great has been the drain on them of late years that the specter of exhaustion is looming up threateningly in the distance, and everywhere the minds of engineers and inventors are bent upon increasing the efficiency of known methods and discovering new sources of power.

Nature has provided an abundant supply of energy in various forms which might be economically utilized if proper means and ways be devised. The sun's rays falling upon the earth's surface represent a quantity of energy so enormous that but a small part of it could meet all our demands. By normal incidence the rate is mechanically equivalent to about 95 foot pounds per square foot per second, or nearly 7,300 horse power per acre of ground. In the equatorial regions the mean annual rate is approximately 2,326 and in our latitudes 1,737 horse power for the same area. By using the heat to generate steam and operating a turbine under high vacuum, probably 200 horsepower per acre could be obtained as net useful power in these parts. This would be very satisfactory were it not for the cost of the apparatus which is greatly increased by the necessity of employing a storage plant sufficient to carry the load almost three-quarters of the time.

The energy of light rays, constituting about 10% of the total radiation, might be captured by a cold and highly efficient process in photo-electric



Page **1** **NEW YORK TIMES** Nov. 8, 1931

SEA POWER PLANT DESIGNED BY TESLA

He Holds Steam Can Be Made Economically by Using Different Temperatures of Ocean

Plans Land Device, Too

Both Embody Improvements in Wollaston's Toy, Says Scientist

Tests To Be Made Soon.

Designs of two new power plants, one to utilize the heat below the surface of the earth, the other to take advantage of the difference in temperature between upper and lower levels of the ocean, are announced by Dr. Nikola Tesla, the inventor, in an article in the December issue of Everyday Science and Mechanics, out tomorrow.

While many attempts have been made in the past fifty years to devise ways to utilize the heat energy of the ocean and the interior of the earth, Dr. Tesla said his design embodied improvements which would make it possible to supply power from ocean and terrestrial sources on an economical basis in competition with other sources of power.

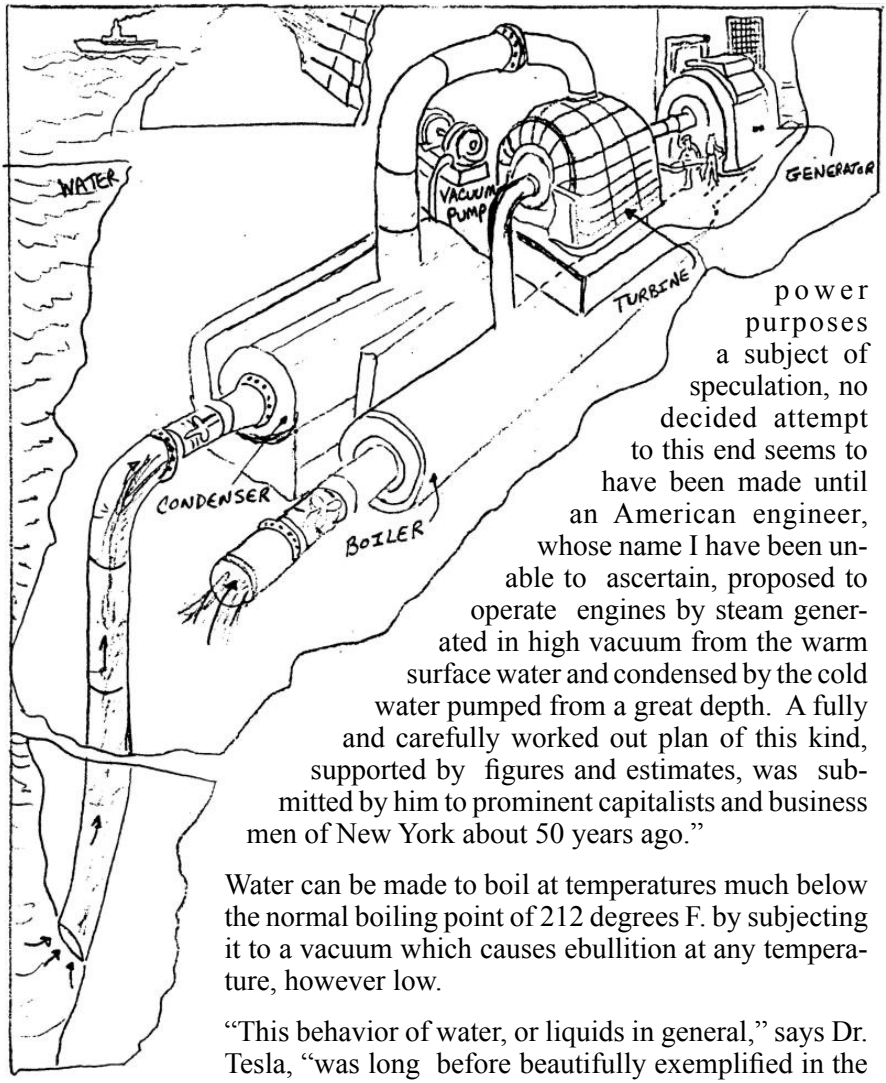
Only last year Professor Georges Claude of Paris constructed at Matanzas Bay, Cuba, an experimental plant for the purpose of harnessing the temperature differences in the tropical seas for power purposes. Several engineers, Dr. Tesla among them, are of the opinion, however, that the Claude plant, while workable, is too expensive to produce power on an economical basis. Dr. Tesla said his own designs do away with the most expensive and objectionable features of former experiments.

Temperatures in Tropical Seas

"It is well known," Dr. Tesla writes, "that there exists, in tropical seas, a difference of 50 degrees F. between the surface water and that three miles below. The temperature of the former, being subject to variations, averages 82 F., while that of the latter is normally at least 32 degrees F., or nearly so, as the result of the slow influx of the ice-cold polar stream.

"In solid land these relations are reversed, the temperature increasing about one degree F. for every 64 feet descent. But while all this was common knowledge for at least 75 years and the utilization of the heat of the earth for

See page 47 for illustration of terrestrial heat plant



power purposes a subject of speculation, no decided attempt to this end seems to have been made until an American engineer, whose name I have been unable to ascertain, proposed to operate engines by steam generated in high vacuum from the warm surface water and condensed by the cold water pumped from a great depth. A fully and carefully worked out plan of this kind, supported by figures and estimates, was submitted by him to prominent capitalists and business men of New York about 50 years ago."

Water can be made to boil at temperatures much below the normal boiling point of 212 degrees F. by subjecting it to a vacuum which causes ebullition at any temperature, however low.

"This behavior of water, or liquids in general," says Dr. Tesla, "was long before beautifully exemplified in the classical device called "cryophoros," consisting of two communicating and exhausted bulbs partially filled with a liquid, which is evaporated in one and condensed in the other. It was invented by W. H. Wollaston, a great English scientific man and investigator (1766-1828) who first commercialized platinum, and was credited by some to have anticipated Faraday in the discovery of electromagnetic rotation.

"The original instrument brought out at the beginning of the nineteenth century had one of the bulbs packed in ice with the result of the freezing water in the other. In conformity with the views of that time it was thought that the cold of the ice was carried to the water, and so the Greek name, meaning "cold-carrier," was given to the device. But now we know that the process is

of the opposite character, the freezing being brought about by the transport of the latent heat of evaporation from the warm to the cold bulb. One would naturally infer that the operation would cease as soon as the water is frozen at the surface, but curiously enough the ice itself continues to yield steam, and it is only because of this that all of the water is solidified."

A Toy on a Huge Scale

The ocean plant originally proposed by the French engineer, Professor Claude, and Dr. Tesla is no more than Wollaston's scientific toy on a huge scale, Dr. Tesla points out, adapted for continuous operation and having an engine interposed between the two communicating vessels.

TEBA Member John Pickard's Combined cycle Tesla Turbine. Combustion gasses from the horizontal steam turbine feed one set of nozzles while the steam output feeds another. The Alternator is a three phase Tesla type operating at 400 cycles per second.

Tesla's Geothermal Solution

Back in the 1960's the late Jake Possell discovered the Tesla turbine, after being introduced to the concept by his mechanic Kenneth Dunn. Jake went on to attempt control of the technology, patenting various configurations and applications. Jake was involved with several projects to employ Tesla disk turbines. The following text and graphs are reconstructed from literature published in the 1980's by Turbines International Inc., a company

for which Jake was providing engineering, As well as more recently built turbines by TEBA member Sonny Entrican (p.67 & 68). This literature presented the revolutionary potential of the technology. Disk turbines for geothermal energy recovery were built and tested in the 1980's.

Though simple in construction, Tesla's turbine must be built and applied correctly for proper result. The original Tesla designs are now available via TEBA.

Jake significantly modified the Tesla pump design, allowing his one time business associate, machinist Max Gurth, opportunity to provide superior pumps of higher efficiency, closer to the original Tesla design. This resulted in an entirely new "Quantum Leap" for the pumping industry beginning in the 1980's (See Page 95).

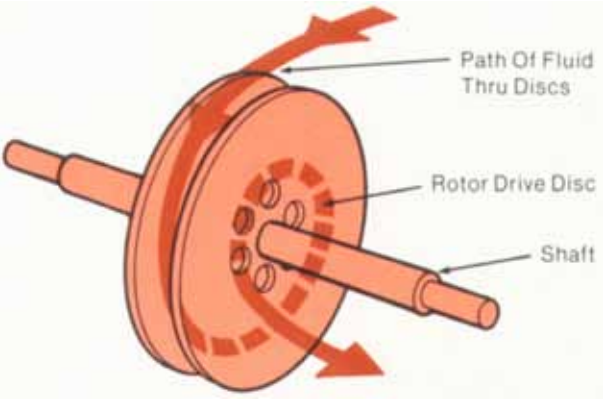
Tesla believed passionately in the geothermal concept, coining it; "Our Future Motive Power." Reproduced on page 47. It is truly unfortunate that an actual Tesla turbine has yet to be employed in commercial geothermal service. Only a Tesla type turbine can survive in applications employing

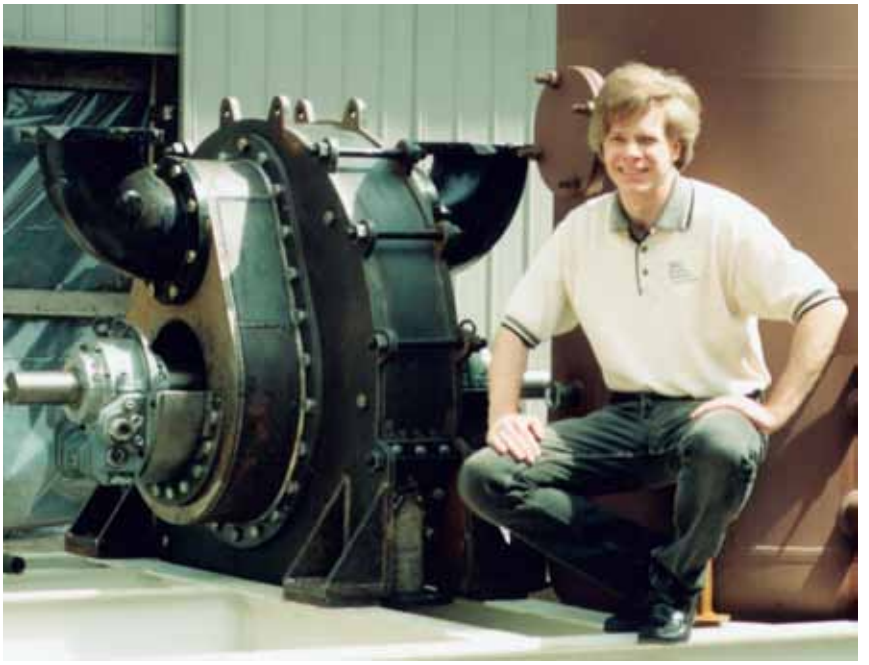
"Total Flow" direct connection to Salt Brine geothermal resources. It has been conservatively estimated that the Salton Sea alone, located in Southern California, could easily provide over 20 times the power requirement for the entire U.S.

Turbines International, Inc., was a privately held company set up specifically to research, develop and manufacture an economically feasible geothermal turbine which would accept the total effluent at the well head. After several months of intensive research, TI designed, built and tested four different turbine configurations. Tests were conducted with working fluids ranging from ambient temperature, high pressure air to ambient temperature, high pressure water. And from 100 percent quality steam to 0 percent quality (hot water) with a temperature range from 190° to 500°F.

Using the latest design minicomputer, modern computer modeling and analysis; TI has analyzed the test data and can effectively "custom design" our production model turbine to fit the well head conditions of virtually any geothermal or geopressure area in order to optimize the output from that particular well.

TI's engineering and manufacturing staffs are thoroughly trained, have a wide variety of experience and are capable of interfacing our turbine/generator units with your system or designing the total system and managing the project from sinking the well to final "on site" checkout.





Geothermal Energy —
The Problem / The Solution

For geothermal energy to take its place among the major energy sources, there must be a revolutionary breakthrough in steam turbines and power plant systems which will eliminate, or at least minimize, the huge energy losses between the well head and the turbine. These losses often amount to 70 percent of the available energy. Several criterion are therefore established for turbines and systems.

- The turbine must be sized for an individual well and be located as near the well head as possible. (Eliminates the long piping runs, small size reduces manufacturing costs and improves system availability.)
- The turbine must accept the total effluent of the well.
- The system must be of the closed loop type. (Eliminates large cooling towers, virtually eliminates environmental pollution problems.)
- The turbine must be capable of operating efficiently and economically with working fluids from 90°C to 300°C and pressure ranges from 100 PSIG to 2000 PSIG.
- The turbine and system must maintain a relatively flat operating curve with working fluids which contain dissolved or suspended solids up to 35,000 parts per million.
- The turbine must be capable of operating economically with wet steam and/or hot water as the working fluid.

(Eliminates need for cyclonic phase separators.)

Obviously, from the above criterion, the turbine has been the major bottleneck to economical geothermal energy until this time. Recognizing the great need, TI set out to develop a turbine which would meet those criterion. After several months of research and concept development, TI designed and built four turbine configurations and four subsequent modifications which were subjected to a matrix of tests including all the temperature and quality ranges found in the foregoing criteria.

Using modern computer modeling and data analysis techniques, TI is now able to "custom design" their standard production model turbine to fit virtually any geothermal or geopressure well to optimize its output. TI's turbine promises to be **the solution** to today's geothermal and geopressure requirements.

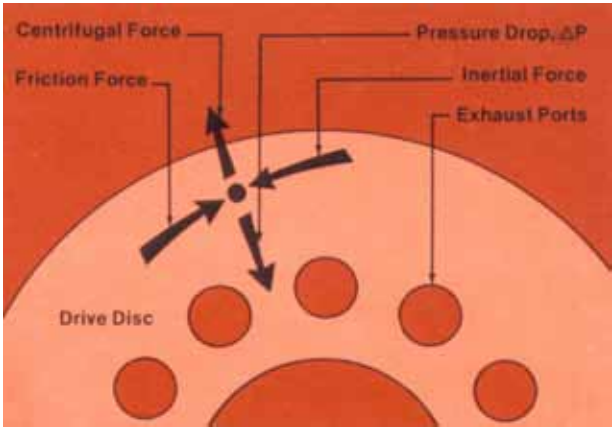
Shear Torque Turbine

Fundamentally, the turbine uses the basic flat, parallel disc design of Tesla and then incorporates a new, full admission nozzle with integral flow guides and a new regenerator concept which optimizes the pressure drop across the working surfaces and conditions the exhausting fluid to present the maximum energy to the secondary stages.

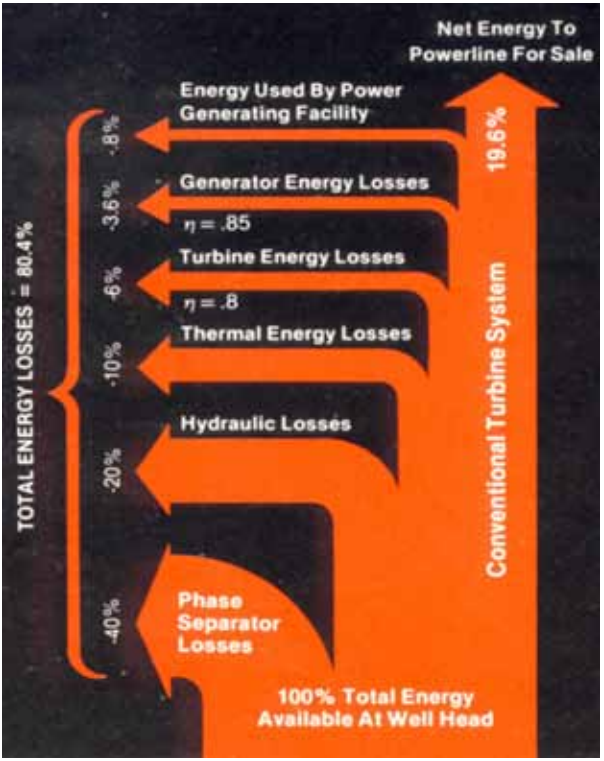
Unique Characteristics:

The ability to function with virtually any temperature fluid and with low quality fluids sets TI's turbine apart from conventional geothermal steam turbines. This capability makes conventionally unfeasible wells productive and economically feasible. The ability to utilize low quality fluids eliminates the need for expensive, energy robbing liquid/gas phase separators upstream form the turbine.

- The primary working portion of TI's turbine rotor is the **Drive Disc** section. Several thin, flat, specially ported, circular discs and spacers are mounted in a unique arrangement on a single shaft. Well head conditions and desired output dictates the number of drive discs, disc spacing and disc arrangement on the shaft.



- TI's departure from conventional turbine design results in a **much simpler** design with significantly lower



manufacturing costs. TI's use of drive discs in place of blades or buckets in conjunction with a unique nozzling arrangement greatly reduces manufacturing difficulty. That savings is passed on to the end user in a selling price 50 percent less than conventional systems. And the lead time for a system installation is reduced from five to eight years to less than two years.

• A side benefit of simpler design is the **Ease of Maintenance**. TI's concept of utilizing 5MW modules employs smaller units, which uses much smaller handling equipment, and will reduce down time by a minimum of 30 percent. The modular concept and reduction in down time will provide a $^{1}/_{4}$ to $^{1}/_{3}$ increase in plant generating capacity. Maintenance expenditures and personnel costs are held at a minimum. Repair parts are "off-the shelf" items requiring lower inventory costs and shorter delivery schedules.

• A safety benefit results from the radial flow path of the fluid and custom disc design: **self - limiting overspeed protection**. Centrifugal forces acting on the fluid are overcome by the forces from the pressure drop across the rotor disc. Inertial forces (from the fluid velocity) overcome friction forces (boundary layer drag and resulting turbulence).

• The **nozzling arrangement** consists of specially designed toroidal expansion, phase separating nozzles with an integral system of flow guide vanes. This configuration directs the fluid into the drive discs uniformly around its circumference at the optimum angle.

(Ed; Possell Pat. U.S. # 4,232,992)

An integral regenerator section is employed to maximize the pres-

sure drop across the drive discs as well as enhance the properties of the working fluid entering secondary stages.

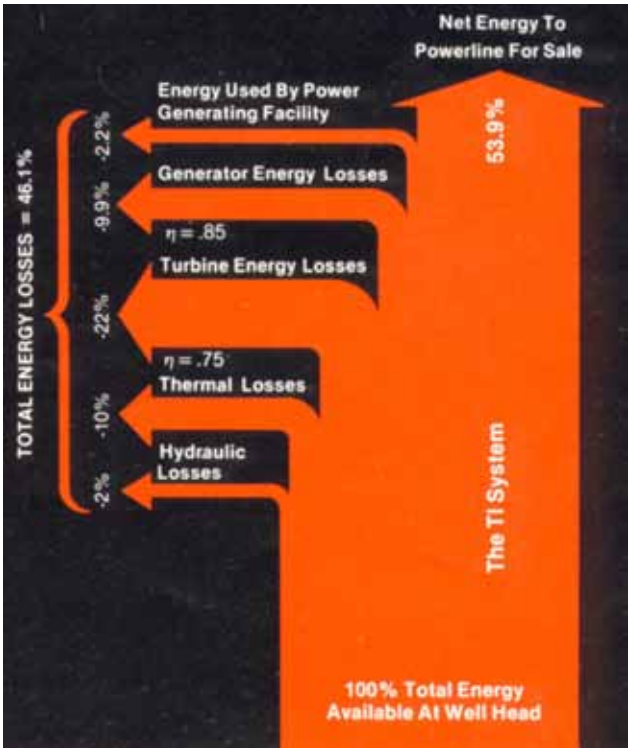
Operating Principle:

TI's turbine converts energy from the incoming fluid (gas, liquid or any mixture of the two) to rotating shaft power through the principle of boundary layer drag. This drag phenomenon is well known to aerodynamicists as a negative factor in aircraft performance.

In TI's turbine, boundary layer drag is utilized to achieve energy conversion by the fluid flowing between the rotor discs.

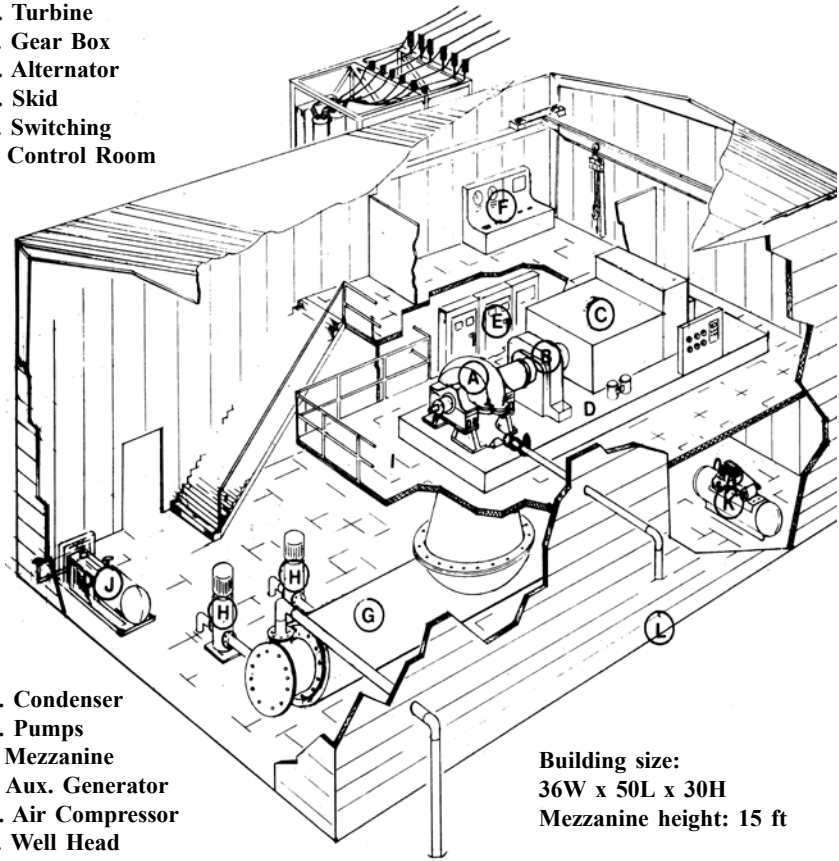
The working fluid enters the turbine housing tangentially and passes through a unique nozzle/flowguide system where it is expanded (and, for the two-phase fluids, separated) and then is guided to a near-tangential entry into the rotor section. This system imparts a high degree of kinetic energy to the working fluid. As the fluid flows in a spiral path between the surface of the drive discs to specially designed exhaust ports, it transfers energy to the discs due to the friction created by the boundary layer shearing with the fluid flowing thru the discs. This drag or shear friction causes the rotor to turn in the direction of the moving fluid.

By definition of the boundary layer, the velocity of the fluid adjacent to the disc is virtually the same as the velocity of the disc. Therefore, surface wear is eliminated since impingement is eliminated. The turbine, with no impinging surfaces, is not subject to the same limitations of input (i.e. clean, dry steam) as conventional equipment. So it functions comparably with all the common geothermal and geopressure effluents as the working fluid.



As the fluid exits the rotor section

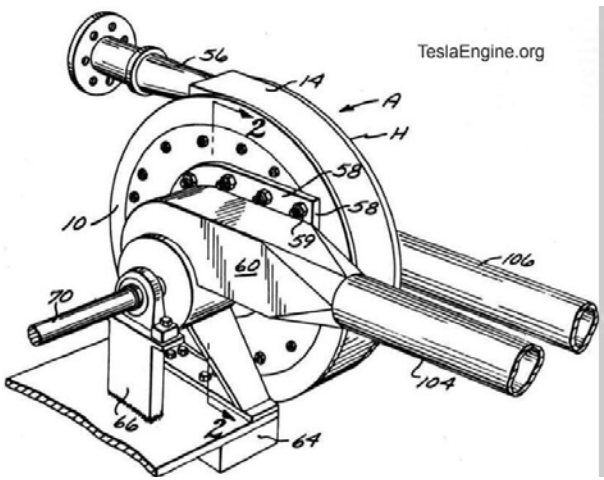
A. Turbine
B. Gear Box
C. Alternator
D. Skid
E. Switching
F. Control Room

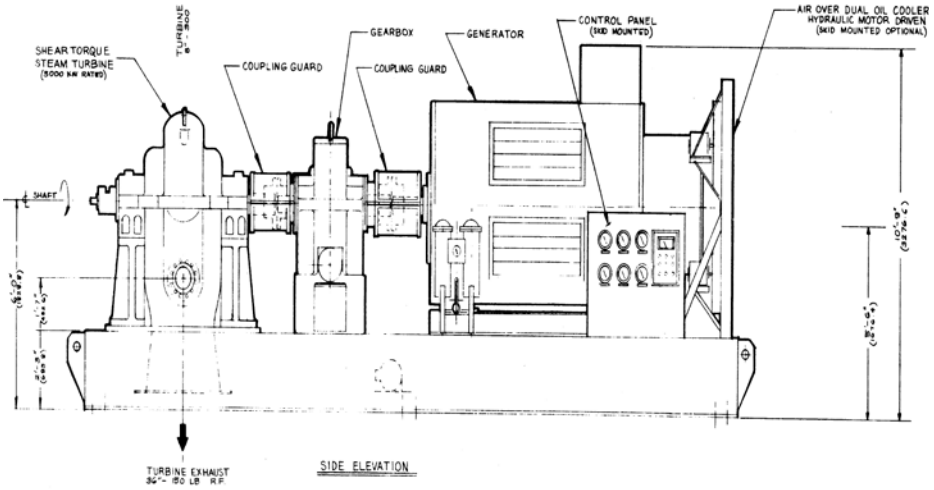


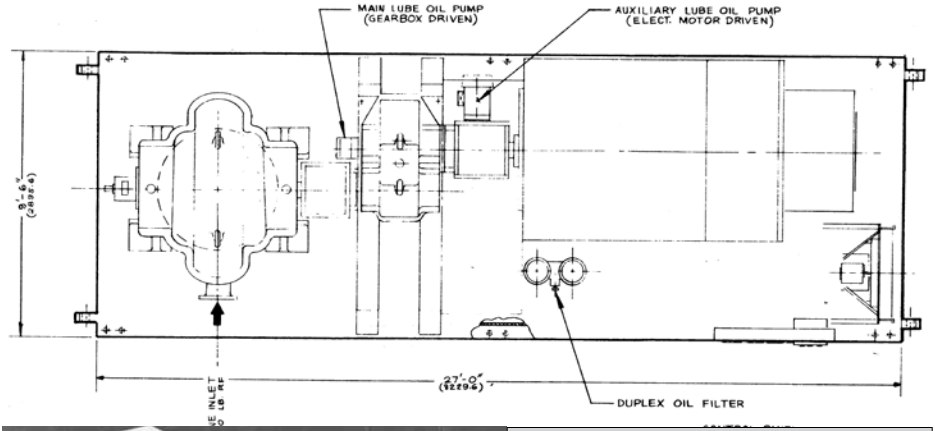
G. Condenser
H. Pumps
I. Mezzanine
J. Aux. Generator
K. Air Compressor
L. Well Head

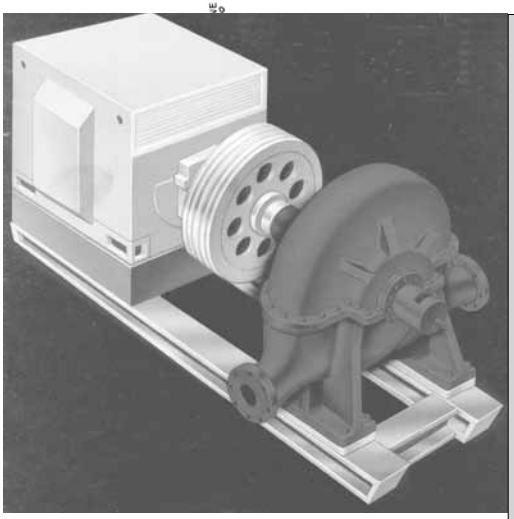
Building size:
36W x 50L x 30H
Mezzanine height: 15 ft

it spirals axially along the shaft through an internal crossover to the regenerator discs through inlet ports located near the shaft and continues in a spiral path thru the regenerator section where it picks up centrifugal pressure before exiting through the tangentially oriented exhaust ports in the wall of the regenerator housing. The regenerator is designed to control the exit pressure of the drive discs and thereby

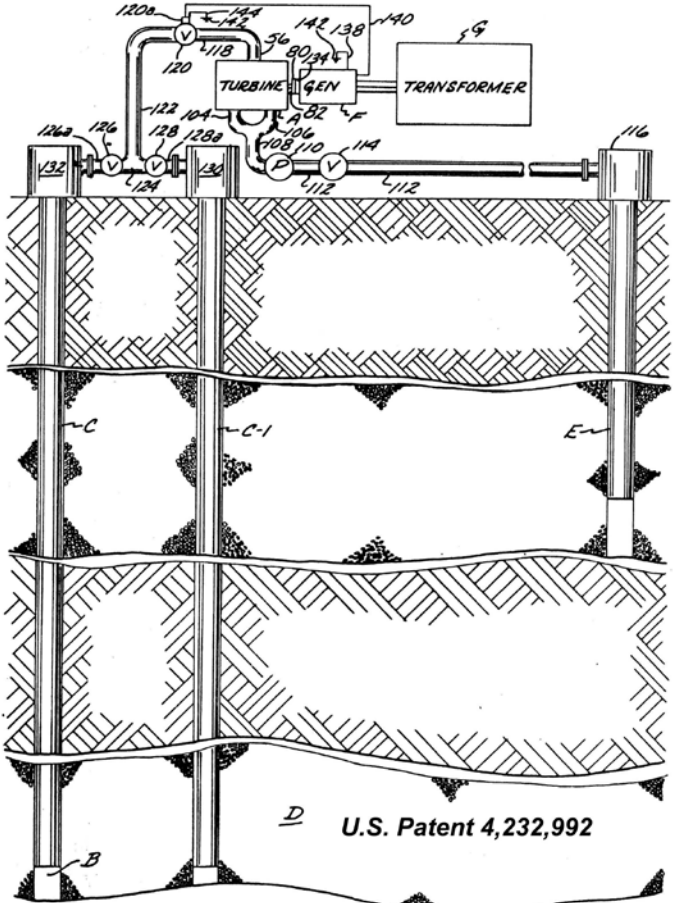








It has been very conservatively estimated that the Salton Sea, located in Southern California, could, alone, supply over 20 times the Entire Power Requirement for the U.S. with this Tesla technology!



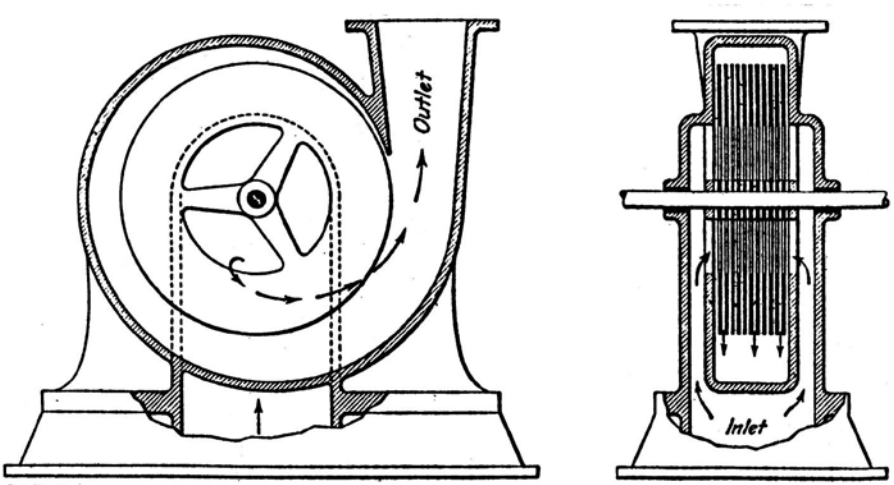
"Prior to the present invention the use of geothermal energy has been limited to those areas that produce dry super heated steam. Such areas are extremely limited in number. In geothermal areas where dry super heated steam is available conventional turbines may be used to produce power.

In most geothermal area the hot pressurized fluid produced from bore holes is of the multiphase type, that is, the fluid is a mixture of steam, droplets of entrained droplets of water, and also finely particled solid materials. If such hot pressurized fluid is to be use for power producing purposes with a conventional turbine the entrained droplets of water and particles of solid materials must first be removed therefrom. Removal of the droplets of water results in the loss of their heat energy as well as the kinetic energy they possess. Furthermore, the removal of the droplets of water results in loss of heat on the pressurized fluid. The use of a mixture of steam and entrained droplets of water for power producing purposes with conventional turbines results in the blades of the latter being eroded in a relatively short time. From the above comment it will be apparent that the greatest amount of power could be produced if the entire effluent could be used for not only does the steam posses kinetic energy but this is equally true of the entrained droplets of water."

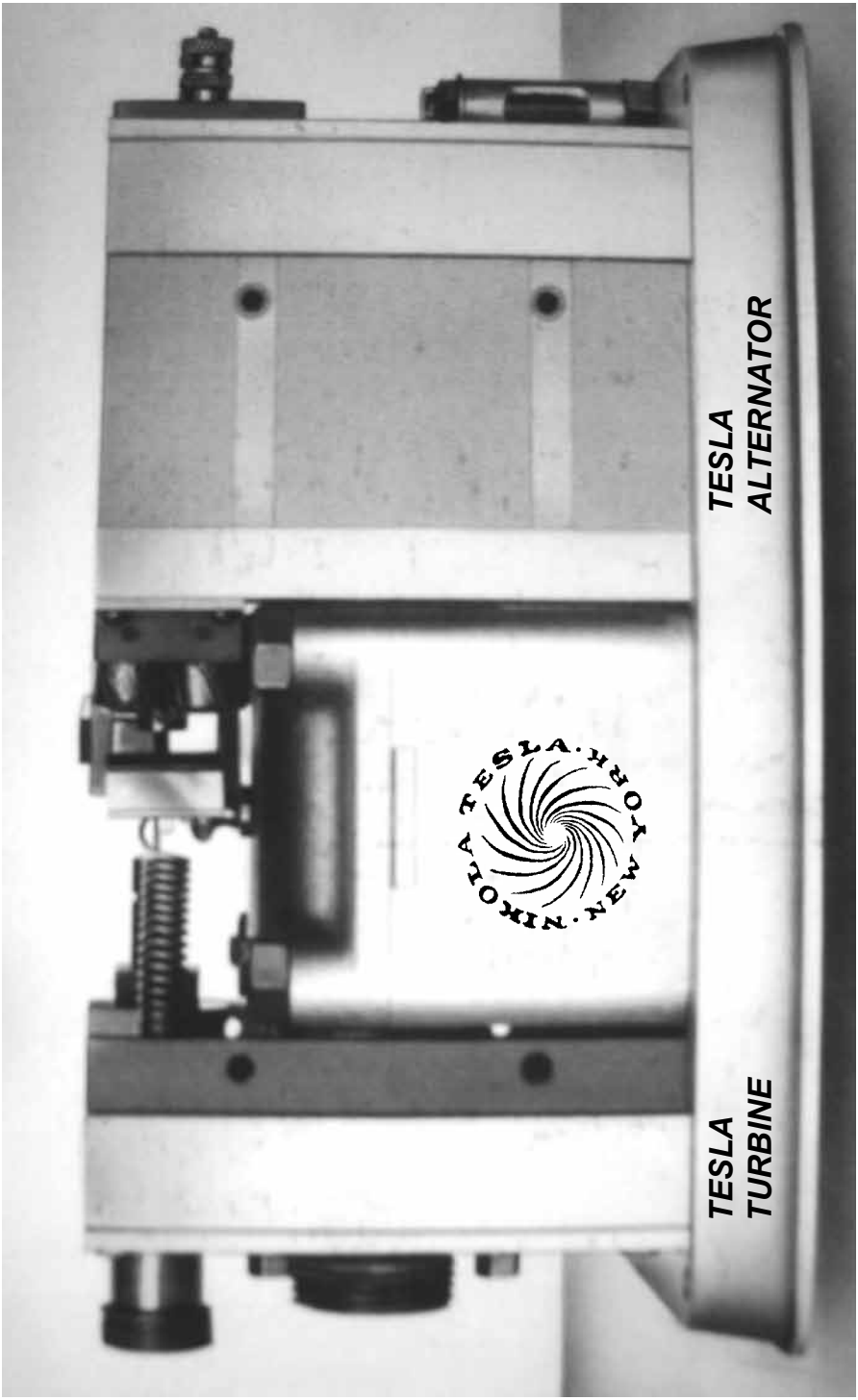
In subduing the forces of Nature to his service man must invariably avail himself of some process in which a fluid acts as carrier of energy, this being an essential step in any industrial undertaking dependent on mechanical power. Evidently then, a discovery or radical departure in that domain must be of extreme importance and far-reaching influence on the existing conditions and phases of modern life.

Fluid propulsion is now effected by means of pistons, vanes or blades, which entail complexity of construction and impose many limitations on the propelling as well as propelled mechanism and its performance. Tesla has dispensed with these devices and produced machines of extraordinary simplicity which, moreover, are in many other respects superior to the old types universally employed. A few words will be sufficient to convey a clear idea of his invention.

Every fluid, as water or air, possesses two salient properties: adhesion and viscosity. Owing to the first it is attracted and clings to a metallic surface; by virtue of the second it resists the separation of its own particles. As an inevitable consequence a certain amount of fluid is dragged along by a body propelled through it; conversely, if a body be placed in a fluid in motion it



THE TESLA DISK-IMPELLER PUMP


TESLA
ALTERNATOR
TESLA
TURBINE
NIKOLA TESLA · NEW YORK

A LIGHTING MACHINE ON NOVEL PRINCIPLES

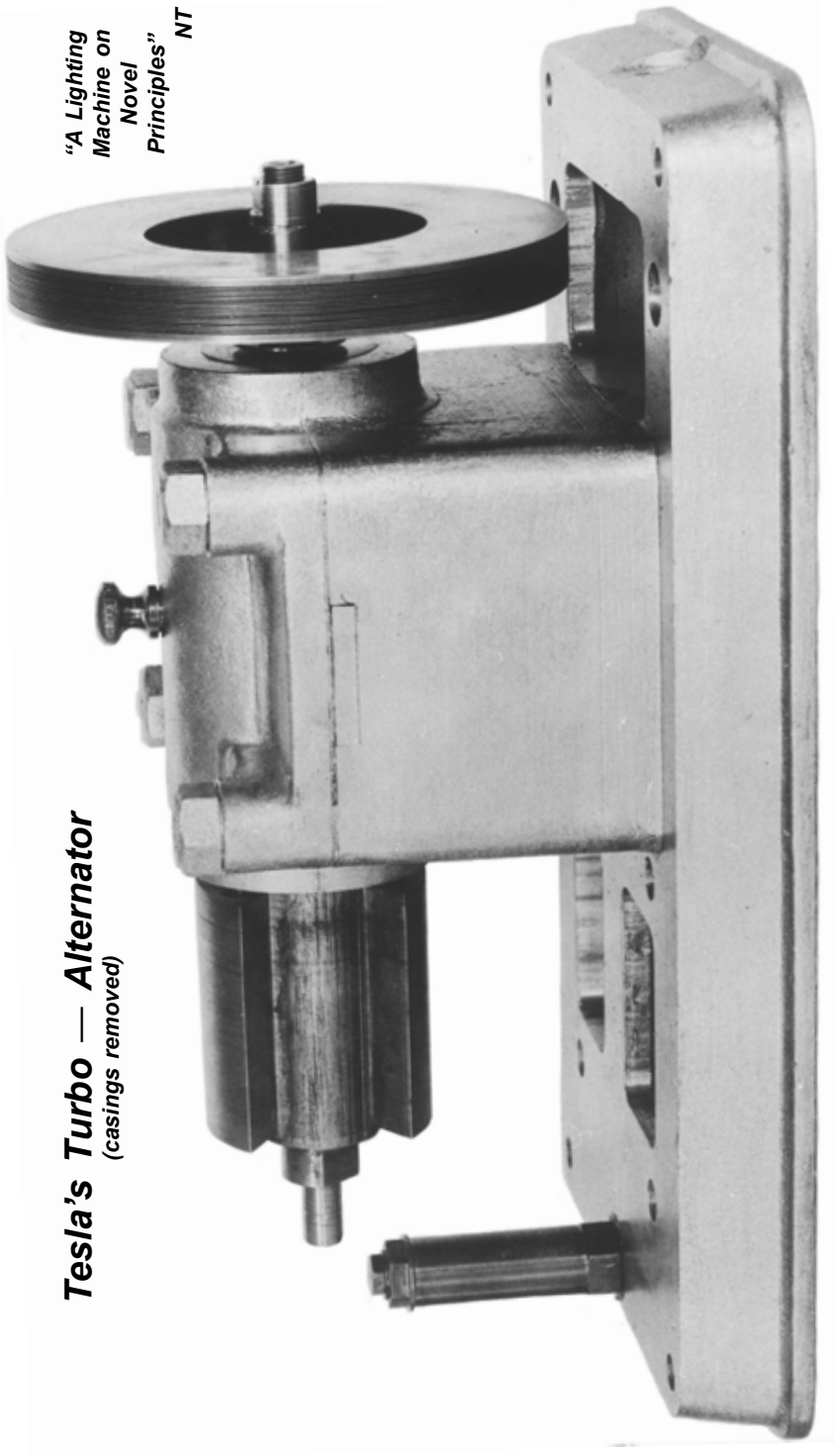
February 7, 1918

by **Nikola Tesla**

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 as well as operation, and intimately associated to constitute a unit. The former has been pronounced revolutionary in its design and performance. It is simplicity itself, being devoid of buckets, deflecting blades, guide passages, vanes and the like, and presents many other decisive advantages over the ordinary prime mover.

In the first place there is no windage, which is the cause of a most serious loss of power in bucket turbines, often amounting to a large percentage of the integral mechanical effort. What is still more important, the new turbine is capable of taking up the whole velocity of the motive fluid in one continuous process, thus saving the expense and avoiding the complication incident to "staging." Furthermore, it has the precious quality of transforming into useful work frictional energy irretrievably spent in other heat motors.

The corrosion and erosion of buckets and vanes in the present turbines is the cause of another great and irremediable waste of energy, the water rate frequently increasing 30% to 40% after but a few months of use. No such hurtful actions exist in the new turbine, and if they did, they would not impair the performance to any appreciable degree. Again, the former are subject to considerable loss owing to unpreventable wear and deterioration of the nozzles. It is essential that the high velocity streams of fluid issuing from them be directed upon the curved blades with great precision, as a failure of this is fatal to good results. To such an extent is this the case that even a slight roughening of the polished surfaces will reduce the useful energy as much as 25%. The new turbine is entirely free from this defect. However the nozzle may be used up, the fluid is made to flow through the wheel smoothly and evenly in natural stream lines, transmitting power to the same with undiminished efficiency. Another feature of superiority is found in its adaptability to high temperatures far beyond those practicable in bucket turbines. For every hundred degrees of increase in temperature, the steam consumption is reduced from 10% to 12%. Great economies are thus made possible by the use of the new prime mover.



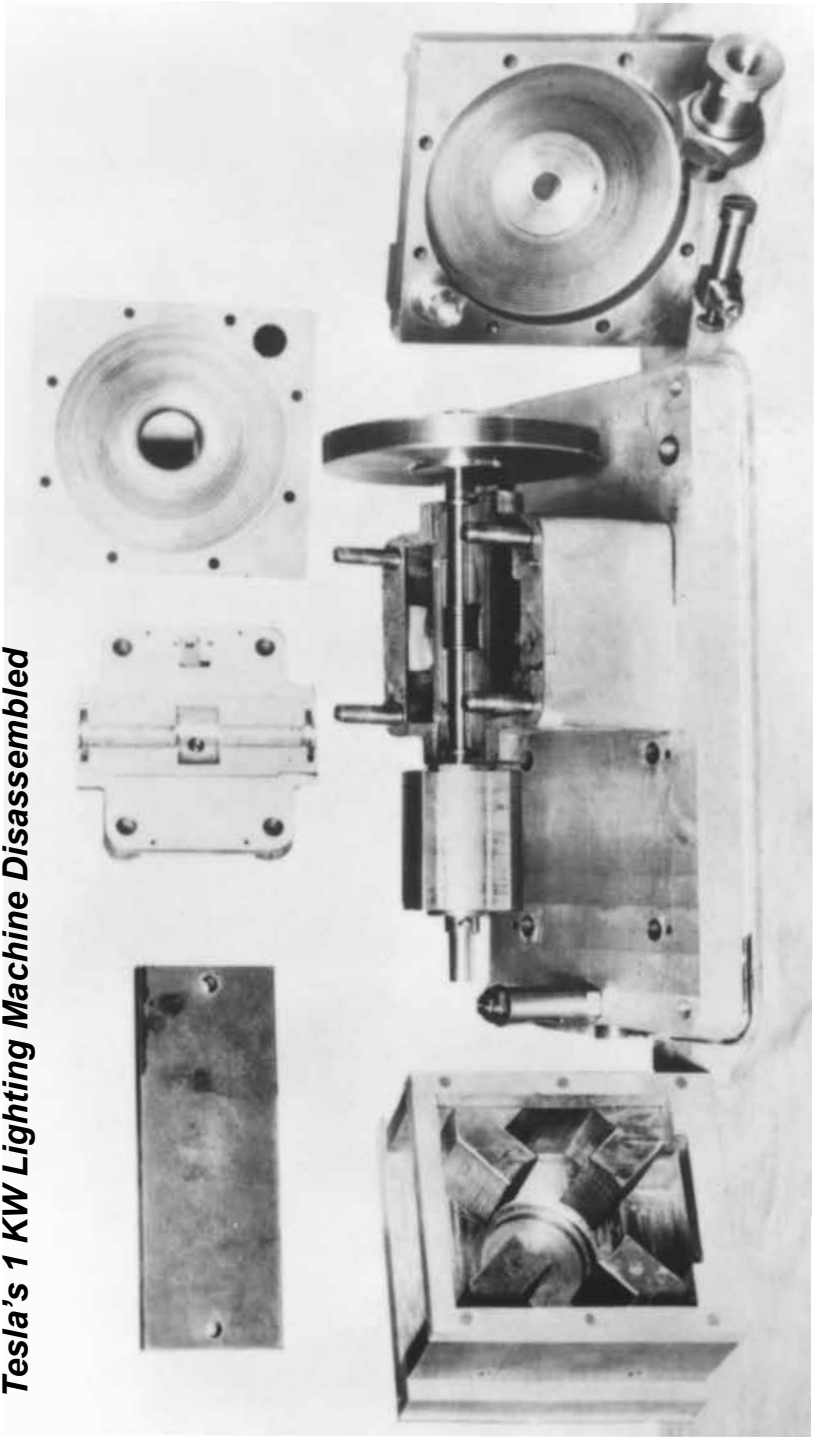
Tesla's Turbo — Alternator
(casings removed)

In every turbine the device regulating the speed of rotation and controlling the admission of the working fluid to the nozzles is of vital importance. With scarcely an exception it is of the centrifugal type driven from the shaft in some or other way and constituting an assemblage of gears, flying weights, links, levers, sleeves, thrust bearings and other parts. It is an apparatus complex and delicate, expensive to construct and easily deranged, often with disastrous consequences. All this has been done away in the new turbine which is controlled in a novel and striking manner. The regulator is elementary in its construction, positive and unfailing in its action, and yet so sensitive as to respond to variations of load amounting to less than 1% of the normal. This simple device is rendered still more valuable by the fact that it adjusts itself instantaneously to pressure changes so that the effects of these on the lamps are inappreciable. To illustrate, the steam gauge on the boiler may indicate fluctuations from 100 to 200 pounds or more and following each other however rapidly without the slightest observable change in the intensity of the light. This remarkable action of the device is independent of its function as regulator of speed.

Another advantage deserving the most careful consideration of the user is the perfect safety of the new turbine. There is an ever present danger in a machine of the old type, that the wheel might burst and destroy life and property. Such a deplorable accident is absolutely impossible with the new turbine rotor, composed of thin discs which expand slightly and come to rest, invariably without damage, as has been shown in exhaustive experiments.

The one feature, however, which has most amazed experts, is the extraordinary power of this form of prime mover. Owing to the great effectiveness of the underlying principle and peculiar construction, ten times more power can be produced than with any other machine known. For example, a rotor of 9" in diameter, weighing less than 20 pounds, can readily develop 200 brake horsepower, and this is by no means the limit of performance.

But the merits of this lighting outfit do not rest on the turbine alone. The dynamo associated with the same is perhaps equally noteworthy by its simplicity of construction, high efficiency and rare and valuable properties it possesses. It consists of a smooth cylindrical body mounted on the turbine shaft and arranged to rotate within a magnetic field of novel form. There is no brush or sliding contact whatever, the current being taken from stationary terminals to which the ends of the generating coils are connected. By employing the best materials and workmanship and resorting to artifices of design, a most economical electrical generator is produced, the efficiency being over 90% even in machines of very small size having rotors of not



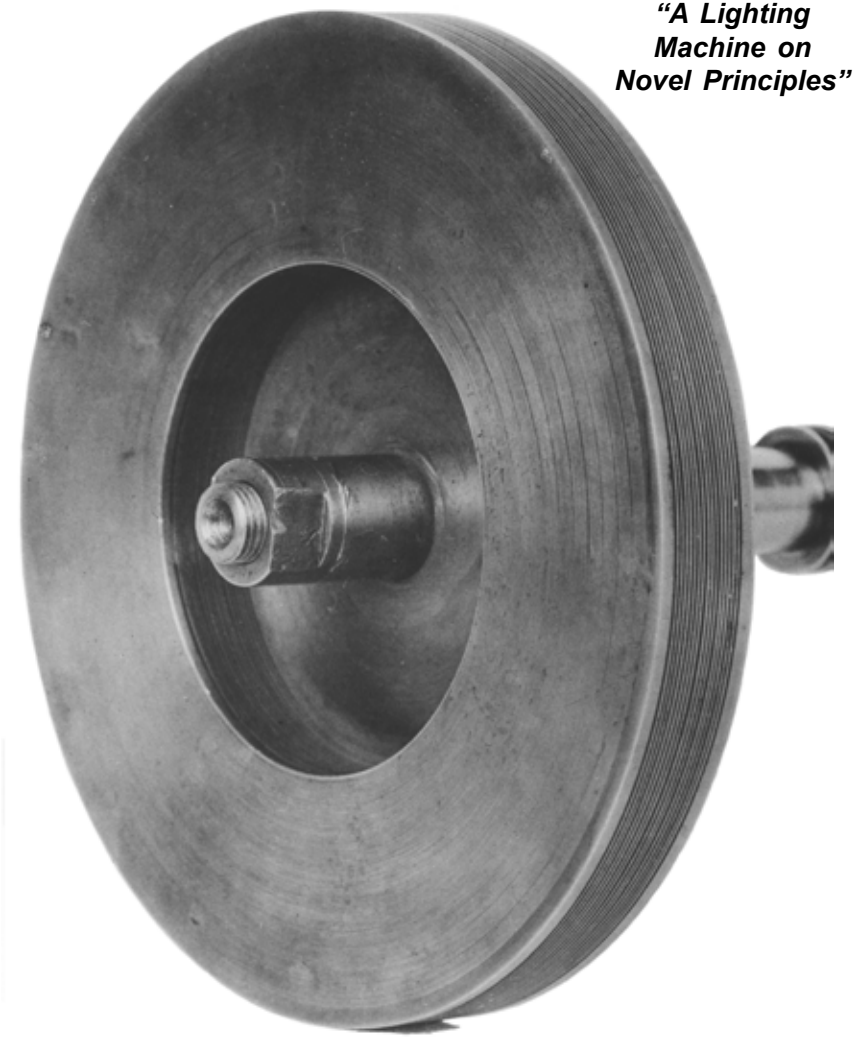
Tesla's 1 KW Lighting Machine Disassembled

more than 2 $^{1}/_{2}$" in diameter. This generator possesses extraordinary qualities, especially desirable in electric lighting. It is capable of furnishing a current constant within a minute fraction of 1% through a very wide range of speed variation, and as such is ideally suited for running arc lamps or kindred electrical devices in series. More surprising still and also of greater commercial import is its capability of maintaining a constant potential. Such results as are obtainable with it are wholly impossible with other types of electrical generators. It has been found in practice that all lamps but one can be turned off suddenly without the slightest perceptible flicker and even without any observable effect on the needle of a delicate instrument indicating the voltage.

That an apparatus of such simplicity and presenting so many salient advantages should find an extensive use in electric lighting might be naturally expected, but its overwhelming superiority will be better appreciated when it is stated that it occupies hardly more than one-tenth of the space of apparatus of the usual forms and weighs less in proportion. A machine capable of developing 1-kilowatt, for instance, goes into a space of 8 x 8 x 10" and weighs but 40 pounds. It takes not more than one-third of the steam consumed in other turbo-generators of that size.

The guiding idea in the development of this new machine was to evolve a mechanism approximating a static transformer of energy in simplicity, efficiency and reliability of operation. Every detail has been worked out with this object in view. There is no exciter, no commutator, brush or sliding contact whatever, no centrifugal regulator, voltage controller or any such complicated and hazardous device. The machine consists of but a stationary solid frame and two smooth cylindrical steel bodies mounted on a strong shaft arranged to rotate in bearings virtually frictionless. No oiling is required, although a small quantity of lubricant is provided rather as a precaution than necessity. A perfect dynamic balance is secured in a novel manner and insures a steady and quiet running without tremor and vibration. The whole apparatus can be boxed up and depended upon to operate uninterruptedly through long periods of time. The outfit can be constructed in various sizes up to 100-kilowatt or more, and should meet more satisfactorily than any yet devised the varied requirements of electric lighting on railroads, boats, in public buildings, factories and mines, and may also be advantageously utilized in connection with existing plants for replacing belt driven dynamos and storage batteries, and relieving larger engines through the night and hours of small load.

"A Lighting Machine on Novel Principles"



1KW Runner for Turbo — Alternator Steam Locomotive Headlamp

Tesla designed this alternator for the Pyle National Company Chicago, where it was manufactured and tested. Tesla worked with the Pyle National Company from June 1917 until November 1918. The square structure at left is the alternator stator housing, in which the alternator rotor (mounted on left side of turbine shaft) turns. Tesla claimed that a device measuring 8x8x10 inches would develop 1kw and weigh 40 pounds.

A Modern Corrosion Resistant, Non-Metalic, Tesla Pump

Manufactured by Begemann Pompen

"It was perfectly well known that a fluid would be dragged by rotating surfaces, but somehow nobody realized the conditions for economic working, nor has any one properly grasped the principles which could be applied to propulsion. So it happens again that it is my good fortune to come to the rescue, and I have produced a highly economical way of compressing or pumping fluids."

Nikola Tesla

From an address before the New York section of the National Electric Light Association May 15, 1911

TESLA PUMPS GENERATING SALES IN THE MULTI-MILLIONS

Opportunist Charges Premium Prices for Tesla's Pumping Technology; Claimed Patent Protection

Tesla's pumps were introduced commercially at premium prices generating sales in the multi-millions. Pumping patents were issued in the 1980's despite the fact that Tesla was refused these patents in 1913. This resulted in an ongoing battle over who is the rightful owner of the lucrative Tesla pumping technology. With the individual involved threatening legal action to those attempting sale of pumps with disk spacing exceeding a certain width claimed as protected. These actions were one of the main reasons for the formation of the Tesla Engine Builders Association in 1993.

Claims being made that the recent patent holder, the rightful and true "*inventor*" of modern bladeless pumping technology, stating that Tesla was not a pump engineer, claiming Tesla's field was electrical not mechanical.

Nothing, however, could be further from the truth. Tesla was by training and **first love** a mechanical engineer. Without Tesla's marvelous mechanical insight his electrical devices could not have functioned. They are, after all, **mechanical** devices operating electrically.

The **fact** of the matter is that bladeless pumping devices were protected by Tesla under U.S. Patent No. 1,061,142 granted May 6, 1913. This patent, featured herein, is entitled "Fluid Propulsion" detailing his pumps construction in the broadest of terms." During this same period Tesla applied for a pumping patent to "impart energy to a fluid," Serial No. 735,914, reference of which is made in the Fluid Propulsion patent. The U.S. Patent Office rejected this application on the grounds that it was duplicative. Bladeless pumping devices, by their judgement, were covered under Tesla's Fluid Propulsion patent.

Tesla formally objected and unsuccessfully argued that separate pumping patents be issued, there being a substantial difference in construction between the two devices, including but not limited to, variations in inlet, outlet, and disk spacing. The decision of the patent office in this matter, as well as correspondence with Tesla's attornies, recorded and archived in the patent wrappers, clearly establishes that bladeless pumping applications fall under and are fully protected by Tesla's Fluid Propulsion patent.

TESLA'S PATENTS ARE NOW PUBLIC DOMAIN.

A QUANTUM LEAP
TESLA PUMPING TECHNOLOGY

DISCFLO PUMPS

- High Viscosity Crudes
- Coal Slurries
- Sewage Sludge
- Fly Ash
- Dredging & Dewatering
- Paper Pulp
- Ore & Mineral Concentrates
- Diatomaceous Earth
- Sand & Gravel
- Phosphoric Acid
- Petrochemicals & Resins
- Glass Char
- Drilling Muds
- Wood Fibre Slurries
- Food & Wine Products
- Salt Brines
- Latex Slurries
- Clay Slurries
- Lime Slurries
- Paint
- Shear Sensitive Emulsions
- Starch
- Low NPSH Solvents
- Gas Entrained Yeast
- Dye Crystals
- Titanium Dioxide
- Oily Wastes

A NEW DIMENSION FOR POWER

The Proven Cost Effective Answer To Difficult Pumping Problems

The BOUNDARY LAYER/VISCOUS DRAG pumping principle encapsulated in the Discflo Corporation pump is the answer to many of today's most difficult material transfer problems. It combines the simplicity of centrifugal pump construction with the materials handling properties of the positive displacement pump — bridging gaps and offering solutions to pumping problems previously unavailable. Discflo's disc pump is a practical and economical answer to the high cost of pumping abrasive, viscous, shear sensitive and delicate materials.

Discflo's disc pump is among the most versatile process pumps available. Proven successful installations show superior performance in handling:

- SEVERELY ABRASIVE MATERIALS with minimal wear and virtually no performance loss as a result of rotor wear.
- DELICATE AND SHEAR RATE SENSITIVE MATERIALS such as latex, polymer emulsions, crystalline compounds, titanium dioxide resin beads, etc., with little or no damage or maceration to the material.
- HIGHLY VISCOUS FLUIDS up to 400,000 SSUs — including thixotropic, dilatant and pseudoplastic materials.
- HIGH SOLIDS CONTENT FLUIDS (up to 80 + % by volume).
- HEAVILY AIR/GAS ENTRAINED MATERIALS without vapor lock, cavitation or vibration.
- LARGE SOFT SPHERICAL AND STRINGY SOLIDS up to 5" in diameter without clogging or malfunctioning.

Customized Pump Configurations

Submersible | Over & Under | Verticle Pit

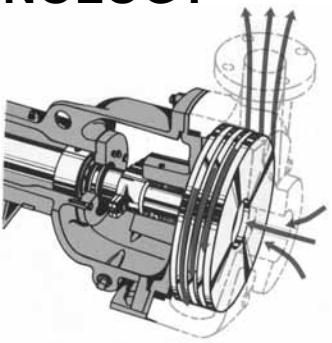
Tesla Pumps manufactured by the Discflo Corporation

A QUANTUM LEAP
TESLA PUMP TECHNOLOGY

The DISCFLO Pump is designed to handle tough pumping problems and not constantly break down in the process. The secret lies in its non-impinging disc rotor. In contrast to traditional pumps which impel or push the fluids through the system, the DISCFLO Pump generates powerful centrifugal frictional forces which pull fluids through the system.

First the fluid is drawn through the central orifice of the pump and confined between the parallel discs. As these discs rotate, they generate within the fluid a combination of friction and pressure by which the entire fluid mass begins to rotate. The discs transfer their rotating energy to the fluid through the mechanisms of boundary layer and viscous drag.

Boundary Layer occurs when fluid molecules attach or "lock onto" the surface of the discs. The force of the moving rotor is transmitted to this attached boundary layer of molecules. Viscous Drag involves the further transmitting of this rotating energy from the boundary layer to other layers of fluid molecules until the entire mass of fluid is rotating. Thus the initial boundary layer attracts and "drags" along with it additional layers of molecules - setting in motion numerous parallel stream bands of physically interacting molecules. What is generated is a powerful centrifugal frictional force field which propels the fluid naturally, producing a smooth hydraulic flow profile and a non-pulsating, vibration-free pumping operation. Moreover, not only does the boundary layer transmit kinetic energy into the fluid, but it acts as a "molecular buffer" between the disc surface and the fluid contents. This protects both the product from the full impact of the disc, and the disc from the full impact of the product - thus eliminating excessive product damage and pump wear!



Customized Discpacs

Discflo's customized discpacs come in a variety of sizes to meet a wide range of individualized applications - from fine polymers to highly viscous abrasives to large and small solids.

SUBMERSIBLE & OTHER TESLA PUMP CONFIGURATIONS

Raw sewage lift stations, chemical overflow tanks, wash-down pits, sedimentation basins and degrit chambers are just some of its typical uses.

Other DISCFLO Pump configurations include the Over & Under Pump, and the Vertical Pit Pump (which has no bearings or seals in the wet).

Service Range

• Hydraulic Flow Capacity	—	– 2 to 7500+ GPM
• Discharge Pressure	—	– 1000+ ft TDH
• Suction Pressure	—	– Low NPSHR
• Operating Temperature	—	– High Temperatures
• Viscosity	—	– 100,000+ CPS
• Drivers	—	– Electric, Diesel, Hydraulic, Air
• Materials of Construction	—	– Most Alloys Available – Also Comes in

If you are pumping waste, sewage, sludge or scum from pits, tanks, ponds or pools, you are probably bogged down in problems with suction lift, low NPSHA, foot valve plugging and excessive product damage and pump wear. Well, DISCFLO's Submersible Disc Pump has been designed to solve these major problems associated with pumping from below the surface.

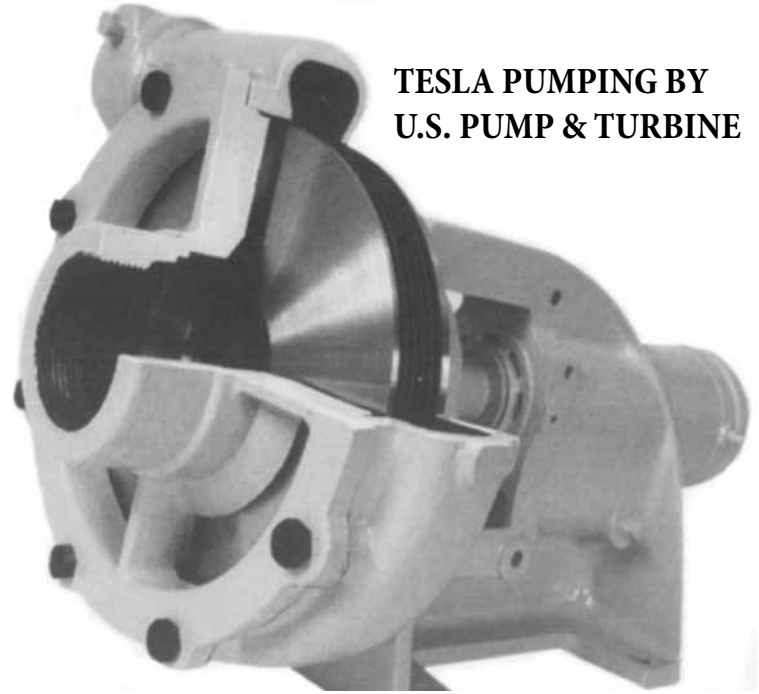
- Acetic Acid-CH_3COOH (Up to 50%)
- Acetone — CH_3COCH_3 (Up to 50%)
- Aluminum Hydroxide — $Al(OH)_3$
- Aluminum Sulfate — $Al_2(SO_4)_3$ (Up to 50%)
- Ammonium Chloride — NH_4Cl
- Barium Chloride — $Ba\ Cl_2$
- Benzene — C_6H_6
- Bromine Water — Br_2/H_2O (HOBr)
- Calcium Hydroxide — $Ca\ (OH)_2$ (Up to 50%)
- Chlorine — Cl
- Copper Sulfate — $CuSO_4$
- Ethylene Glycol — $(CH_2OH)_2$
- Ferrous Sulfate — $FeSO_4$
- Glycerol — $(CH_2OH)_2CHOH$
- Heptane — C_7H_{16}
- Hydrochloric Acid — HCl (Up to 37%)
- Hydrogen Peroxide — H_2O_2 (Up to 30%)
- Magnesium Hydroxide — $(Mg(OH)_2$
- Nitric Acid — NHO_3 (Up to 50%)
- Potassium Ferrocynaide — $K_4(FE[CN]_6).\ 3H_2O$
- Sodium Bicarbonate — $NaHCO_3$
- Sodium Hypochlorite — NaOCl (Up to 12½%)
- Sulfuric Acid — H_2SO_4 (10% to 98%)
- Trichloroacetic Acid — CCl_3COOH (Up to 50%)
- Xylene — $C_6H_4\ (CH_3)_2$
- Zinc Sulfate — $ZnSO_4$

Solving Those Special Problems With Corrosive And Abrasive Fluids

In response to the explosive growth in the field of aggressive fluids, Discflo has developed a full line of non-metallic pumps. When combined with its revolutionary non-impinging Disc technology, the new Discflo non-metallics solve the problems of pumping corrosive and abrasive fluids in a whole new way.

Discflo Advantages

- No Close Tolerances
- Non-Impinging
- Non-Pulsating
- Non-Clogging
- Little to No Shearing
- Little to No Maintenance
- Little to No Downtime



TESLA PUMPING BY U.S. PUMP & TURBINE

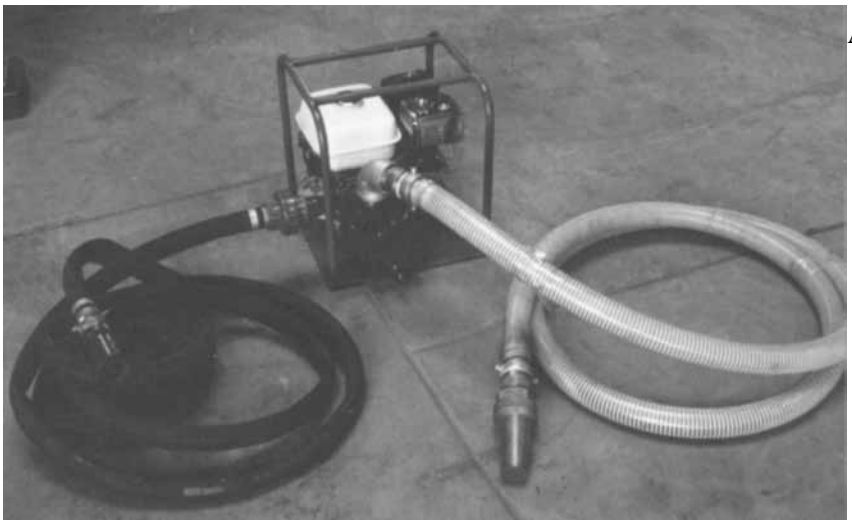
TESTIMONIAL OF A FIRE FIGHTER

by Ray Russell

May 1990

I was first introduced to the boundary layer pump quite by accident. I was attending a demonstration of a fire retarding agent called Flame Out. The demonstration was to show how this product could protect the grass and wild-land. An area of dry grass was to be completely surrounded by the flame out material.

A small pump and a 55 gallon drum was used to apply the flame out material. When we were filling the 55 gallon drum from the fire truck the pump was started up. *This is absolutely unheard of* in the centrifugal pumping industry. You *never ever* run a centrifugal pump without water in it. My first thought was that the pump was going to burn up. The operator said; "No I want the motor to warm up." I thought: go ahead but you'll burn the thing up. After it was started he hooked the water suction hose to it. The operator then hooked up 50 feet of the 1 $^{1}/_{2}$ inch output hose. My men had also noticed that the pump was now running with no water input. They commented that the pump was going to blow up when water hit it. Its going to steam like crazy. Everyone twinged when the operator opened up the valve. As the water came into the pump, to my surprise, the pump didn't explode or even labor as a centrifugal pump would. Water came out the nozzle and we sprayed down the area. When we were done there was water left in the suction hose. I hollered you better shut it off. In the pumps I was familiar with, if you leave a pump running with water in it and the output shut off, it will become very hot and explode and possibly



A

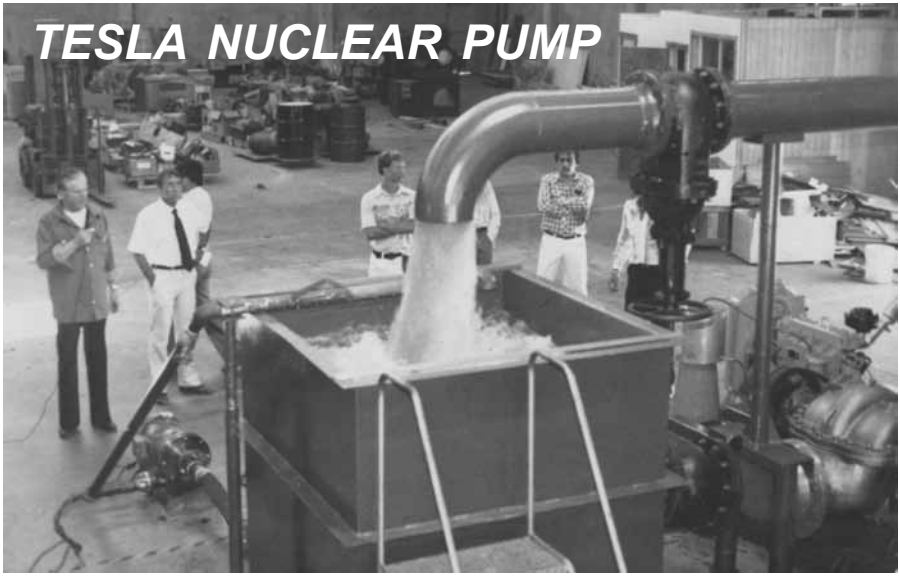
hurt someone. So I ran down to shut it off. Before I shut it off I touched the back of the pump with my finger and it was ice cold. I walked over to the operator and said; "what kind of centrifugal pump is that." He said; "It's not a centrifugal pump it's a boundary layer drag pump." Of course I said; "I need that." Suddenly I didn't care about the Flame Out material, I was thinking of nothing but the possibilities of these pumps in fire fighting. It is my belief that this technology will revolutionize pumping in the fire service in the 90's.

This is probably the most progressive thing that has happened to fire pumps. Unfortunately the fire service is noted for being 200 years of tradition unhampered by progress. The main drawback of the conventional fire pump is cavitation and its weight and its tendency to heat up. If small particles or air bubbles hit the lifting surfaces of a conventional centrifugal pump it creates about 23,000 pounds PSI of energy hitting the lifting surface. This does not happen with the boundary layer pump. I am totally convinced that this is the pump to go into the future fire fighting equipment and that it will totally eliminate centrifugal pumping. This is more than a fly by night thing that will be around for a few years and then disappear. This technology has been around since Tesla.

Sanitary Tesla Pump used by Tesla Engine Member Frey Organic & Biodynamic Wines. Used to avoid the sheering effects that damages conventionally pumped wines

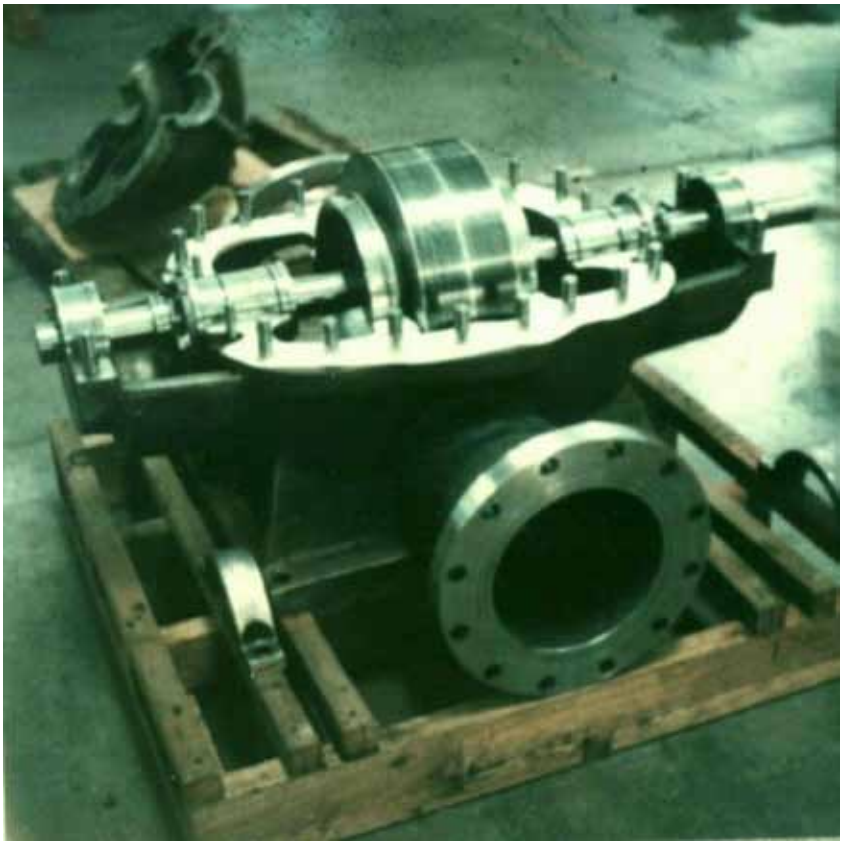
Above is pictured an electric motor with a bladeless cooling fan installed. Another "runner" of the Tesla fan or blower is Displayed next to the bladed version it has replaced.

3600 RPM Tesla 3 phase induction motor shown with and without fan housing as conventionally used. Almost the entirety of noise produced is a result of the bladed fan. Tesla's Fan corrects this deficit.



Only a Tesla Type Not Destroyed by Pumping Boiling Liquids

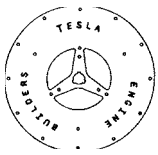
Pictured here is the late Jake Possell (far left) and his most ambitious pumping project. The following is Jake's description of the pump and its operation: "This pump is a double inlet type with two pumping rotors placed back to back that both pump into a common discharge. The outer case is a casting made to nuclear pump specifications. It is one of the few bladeless pumps that have employed a cast housing. Usually the bladeless pumps are fabricated. This particular pump can pump 10,000 gallons a minute of boiling water. Conventional pumps can not pump boiling water. As the water temperature approaches 150-180 degrees F the pump begins to cavitate due to the gas that is formed in the suction side of the pump. When the static pressure on the suction side of the pump is lowered below atmospheric pressure, the water begins to boil. When those bubbles of gas reach the inlet of the pump the pump begins to cavitate. The lifting surface in a conventional pump hits the bubbles of vapor in the liquid at a very high velocity. As a result the bubbles implode or collapse and the water rushes into the hole at very high velocities. Physicists have estimated that the pressure pushing the liquid into the empty space are implosion pressures up to 20,000 atmospheres. This accounts for the dramatic damage done to the lifting surfaces of conventional bladed type pumps. Tesla type are immune to this effect.



TESLA NUCLEAR PUMP

Tesla's turbine is so violently opposed to all precedent that it seems unbelievable, even when you see it at work!

Technical World Magazine -

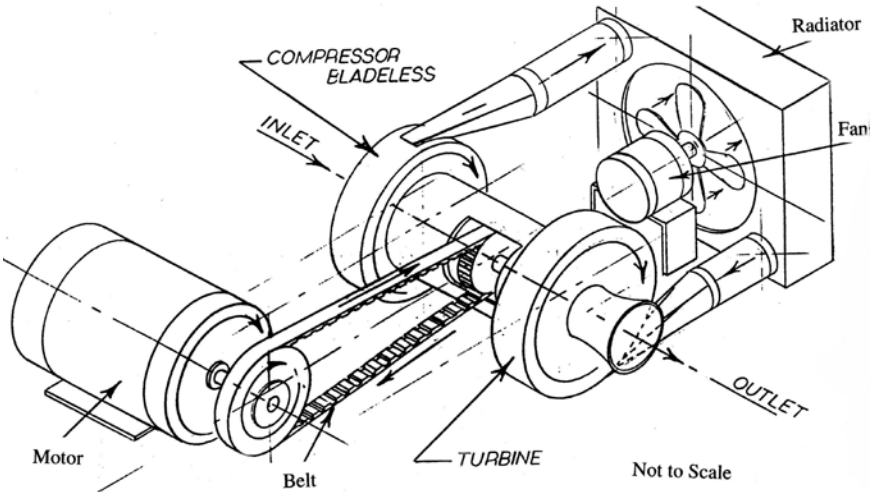


Freon Free Air-Conditioning

Because of the tremendous compression and expansion possible with the Tesla Compressor and Engine, air conditioning can be accomplished without the use of Freon or other expensive refrigerants. The use of Freon or its substitutes is entirely unnecessary.

Tesla stated: *"As an air compressor it is highly efficient... Refrigeration on a scale hitherto never attempted will be practical through the use of this engine in compressing air."* (see page 33)

An air to air refrigeration system is conceptualized on the opposite page. A Tesla Compressor and Tesla Engine are mounted on a common shaft driven by an electric motor via a belt. As the shaft turns it drives both compressor on one end of the shaft and the engine on the other. Air is drawn into the compressor, concentrating heat at its output, which is then fed to a radiator removing the excess heat. The high pressure output of the radiator is then fed to the input of the engine. The air is greatly expanded, giving up its heat energy as it preforms work through the shaft of the engine. This is an extremely efficient configuration, energy being returned and recycled through the shaft back to the compressor.



The Basic Components of a Refrigerant Free Air Conditioning System

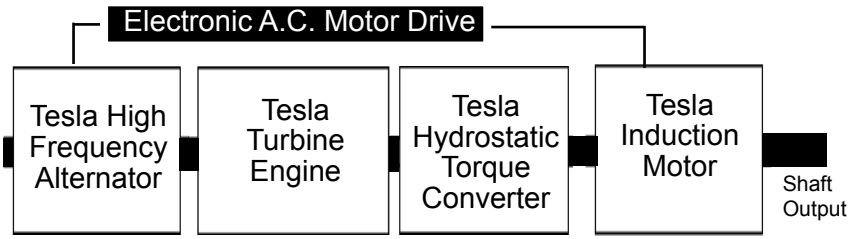
Tesla was proven correct with this hybrid system being implemented and proven in our present day rail system with diesel electric locomotion becoming the standard and electronic "Drives" allowing use of his A.C, Motors.

Quoting Tesla:

"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. A similar reception was accorded to my wireless boat repeatedly described in the Herald of 1898. The patents on these inventions have since expired and they are now common property. Meanwhile insane antagonism and ignorance have been replaced by helpful interest and appreciation of their value."

Volvo has recently introduced a concept car that uses just this principle but is using a conventional bladed turbine engine. This engine is coupled to a Tesla high frequency alternator which feeds an electronic Drive control. The electronic motor control is used to adjust the supply frequency, and therefore the speed, of a Tesla polyphase induction motor. This full size concept car by Volvo is reported to perform very nicely while at the same time attaining 45 miles per gallon at 55 miles per hour. Volvo has coined this vehicle "The Environmental Concept Car" or ECC. The only mechanical part of the system that is not Tesla's is the turbine engine. See next article.

Tesla did, however, provide plans for this part of the system. Tesla's Engine

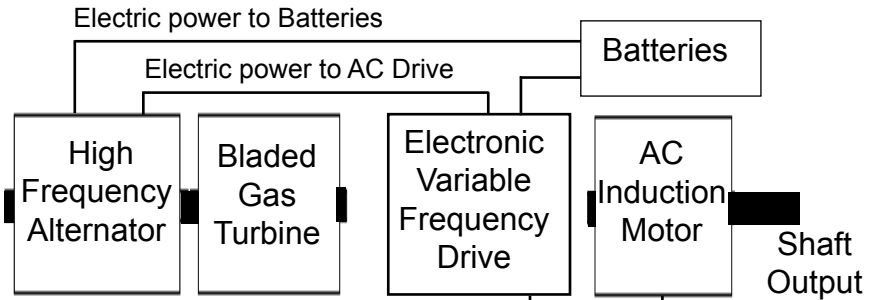


The engine operates at a fixed high speed in the tens of thousands rpm range for highest efficiency. The unique gearless transmission, which is a variation of the Tesla Engine design, converts this high speed to controllable lower speeds with high torque. The transmission is disengaged and only electrical power is provided, unless heavy loads require direct engine assistance. This allows a fuel sipping, economy miser, conversion to a monster horse power, muscle machine, almost instantly, on command!

Tesla Turbo/Electric Hybrid Design

Current Hybrid vehicles such as the popular Prius by Toyota are changing the automotive landscape as fuel prices escalate. However, this is a very crude example of what is possible using the hybrid system first proposed and detailed by Tesla. It has recently been reported that if total energy inputs are considered, between a gas guzzling "Hummer" and the more energy intensive manufacturing and material costs, including battery replacement, of the Prius, lifetime energy consumption is approximately the same. This equation changes completely, however, when a hybrid is built to the complete Tesla spec.

Volvo came the closest with its: "Environmental Concept Car," or "ECC." It enabled the high performance Volvo "850" to achieve a doubling of mileage; comparable to that of the smaller Prius. This is even more impressive when it is considered that Volvo doubled the weight of the 850, with batteries; required to meet the then pending, "Zero Emissions" requirement of the California legislature. Despite this



Block Diagram of Volvo's ECC

doubling of weight, the performance of what is a high performance stock vehicle increased dramatically in the hybrid mode.

Volvo employed a specially built conventional gas turbine as a power plant to achieve this. Conventional turbines are not practical for automotive applications, however, because of their cost, complexity and safety considerations. These problems are resolved if the "Tesla Turbine" engine were to be employed. The Tesla turbine is simple and

low cost while being the safest type of turbine. The only turbine that self regulates over speed when unloaded, instead of running away to explosion, as does a conventional bladed turbine.

Volvo ECC

It is also, as documented in this newsletter, the only type of turbine that can ingest solids without damage. This includes dirty water. Water injection can be used with conventional turbines to drastically increase thermal efficiency, but with a conventional type it must be ultra pure. But water can be used for up to half the fuel volume and thereby the potential to again double mileage! Highly purified water is very expensive, however, limiting its use with the conventional machine to special applications. Not so with the Tesla type.

The Tesla turbine is the only type that is, by its nature, a flywheel, allowing for non-battery energy storage. The promise of high speed composite flywheels has been made for many a decade now but always seems to be "five years" away. The only proven commercial flywheel technologies are those that employ metallic mass and speed for storage. The Tesla turbine is inherently a metallic flywheel which stores energy in the same way.

Multiple fuels can be employed with all turbines but the Tesla can even ingest heavy crude and "bunker fuels" that destroy a conventional type. This means refining could be scaled back with a huge reduction in total emissions. The Tesla turbine engine can even burn dirty waste oils, at extremely high temperatures, thereby detoxifying this waste while powering the vehicle. The Tesla turbine could even run on powdered coal!

When not in use it could feed power into the grid with very little wear and tear, making a decentralized power system a reality. So unlike the Prius — the complete Tesla hybrid beats the "Hummer" — hands down.

Tesla Motors has built only half of Tesla's vehicle, opting to go totally electric while being completly unaware of Nikola Tesla's engine and its hybrid possibilities, as confirmed during conversation with Tesla Motors chief technical officer and cofounder J.B. Straubel. Problem is batteries have to be charged, are polluting, dangerous and expensive with limited range.

Only the Tesla Hybrid system can generate clean distributed power at a higher efficiency and lower cost than the polluting central power

ELECTRIC DRIVE FOR BATTLE SHIPS

New York Herald, Feb. 25, 1917

By Nikola Tesla

The ideal simplicity of the induction motor, its perfect reversibility and other unique qualities render it eminently suitable for ship propulsion, and ever since I brought my system of power transmission to the attention of the profession, through the American Institute of Electrical Engineers, I have vigorously insisted on its application for that purpose. During many years the scheme was declared to be impracticable an 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.

A similar reception was accorded to my wireless boat repeatedly described in the Herald of 1898. The patents on these inventions have since expired and they are now common property. Meanwhile insane antagonism and ignorance have been replaced by helpful interest and appreciation of their value. Recently the Navy Department has let contracts aggregating $100,000,000 for the construction of seven war vessels with the induction motor drive, and an equal sum is appropriated to cover the cost of four huge battle cruisers which are to be fitted out in the same way. This latter project is resisted by some shipbuilders, turbine makers, electrical manufacturers and engineers who, in fear of a fatal mistake by the government and under the sway of patriotic motives, urged upon the authorities the employment of the geared turbine.

CONTROVERSIAL CORRESPONDENCE

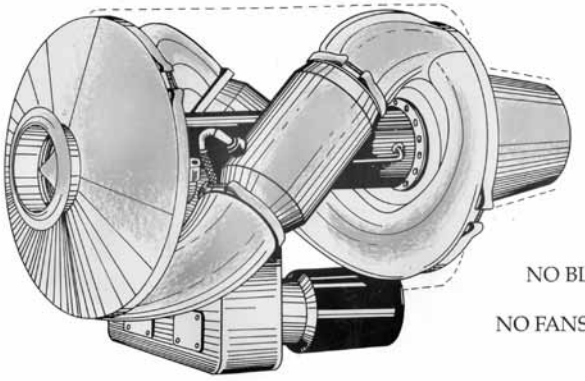
Numerous letters of protest have been written to C. A. Swanson, of the Senate Naval Committee, but what has so far come out of this correspondence is purely controversial and of no profit whatever to those who seek information. It is regrettable that the question should have been raised at this critical moment, when speedy preparation against threatening national perils is recognized as imperative, and in view of this no doubt should be permitted to remain in the public mind as to the superiority of the equipment recommended by the naval experts. In the following I shall endeavor to make this clear to the general reader.

TURBO Telesis

1417 South Gage Street • San Bernardino, CA 92408
714/ 799-8059 • FAX 714/ 796-7721

Boundary Layer Vortex Turbo Jet Engine

SAFE
SIMPLE
QUIET
POWERFUL
EFFICIENT



NO BLADES

NO FANS

SPECIFICATIONS:

- Thrust 1,200 lbs
- Weight 150 lbs
- Specific Fuel Consumption .9 lb/hp/hr
- Size - 15 in. diameter x 30 in. long overall
- TBO - 2,500 hrs. Hot Sec 750 hrs

ACCESSORIES:

- Starter/Generator 12v / 24v
- Fuel Pump/Engine Oil Pump

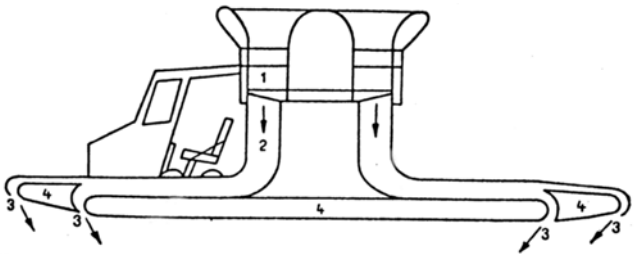
PROVISIONS FOR:

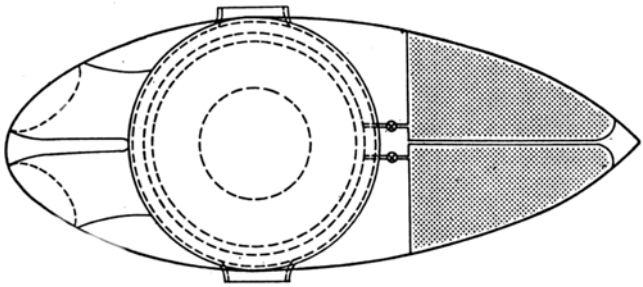
- Hydraulic Pump
- Vacuum Pump
- Air Conditioning Pump

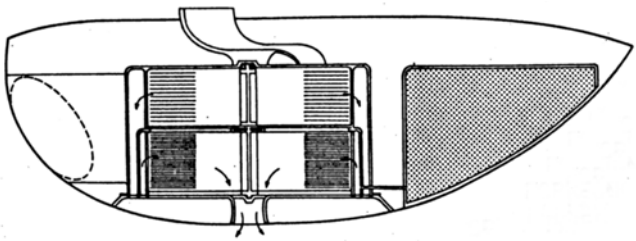
REPRESENTED BY:

TeslaEngine.org

Tesla's Hovercraft Design Employing His Bladeless Turbine and Compresor







Tesla Jet Engine

Tesla's main objective in developing the bladeless engine was for use in aircraft. He conceived aircraft that would not require airports or runways, with an ability to rise vertically.

If engine inlet temperatures are raised only a few hundred degrees Fahrenheit, substantial increases in power are developed. It is very significant if power can be doubled or tripled for a given size and weight of aircraft engine. Today conventional bladed turbines are limited to a turbine inlet temperature of around 2,000 degrees F. Yet fossil fuels, in use today, can burn at temperatures as high as 3,400 to 3,500 degrees F. These temperatures dare not be applied to the blades of a conventional turbine engine. It would be too hot, resulting in the blades coming apart with the catastrophic demise of that particular turbine engine. Another disadvantage of the conventional bladed turbine aircraft engine is the tremendous noise created. This is one of biggest negative aspects of these engines. The noise is an unwanted parasitic energy that is largely reduced with the Tesla Engine.

The Tesla Engine offers tremendous advantages. The conventional bladed turbine engine operates under the most difficult stress levels imaginable, called combined bending, occurring at the root of each blade. The impulse or reaction, applied to which, causes this very severe stress and can result in the destruction of a conventional engine. The Tesla Engine has a tremendous advantage in this case. The stress level is entirely different on a Tesla Engine than on the bladed turbine engine. There is no combined bending in the Tesla Engine.

The *bladeless* Tesla Engine can survive operating under conditions that a bladed turbine engine cannot. It is possible today to build a Tesla Engine that can operate at much higher power outputs than the present state of the art bladed turbines. The overall thrust and efficiency can also be increased by raising the compression ratio of the compressor. That is true of almost any engine including the internal combustion engine of an automobile. By staging, the compression ratio is raised and the efficiency and power of the engine is increased significantly. If the compression ratio is raised in a Tesla Engine from simple cycle (around five to one compression ratio) to twelve to one or as high as twenty five to one, with an increase in the engine inlet temperature at the same time, an unusually powerful and light-weight engine will result.


Dragon

Year of the Phalanx: Tesla and the Dragon

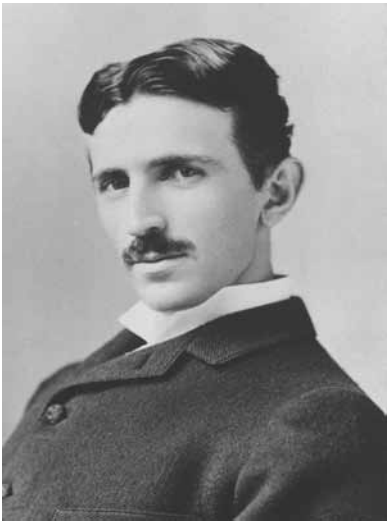
January 1986

by Jim Crogan

This is one dragon that Bruce Lee or Merlin the Magician probably never envisioned.

Looking at this particular Dragon, one might easily be tempted to grab the keys, strap on a helmet, slip into a flight suit and start hunting down the nearest Jedi. This strange looking craft seems more likely to be found at Disneyland or on set of "Star Wars IV" than inside a small hangar in Long Beach. Yet that's exactly where you'll find this soon-to-be high flying

Dragon or -- as it's officially known in the corridors of Phalanx Corporation-- the MP-18.



Nikola Tesla

This two-year-old Delaware corporation, headquartered in Long Beach, is tucked beneath the looming presence of the gigantic McDonnell Douglas aircraft plant on East Wardlow Road. Inside Phalanx, a small but dedicated ban of engineers an business people have grown accustomed to the naysayers, the wisecracks an the jokes about their strikingly new design for the delta-winged, vertical take-off and lift (VTOL) jet airplane. They seem to accept it all with humor and grace. Perhaps, because for them, it's no longer a question of if it will fly but how soon.

The heart of any aircraft is its engine, and unquestionably the heart of the MP-18 an its parent company, is the energy an force generated by the jet's designer, corporate Chief Executive Officer an board chairman William Moody, Jr. For the past two years, the creation an eventual first flight of the design which has evolved into the Dragon, has been the all-consuming passion of the 53-year-old, bespectacled, pipe-smoking, stocky, six-foot, four inch, architect and Massachusetts Institute of Technology (MIT) graduate.

"The development an production of the Dragon could be as significant to the aircraft industry as the Model T was to the automobile," said Moody. Self-described as an "imagineer," this determined designer is utterly con-

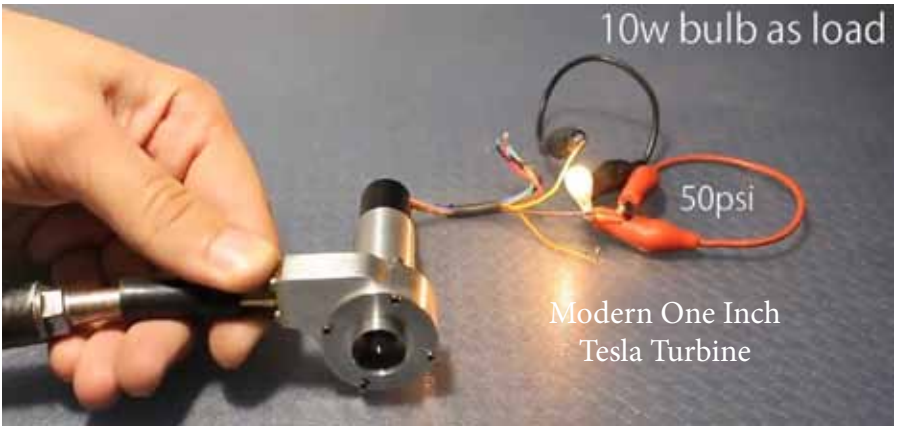
page 499 **ELECTRICAL REVIEW & WESTERN ELECTRICIAN** Sept. 9, 1911

FLUID PROPULSION

On other pages of this issue we present Dr. Nikola Tesla's description of a new principle of fluid propulsion, which is the culmination of his labors of a number of years. As all generation of mechanical power involves the use of a fluid as the vehicle of energy, the underlying idea is a broad one and bears on all the branches of mechanics.

Dr. Tesla avails himself of the two fundamental properties of a fluid, adhesion and viscosity, in an effort to produce a highly efficient mechanism. The fluid, whether receiving or imparting energy, is made to pass along the surfaces of a system of rotating disks in free natural spirals—that is, along paths of least resistance. The efficacy of the machines he has constructed on this principle is evidenced by their remarkable performance, small turbines or rotary engines being run at a peripheral speed scarcely more than half of that of reaction turbines, and giving several times the output of the latter. For example, a small steam turbine exhibited at the Edison station in New York, having a rotor of only nine and three-quarters inches in diameter and two inches wide, was capable of developing 110 horsepower with free exhaust. This machine had no blades, vanes, valves or sliding contacts of any kind.

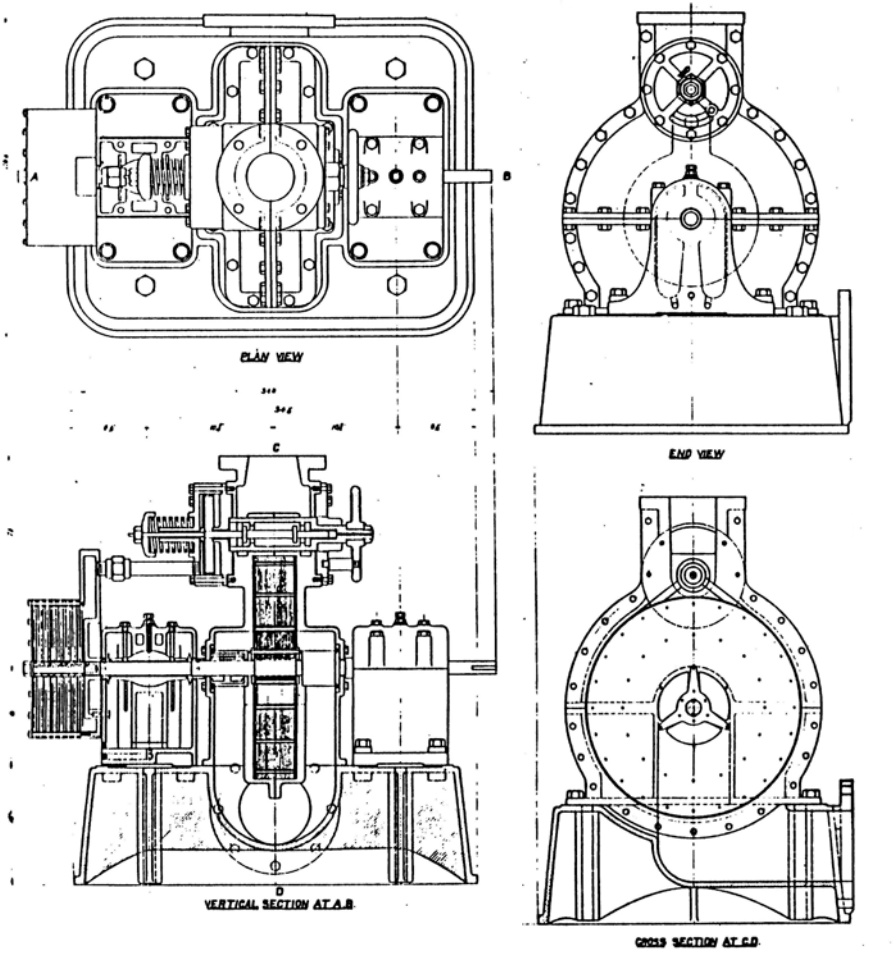
On account of the great simplicity of this apparatus, reversibility and extraordinary output, it will undoubtedly find an immense variety of uses, and the commercial world can not fail to be deeply interested in this new development. The electrical industry, in particular, should be greatly benefitted by this latest effort of Dr. Tesla.



Says His Engine Could Convert Factory Gases Now Wasted Into Prodigious Power for Use on Land or Sea or in the Air - Believes He Proved It.

Dr. Nikola Tesla leaned back in his chair at the Waldorff last night and talked calmly of airships without planes, propellers or any of the other gear of the now familiar aeroplanes hurtling through space at tremendous speed or driving more slowly carrying great loads, and in either case always as safely as the most prosaic of wheeled vehicles.

He spoke of harnessing the energy of the gases given off by the great steel plants and producing therefrom 25,000,000 or 50,000,000 horse-power with a value of say $450,000,000 a year. He spoke of these things already accomplished.

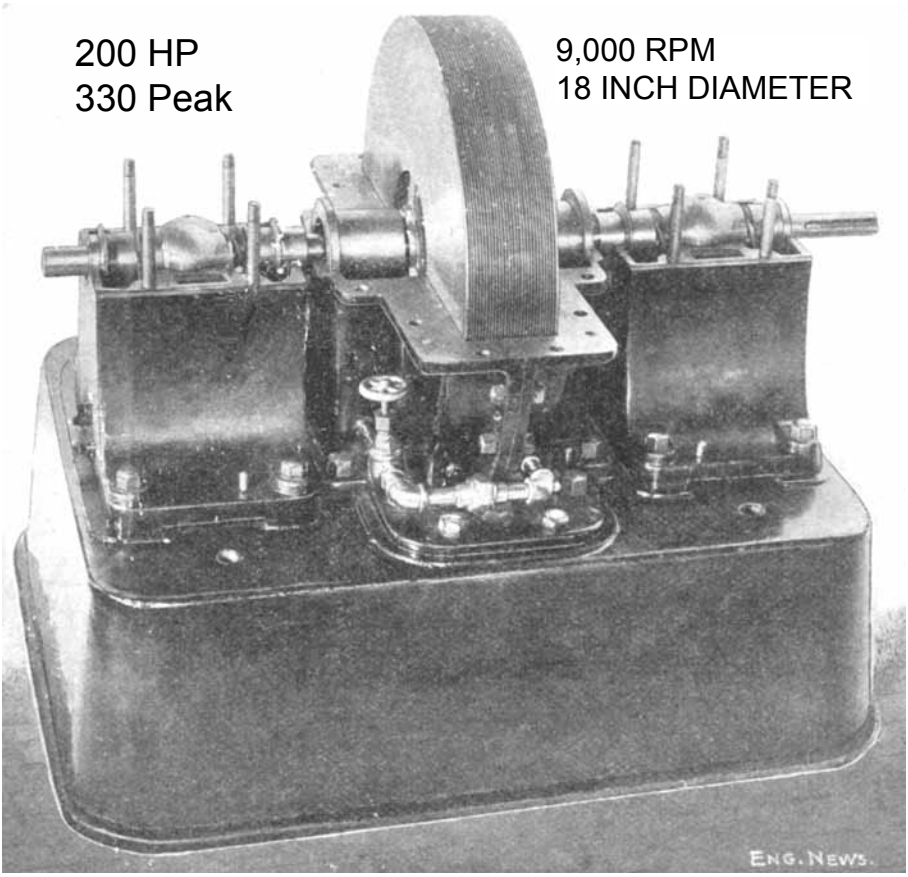


Assembly Drawing for 200 Horse Power Tesla Turbine Engine

TESLA TURBINE
ASSEMBLY DRAWING
135

Believing that the turbine method of converting the kinetic energy of gas into rotary motion is the most efficient and promising yet evolved, engineers continue to watch its development with keenest interest. Up to this time, however, the gas turbine, meaning that driven by products of combustion which still retain very high temperatures, has not made much head-way. Many serious obstacles remain to be overcome though there seems no logical reason why they should not be surmounted in due process of time. What is required is the application of just such mutual effort as in their days have brought forth the no less marvelous developments in submarine and aerial navigation and wireless telegraphy.

Difficulties already encountered include those resulting from high temperatures and pressures from high natural velocities and from the inadequacy of the usual devices for securing the required high degree of compression. There is reason to expect that the solution of the latter problem ultimately will be found in the turbine principle itself, while the gradual accumula-



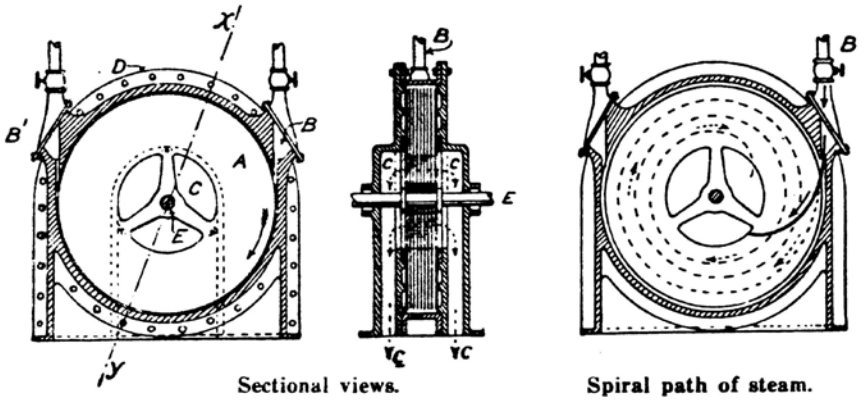
page 290 **Scientific American** Sept. 30, 1911

From the Complex to the Simple

A MARKED step was taken in the simplification of prime movers when Watt's cumbersome steam engine, with its ingenious but elaborate parallel motion, gave way to the present standard reciprocating type, with only piston rod, cross head and connecting rod interposed between piston and crank. An even greater advance toward ideal simplicity occurred when, after years of effort by inventors to produce a practical rotary engine, Parsons brought out his compact, though costly, turbine, in which the energy of the steam is developed on a zig zag pattern through multitudinous rows of fixed and moving blades.

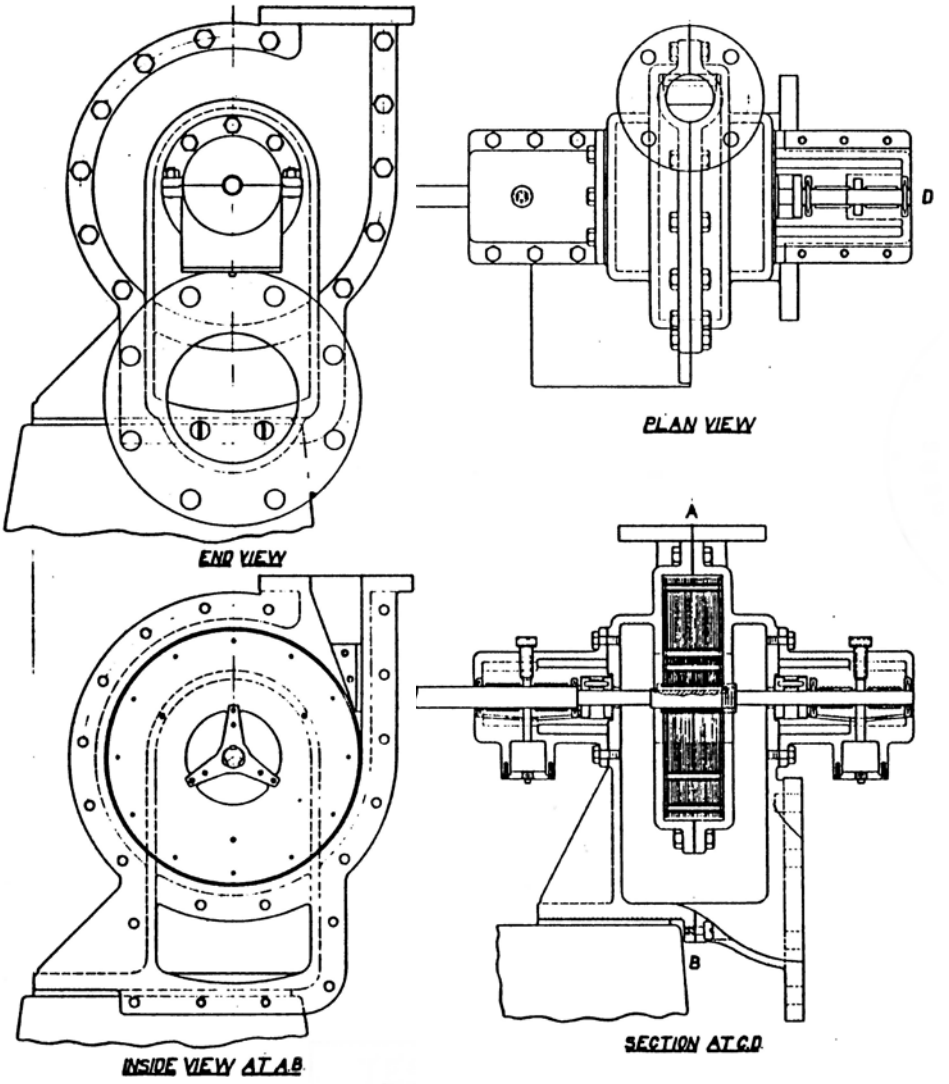
And now comes Mr. Tesla with a motor which bids fair to carry the steam engine another long step toward the ideally simple prime mover - a motor in which the fixed and revolving blades of the turbine give place to a set of steel disks of simple and cheap construction. If the flow of steam in spiral curves between the adjoining faces of flat disks is an efficient method of developing the energy of the steam, the prime mover would certainly appear to have been at last reduced to its simplest terms.

The further development of the unique turbine which we describe elsewhere will be followed with close attention by the technical world. The results attained with this small high-pressure unit are certainly flattering, and give reason to believe that the addition of a low pressure turbine and a condenser would make this type of turbine as highly efficient as it is simple and cheap in construction and maintenance.



Sectional views. Spiral path of steam.

Details of Turbine



Assembly Drawing for the
110 Horse Power Tesla Engine

TESLA TURBINE
ASSEMBLY DRAWING

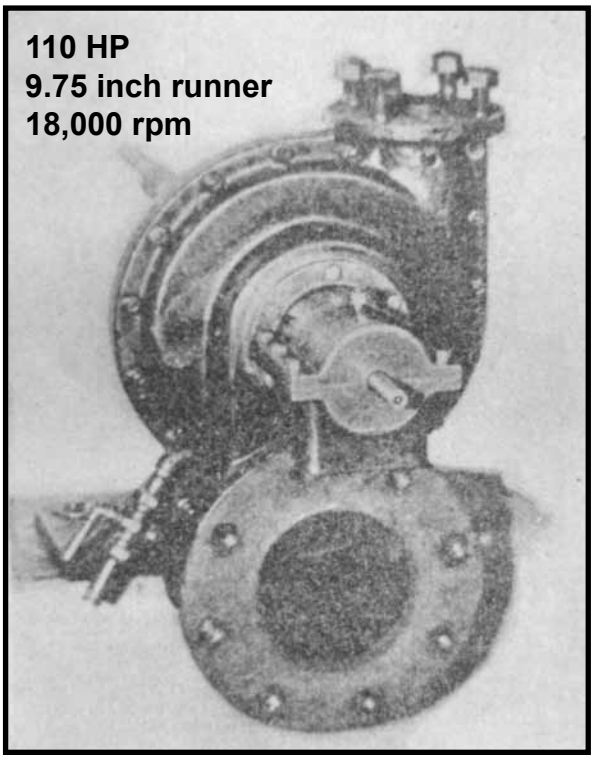
The accompanying illustrations show the new turbine invented by Nikola Tesla, the noted electrical and mechanical engineer. With slight changes of the rotors and accessories this turbine may be operated as a steam, water, air or gas engine. The rotor part of the turbine illustrated herewith is only about one foot in diameter. The inventor, in speaking of the design and operation of the machine to a representative of the HORSELESS AGE, said in part:

"The turbine consists of a set of flat steel discs mounted on a shaft and rotating within a casing, the power medium of fluid used entering with high velocity at the periphery of the discs, flowing between them in free spiral paths and escaping through the exhaust port at the centre. Instead of developing the energy of the steam or gas by pressure or impact upon vanes or buckets, the operation of this motor depends upon the adhesive and viscous properties of fluids. The attraction of the fluid to the faces of the discs and the resistance of the particles to molecular separation combine in transmitting the velocity energy of the motive fluid to the plates of the rotor."

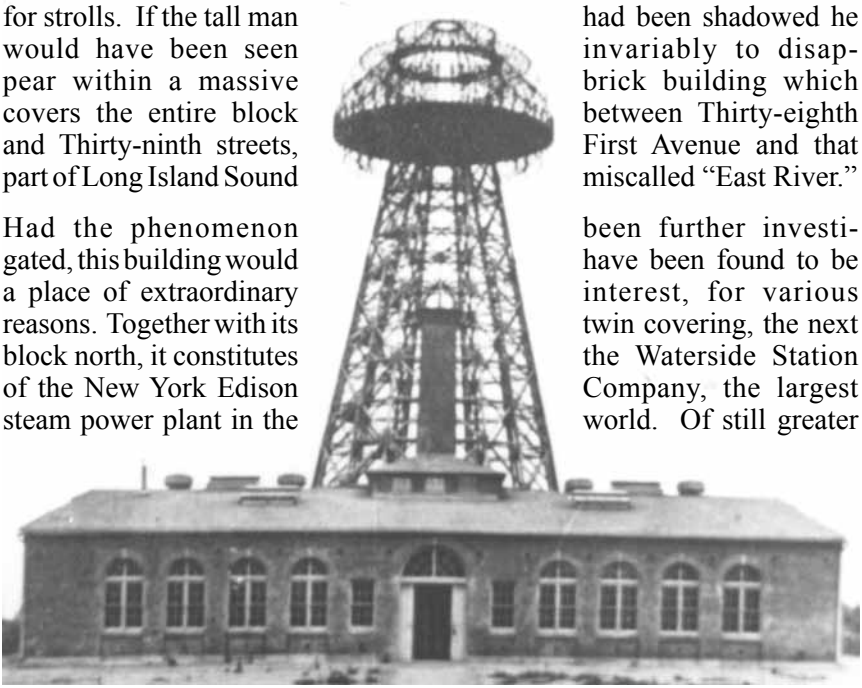
"In order to bring out a distinctive feature assume, in the first place, that the motive medium is admitted to the disc chamber through a port; that is, a channel which it traverses with nearly uniform velocity. In this case the

We publish the above because certain of our readers expressed an interest in the motor. Personally we do not believe in turbines for automobiles.

Ed. It is no wonder that the Horseless Age did not believe in this engine for autos as its success would eliminate almost all of the engine components and service equipment that were the majority of this magazine's advertizing content!



ALMOST any evening last fall a tall, spare man, whose discouraged looking mustache remains a glossy black without any aid from the barber in spite of the fact that its wearer is well past his fiftieth year, might have been seen wending his dignified way down East Thirty-eighth Street toward First Avenue, New York City. He was a man who would attract attention anywhere, but especially on East Thirty-eighth Street, which is not a thoroughfare one would choose for an evening stroll, unless one chanced to be hard up for strolls. If the tall man had been shadowed he would have been seen invariably to disappear within a massive brick building which covers the entire block between Thirty-eighth and Thirty-ninth streets, First Avenue and that part of Long Island Sound miscalled "East River."



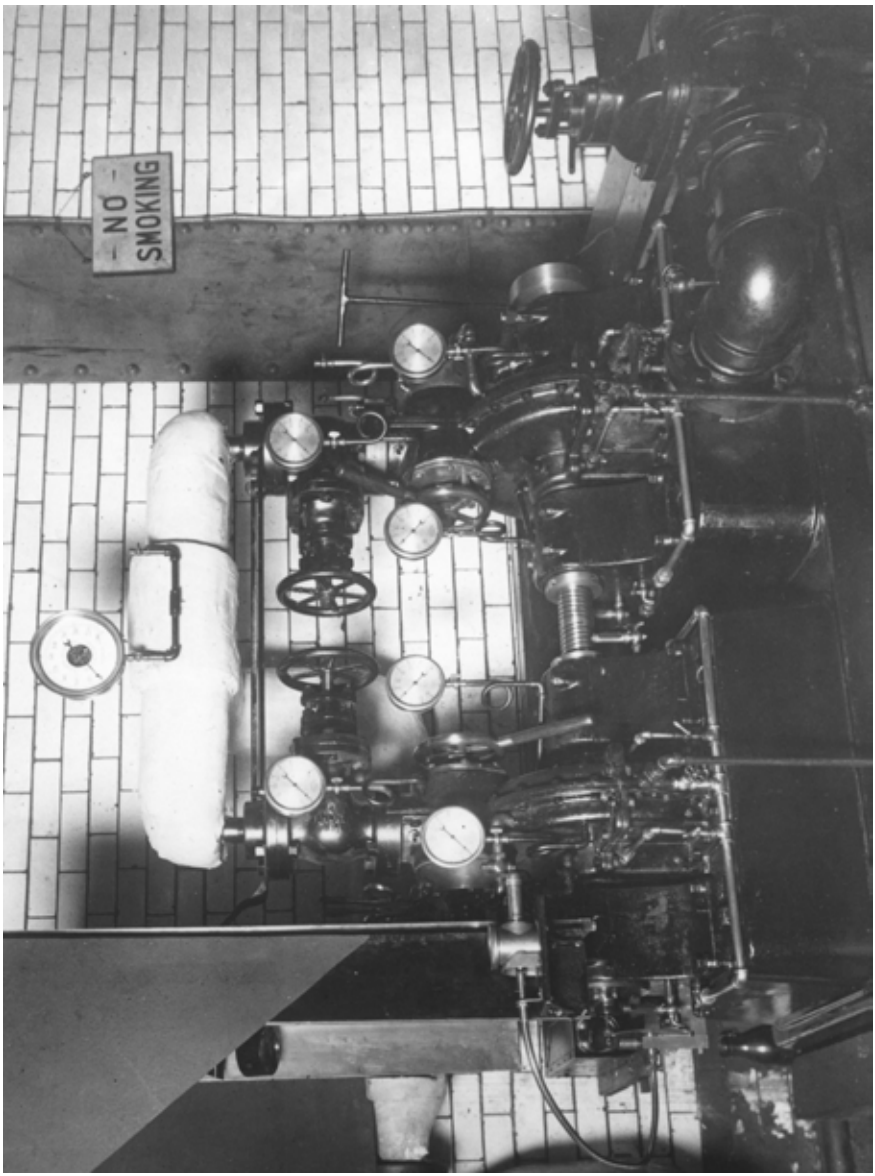
Had the phenomenon been further investigated, this building would have been found to be a place of extraordinary interest, for various reasons. Together with its twin covering, the next block north, it constitutes the Waterside Station of the New York Edison Company, the largest steam power plant in the world. Of still greater

Plant On Long Island Where Tesla Has Made Some Extraordinary Experiments In Electricity

interest than its size is the fact that ever since it was built there could be found within its thick walls the living history of the evolution of the steam engine epitomized and in action. Unlike all other histories of the steam engine, the opening chapter did not begin with the exploits of Hero, of Alexandria, 120 years before Christ, but started in several pages ahead of October, 1901, on which date the plant sent out its first electrical impulse.

When the New York Edison Company decided to build Waterside Station it took the bridles off the engineers and allowed them to go as far as they liked in designing a plant that would be the last word in steam engineering, for the plant was intended to be big enough to meet all demands for years to come. Power was furnished by vertical, three cylinder compound engines of 5,000 horse power, which were considered something marvelous both in size and

economy, eleven years ago. But before steam had been turned on for the first time the Curtis turbine had thrown down the gauntlet to reciprocating engines of whatever size or kind, offering to give them cards and spades and beat them out in the matter of economy. So a turbine of 2,000 horse power was installed almost at the beginning to show what it could do. It did so well that a turbine of 10,000 horse power soon took its place beside



Tesla's Dual Engine Test Dynamometer Fully Assembled

Page 263 **THE BOY'S BOOK OF NEW INVENTIONS** 1912

THE TESLA TURBINE

By HARRY E. MAULE

DR. NIKOLA TESLA TELLS OF HIS NEW STEAM TURBINE ENGINE A MODEL OF WHICH, THE SIZE OF A DERBY HAT, DEVELOPS MORE THAN 110 HORSEPOWER

HOW would you like to have an engine for your motor boat that you could almost cover with a man's derby hat and yet which would give 110 horsepower?" asked the scientist of his young friend one day when they had been talking about boats and engines.

"I never heard of any real engine as small as that," said the boy. "I used to play with toy engines, but they wouldn't give anywhere near one horsepower, much less 110."

"Well, I think I can show you a little engine that, for mechanical simplicity and power is about the most wonderful thing you ever have seen, if you would like to make another visit to Dr. Nikola Tesla, who told us all about his invention for the wireless transmission of power the other day. Doctor Tesla invented this little engine and he is going to do great things with it."

Of course the boy jumped at the opportunity, for what real boy would miss a chance to find out all about a new and powerful engine?

"Is it a gasoline engine?" he asked.

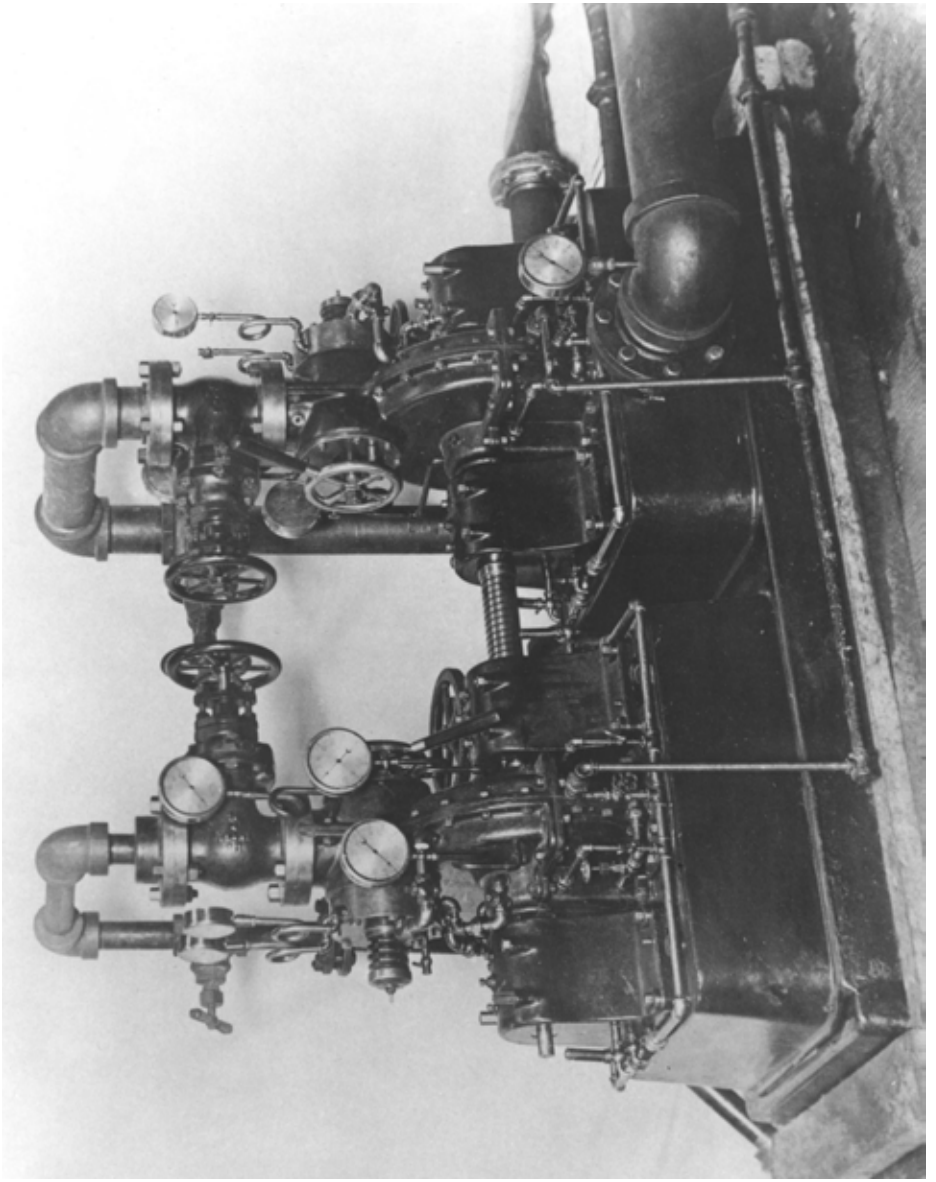
"No, it is a steam turbine, but if you know anything at all about turbines you will see that it is entirely different from any you ever have seen, for Doctor Tesla has used a principle as old as the hills and one which has been known to men for centuries, but which never before has been applied in mechanics."

After a little more talk the scientist promised to arrange with Tesla to take the young man over to the great Waterside power-house, New York, where the inventor is testing out his latest invention. We will follow them there and see what this wonderful little turbine looks like.

Picking his way amid the powerful machinery and the maze of switchboards, the scientist finally stopped in front of a little device that seemed like a toy amid the gigantic machines of the power-house.

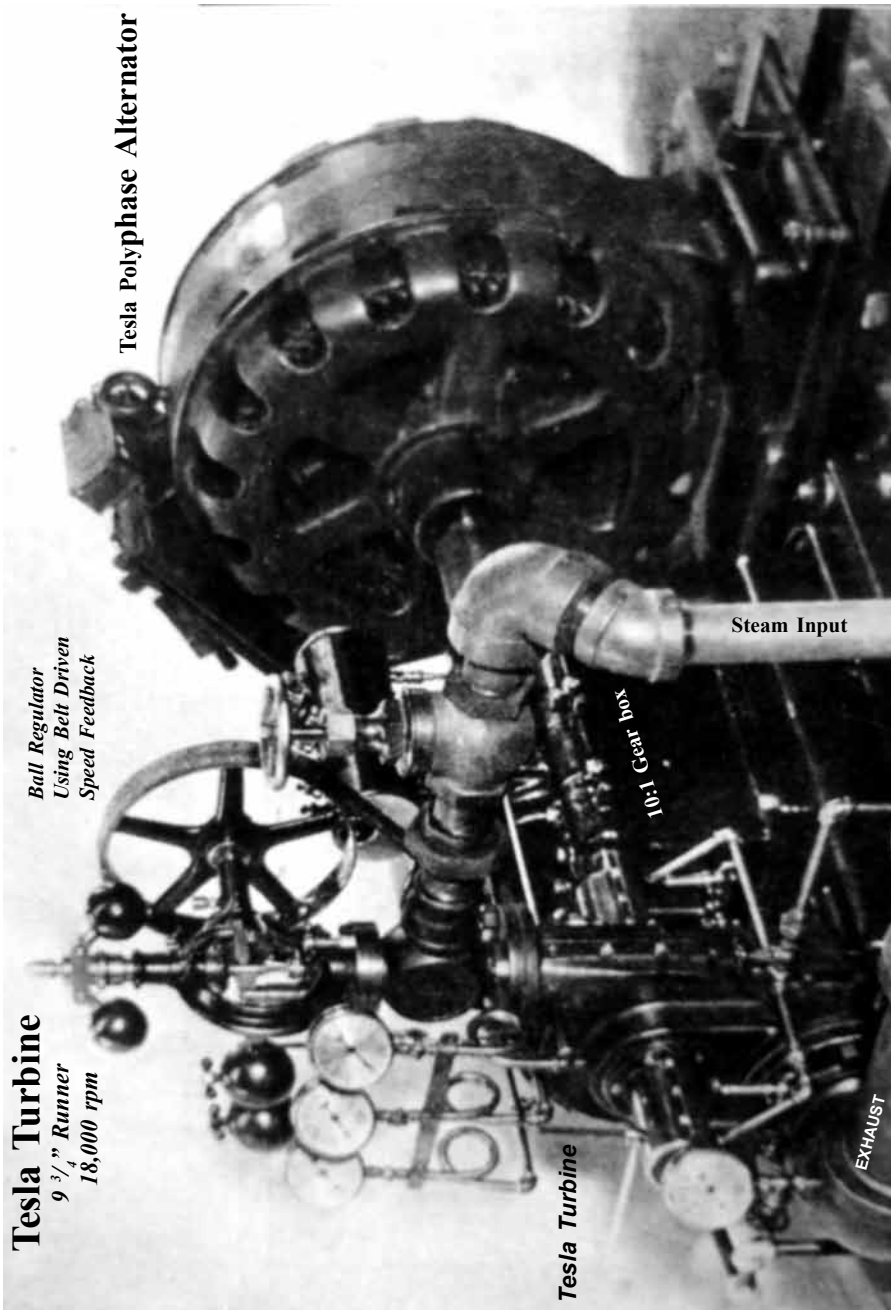
"This is the small turbine," says Tesla. "It will do pretty well for its size."

Illustrations and Photographs which originally appeared in this article can be found on pages: 61, 31, 32, 35, 151 and 196

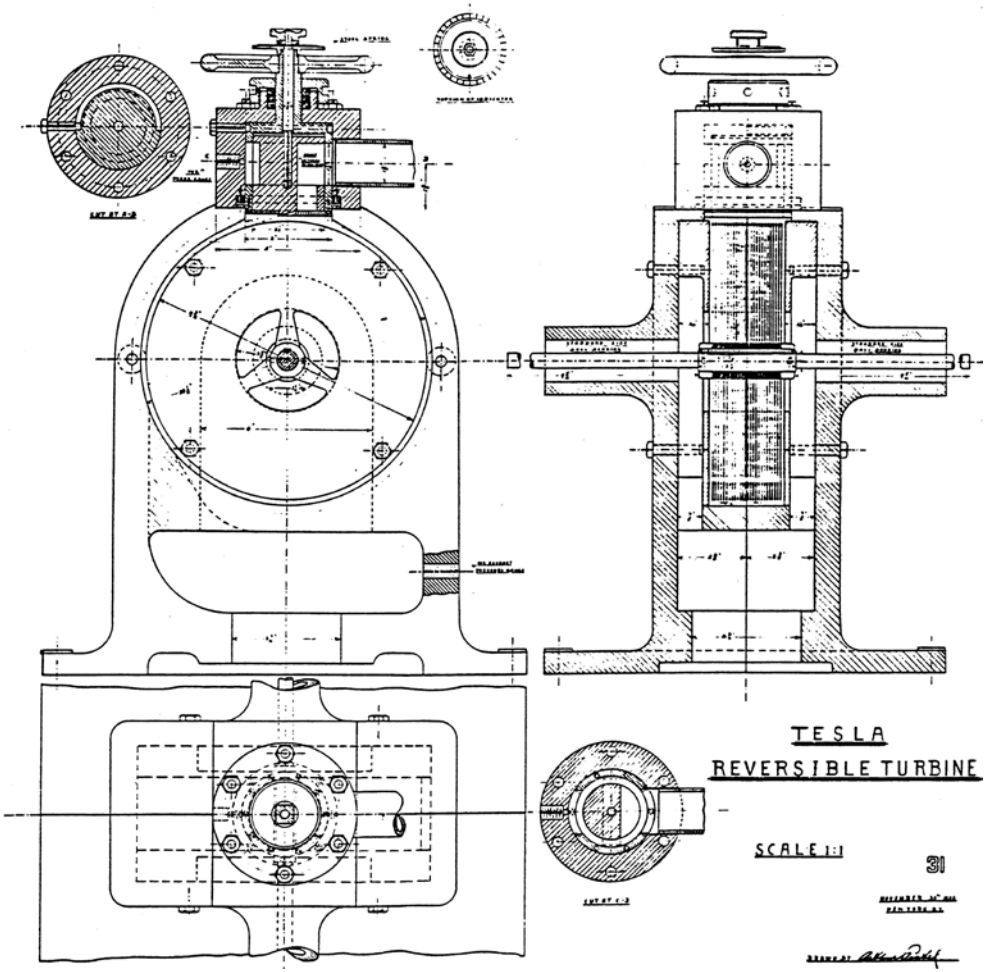


Tesla's Dual Engine Test Dynamometer Fully Assembled

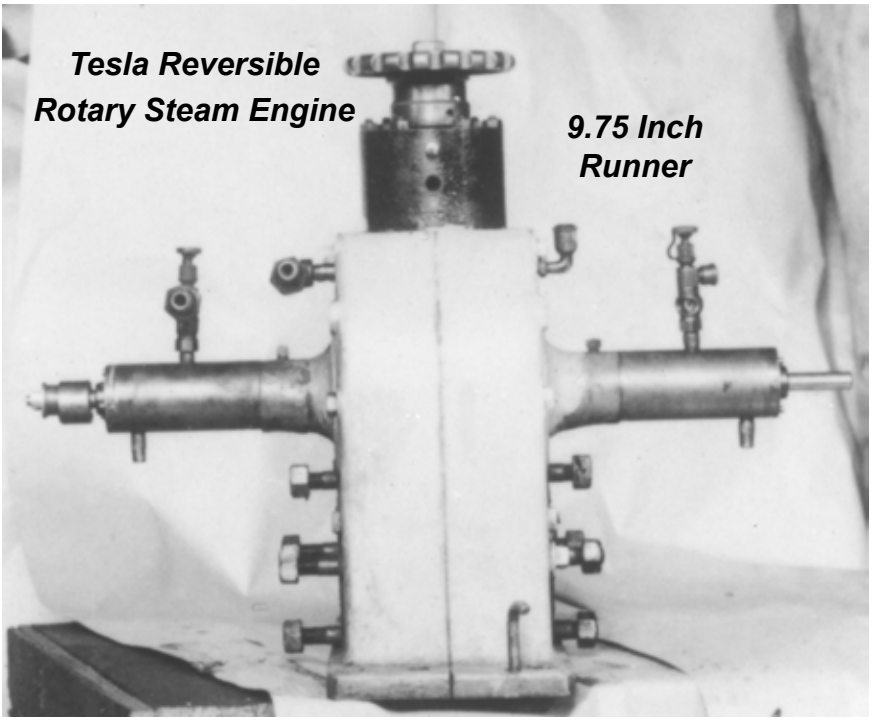
The engines are set up in a slightly different configuration than that pictured on page 185. Note the separate steam feeds to each engine instead of the common supply appearing earlier.

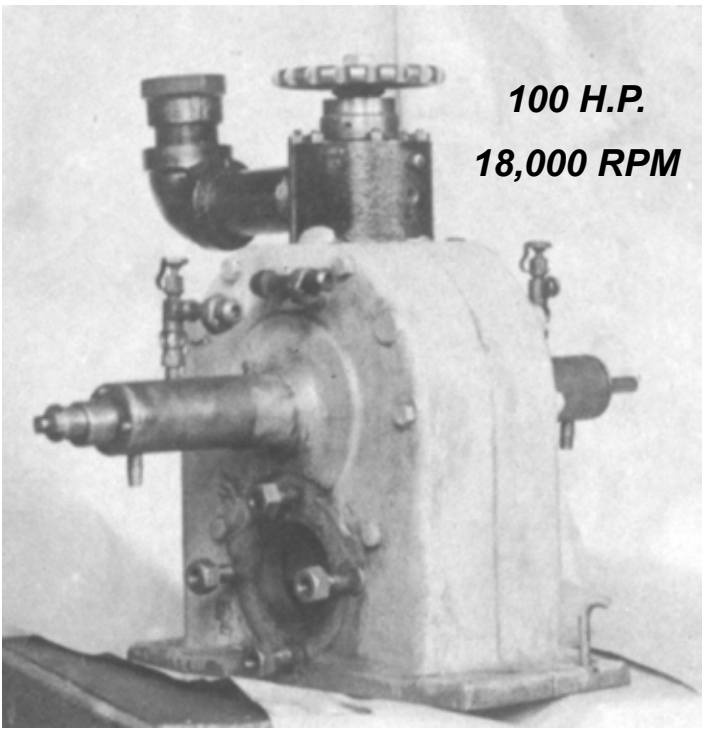


The 110 HP Tesla Steam Engine Driving a 50KW Tesla Alternator



Tesla Reversible Rotary Steam Engine


Tesla Reversible
Rotary Steam Engine
9.75 Inch
Runner


100 H.P.
18,000 RPM

BIOMASS BOUNDARY LAYER TURBINE POWER SYSTEM

by Darren Schmidt

UNDER CALIFORNIA ENERGY COMMISSION ENERGY INNOVATIONS SMALL GRANT PROGRAM*

*Abridged

TEBA — ed: Following is an abridged version of a report detailing successful biomass combustion tests sponsored by the California Energy Commission. This testing is a direct result of a presentation given by TEBA, at the First Annual Telluride Tech Festival, held in August of 2000. Those attending the TEBA presentation discovered and relayed that this device was a possible solution to turbine biomass combustion problems, attempting to be overcome by the Energy and Environmental Research Center (EERC), Grand Forks ND, where "Principle Investigator" Darren Schmidt is employed. Investigator Schmidt established that the Tesla turbine, according to the "respected" literature, and available empirical testing, could be operated very efficiently. He discovered Russian research on a Tesla type micro turbine, indicating very high efficiency (reproduced herein page 250). Investigator Schmidt applied for and obtained a $75,000 California Energy Commission Grant to establish its claimed ability to ingest solids, as indicated by other research, particularly that of Dr. Warren Rice; Professor of Mechanical Engineering, Arizona State University, Tempe, as well as in established commercial pumping applications.

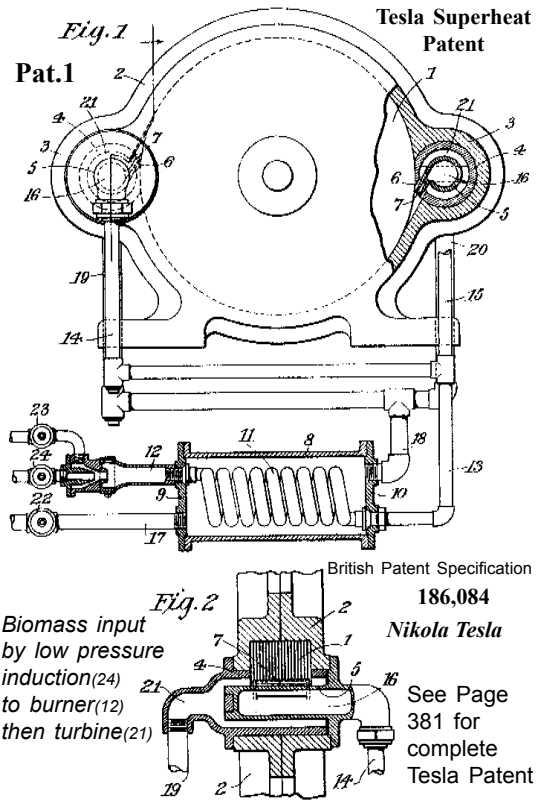
The EERC could not directly receive the funds for testing, however, instead being directed through a newly formed private company; "EnergySchmidt." According to investigator Schmidt this left approximately $50,000 for actual testing at the EERC, where investigator Schmidt is employed.

The main interest was in the determination of the level of damage the turbine would suffer when fed various percentages of solid fuels. Conventional turbines can tolerate very little to no solids content and

How To Operate A Tesla Turbine Efficiently

Using Biomass Fuels

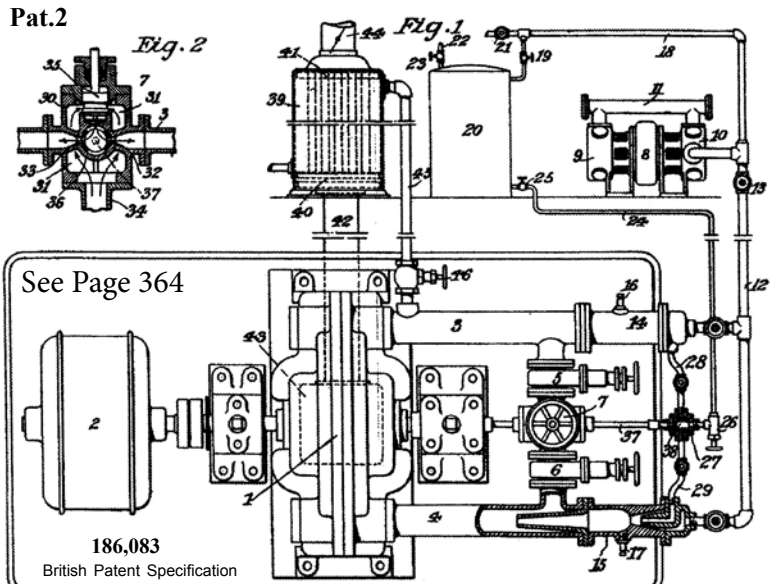
Only Turbine Proven Undamaged by Direct Biomass Combustion!



The previous article is very instructive, documenting successful operation of directly combusting 100% biomass through a Tesla Turbine. Although successful in establishing that the Tesla turbine is not damaged, by any degree of solids ingestion, the combustion techniques employed in these tests were not practical for this mode of operation. Efficiency of operation both thermally and mechanically were very poor in the configuration used for these tests. Although initially excited about the turbine's solids ingestion ability and previous documented testing, proving empirically that the Tesla turbine can indeed operate very efficiently, researcher Schmidt succumbed to classic misunderstandings as to how efficient Tesla turbine operation should be achieved.

Efficiency increase was thought possible by simply increasing the fuel mass, while ignoring pressures at the nozzle. It was not understood that the Tesla turbine is a *Velocity Machine* that *MUST* have proper applied pressure and resultant velocity, *at the nozzle*, for speed, and therefore, rated power and efficiency. Even though considerable pressure was recorded at the compressor employed for these tests, these pressures are *meaningless* as they were not recorded at the nozzle. The only way to achieve efficiency is to give the nozzle the high pressure it requires (125—185 psig), while at the same time giving the biomass combustor the low pressure it desires (15 psig). Herein is explained how this can be achieved with the highest degree of efficiency.

Tesla Combined Cycle Recuperation Patent



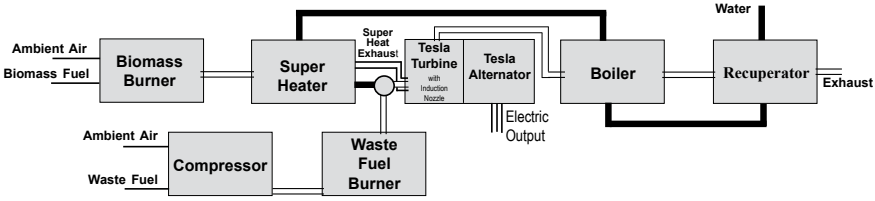
Researcher's Schmidt's frustrations are expressed in his last known communication on the subject, submitted to a biomass news group, describing his experience using house steam as the working fluid. Researcher Schmidt attempted to establish baseline performance, reported by others, without understanding the 90° torque knee of the Tesla turbine. Not realizing nozzle tuning is critical to resultant velocity and runner speed required to transcend the "knee." This turbine was, therefore, never run at its operational speed.

From Darren D. Schmidt, Energy & Environmental Research Center, Grand Forks, ND.

Over the past 6 months I acquired a donated boundary layer turbine (Tesla Turbine) and measured the performance. (ed: First time Researcher Schmidt refers to a "Tesla Turbine.") The turbine consisted of a 12 inch rotor and two steam inlet nozzles. The turbine was connected to house steam. 350°F, 135psig. (ed: Measured at the boiler not the nozzle.) With limited funding, we connected the turbine to a dynamometer, and instrumented with pressure, temperature, orifice flow meters, and a hand held rpm meter. The turbine was operated at 6,500 rpm so data at higher rpm could be estimated. (ed: Incorrect Concept) The following are the results. Basically, efficiencies were low. I was hoping to see about 25%.

(Energy in vs shaft power out) 2,000 rpm, 4.5hp, 0.6%
4,000 rpm, 8hp, 1.3%
6,500 rpm, 14hp, 1.75%
Estimated max.: 12,000 rpm, 24hp, 3.5 - 5%

Researcher Schmidt, in this final communication, expressed none



of the previously reported facts regarding known efficiencies contained in his report. Having stated during telephone conversation that further funding for this research was not in the cards politically and only now attributing low efficiency to a "Tesla Turbine," Classic! Researcher Schmidt has, however, been of great service, despite his confusions and subsequent caving; reporting to the California Energy Commission, before this realization, that this technology has indeed proven very efficient, by previous legitimate researchers, obtaining empirical data. It was also reported revolutionary, that a turbine, any turbine, could actually continuously ingest 100% biomass combustion products, without so much as a hint of damage. Concluding that the "*Boundary Layer Turbine*" has tremendous potential that should be explored further by his private company, established exclusively for this purpose. This is all now very old but important information. It may be that the current concern over "Global Warming" will be helpful in propelling this technology forward. Researcher Schmidt was planning to dedicate his career to this technology before discovering that funding would not be forthcoming or allowed.

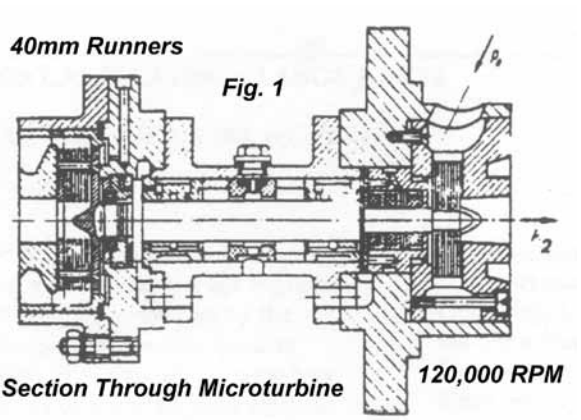
So how do you operate a Tesla turbine efficiently on biomass fuels, giving the nozzle the pressure it requires, while at the same time combusting the biomass efficiently at low pressure? Revealed here is the required technique of low pressure combustion of the biomass fuel, while satisfying the velocity requirement necessary to transcend the 90° torque knee unique to the Tesla turbine:

The answer is quite simple, involving combinations of techniques that have already been patented by Tesla himself. Using the Tesla Superheat and Induction Nozzle **(Pat. 1)**, in combination with primary heat generation via direct combustion, as described in the Tesla's Recuperation patent **(Pat. 2)**. These two patents complete the scheme. (See block diagram.) Biomass is combusted at low pressure using ambient air, via vacuum that is created by the Tesla induction nozzle. This provides superheat exhaust around the main nozzle with combustion products drawn through the turbine itself, having the proven ability to ingest 100% of the combustion products without damage. Primary nozzle pressure is developed as described in Tesla's combined cycle recuperation patent, which employes steam injection, in conjunction with waste fuel combustion.

EXPERIMENTAL RESEARCH ON A DISC MICROTURBINE

A.B. Davydov, A.N. Sherstyuk

From the Russian Publication: Vestnik Mashinostroeniya, Vol.60, Issue 8, 1980, pp. 26-28

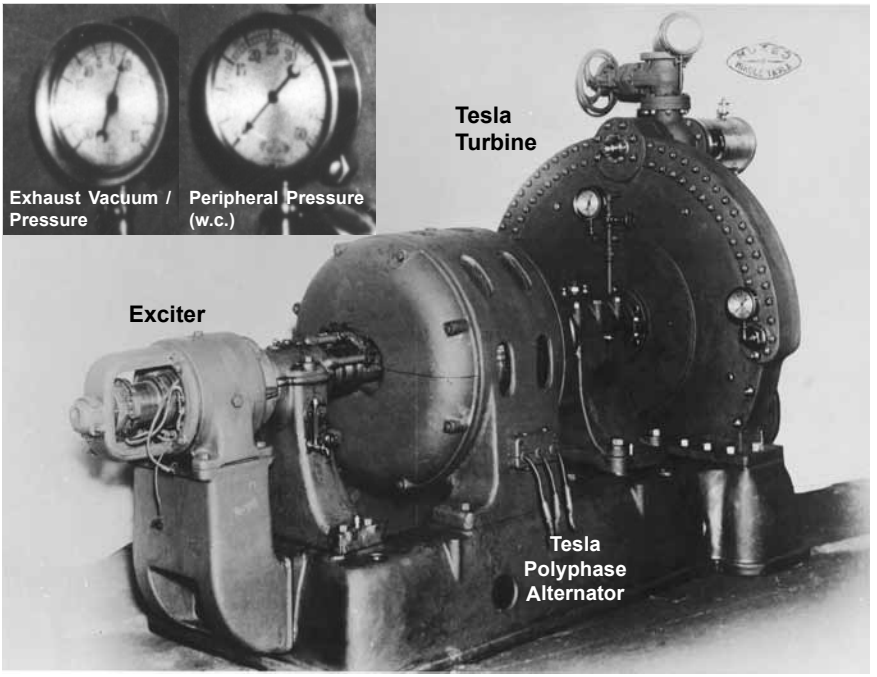


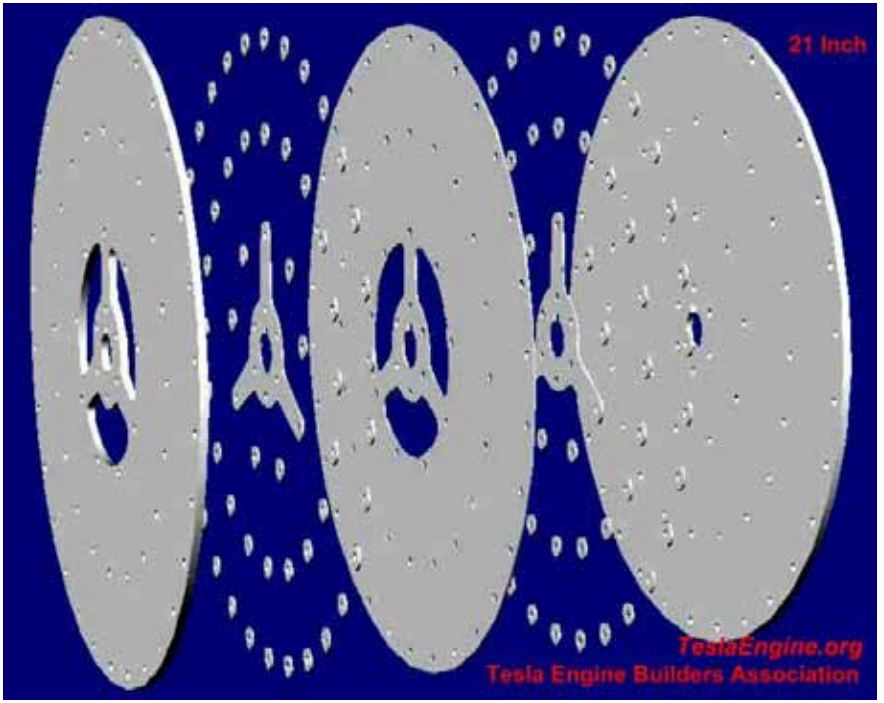
The problem of increasing the efficiency of microturbines can be solved both by improving existing models and by producing new types of turbines[1]. As regards the latter method the change from the traditional bladed micro-turbines to disc turbines may be practical. In disc turbines the torque is produced by the setting up of tangential stresses on the surface of the discs which are separated by thin slot shaped channels into which the liquids or gas are supplied via the nozzles of the stator with the nozzles arranged tangentially to the external diameter of the discs[2].

Disc turbines besides operating with the traditional types of operating medium such as air and water can also be operated with powders, colloidal mixtures and with dense and viscous liquids[3].

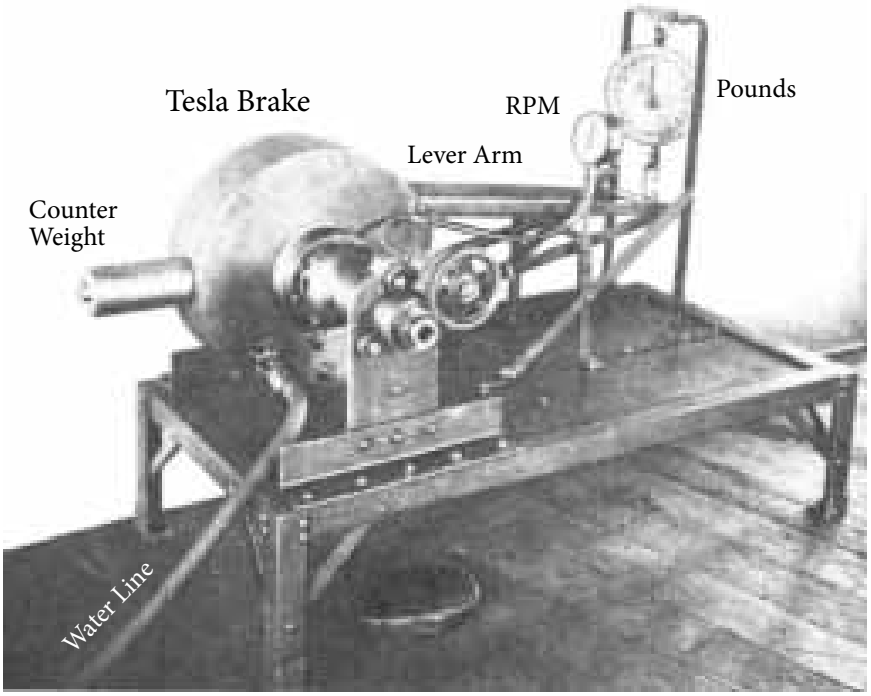
In our national and in foreign articles there are practically no data dealing with experimental researches in disc turbines with small diameter rotors. An examination of the results of experimental research on a centripetal disc microturbine should, therefore, be of interest. This turbine (Fig.1) was designed for air expansion using the following parameters: Input pressure Po=0,3 to 0,6MPa; output pressure $P2$=0,1MPa; input temperature To=280 to 300K; rate of flow of air, Q=0,005 to 0,3kg/s; power, N=0,1 to 1,5kW.

The microturbine is designed as a single rotor machine with a two sided cantilever arrangement for the turbine stage and a disc braked blower for power relief. The rotor is suspended on gas blown bearings which ensure reliable operation at rotary speeds up to 120,000 *rev/min*. The turbine is made as a set of plane parallel aluminum discs. These discs, with an external diameter d_1=40mm), have holes for the axial exit of the air, and are arranged at equal distances from one another with spacing rings. During the course of the experiments changes were made in the number of discs and the clearances between them and also in the

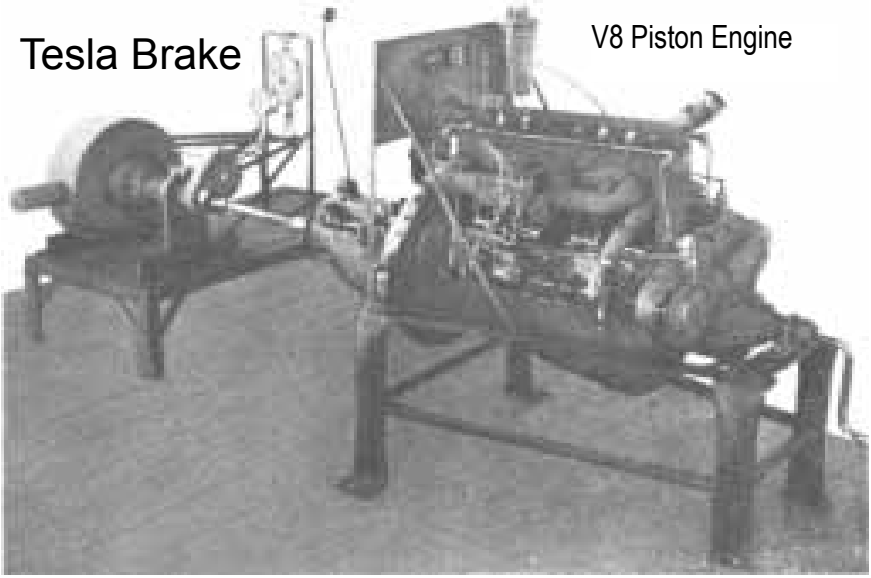

Exhaust Vacuum / Pressure
Peripheral Pressure (w.c.)
Tesla Turbine
Exciter
Tesla Polyphase Alternator


21 Inch
TeslaEngine.org
Tesla Engine Builders Association

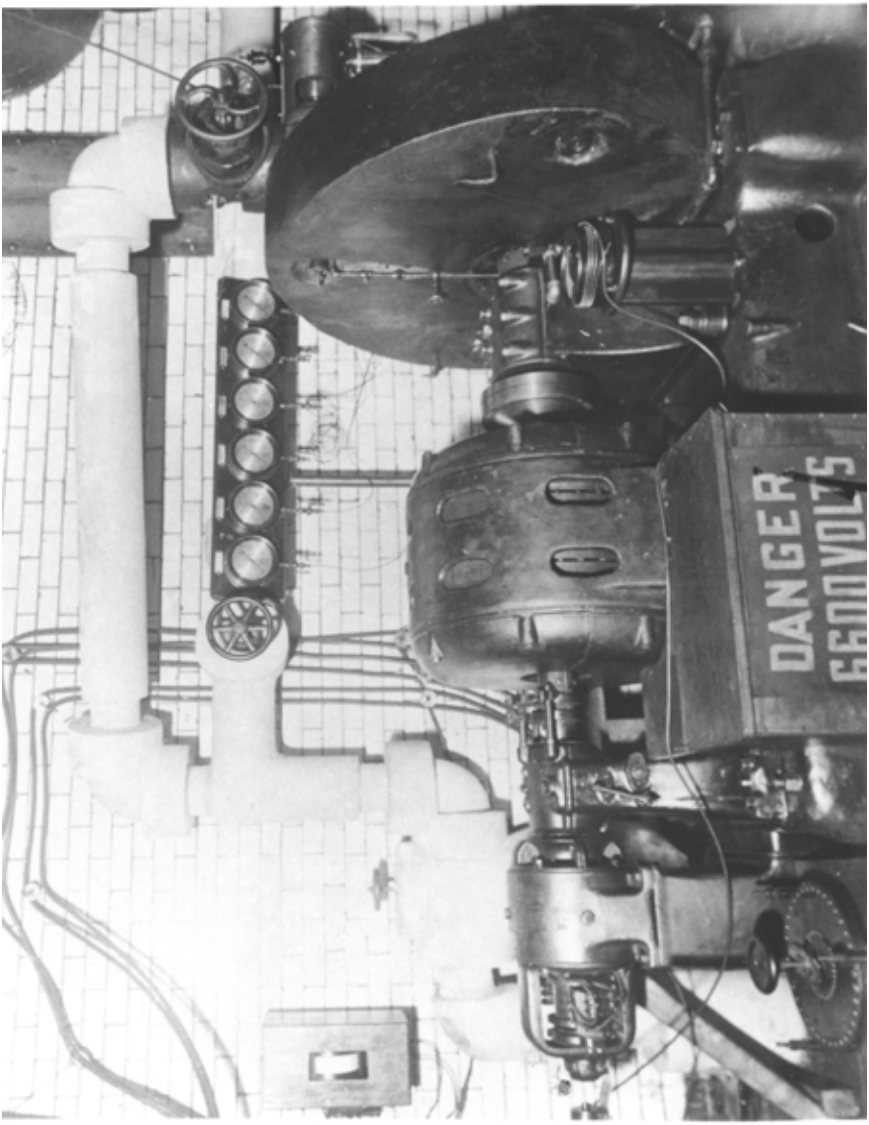
Tesla Hydraulic Dynamometer



Hyraulic dynamometers are made in a number of different type. The one shown consist of a cast iron housing within which are mounted twenty stationary plates. The dynamometer housing itself is carried on a center boss, which supports not only the housing within the dynamometer frame and roller bearings, but the shaft within the center of this boss. The shaft projecting into the housing is fitted with 21 rotating plates. These plates are mounted to rotate between the stationary plates so that the device is very similar to the multiple-disk clutch. The holding effect with this disk-type dynamometer is obtained by running water into the housing where it passes between the stationary and rotating plates. By varying the amount of water flowing into the dynamometer it is possible to increase the load on the plates. It has been found by experiment that an eighteen-inch plate, rotating between other eighteen-inch plates, with just a slight amount of clearance and water the full depth of the plates, will hold from two to three horsepower at speeds of 1,500 to 2,000 r.p.m. At higher speeds each plate will hold a larger amount, so that the dynamometer of 18" inside diameter, fitted with 20 to 22 plates, will hold as much as 80 to 100 horsepower. In other words, the friction possibilities within the dynamometer are sufficient to con-

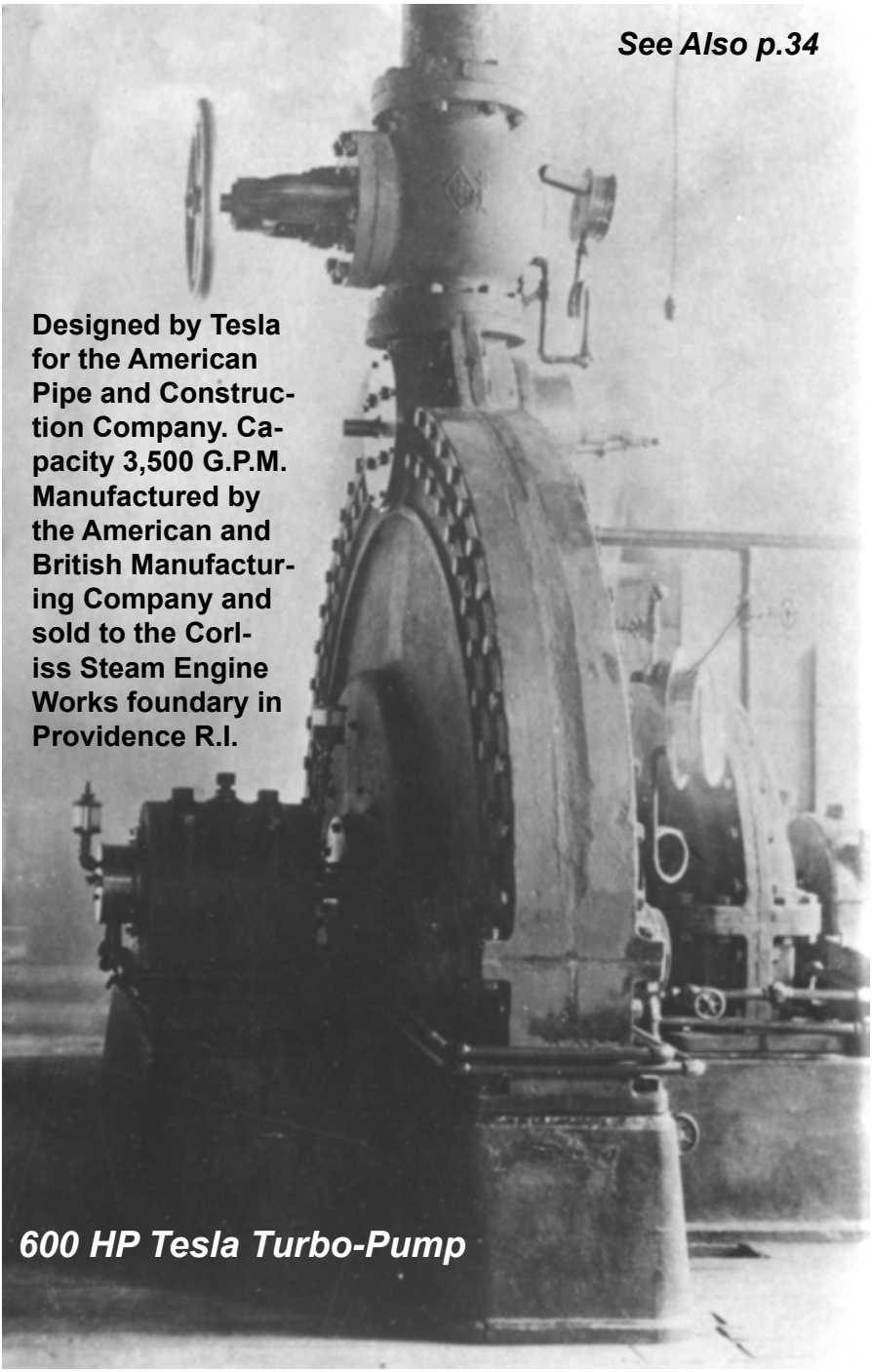


sume and absorb the output of an engine developing up to 100 hp. This type of dynamometer is mounted on a stand so that it may be hooked up to any engine on the test floor. This distance from the center of the dynamometer shaft to the floor should be the same as the distance from the crankshaft, or propeller-shaft center to the floor. Make very certain that a setup of this kind is hooked up so that it is impossible for the two units to separate, as a serious accident would be certain to result. In the device shown hooked up to the four-cylinder engine, a steel tube or pipe (not shown) has been planned to go over the propeller shaft and universals. This simply is a guard to protect workers from contact with rotating parts and in case the propeller shaft should be broken. Dynamometers of this type may be built with a lever arm 311/2" long - that is, from the center of the dynamometer shaft to the point at which the scale is applied, the length is 311/2". A dynamometer built on this plan will show brake horsepower according to the following formula: Brake Horse Power = RPM x W/2,000 Here RPM equals the revolutions per minute of the engine and dynamometer shaft; W equals the weight or load recorded on the scale, and 2,000 is a fixed number or constant T.



Original

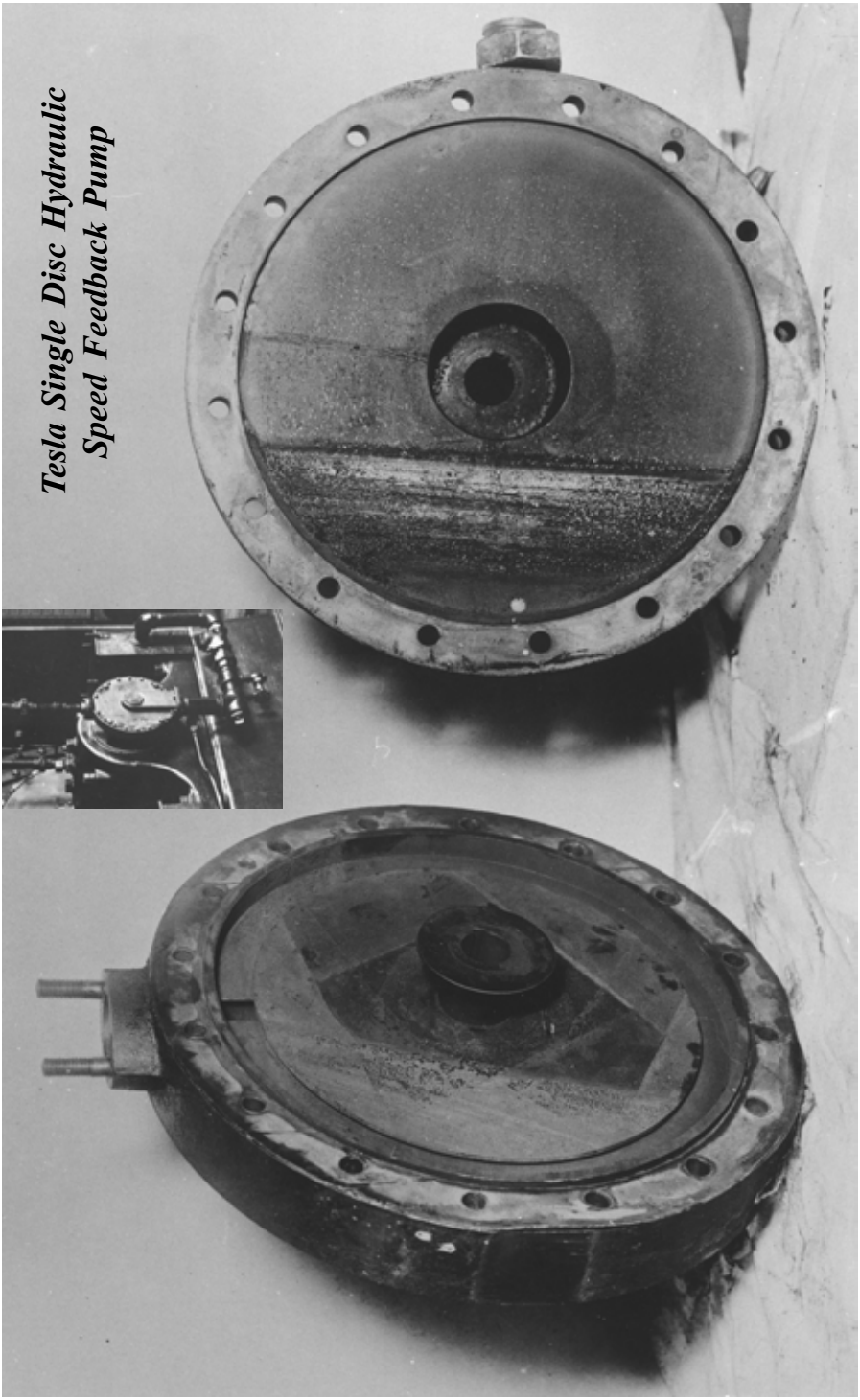
Tesla Turbo/Alternator



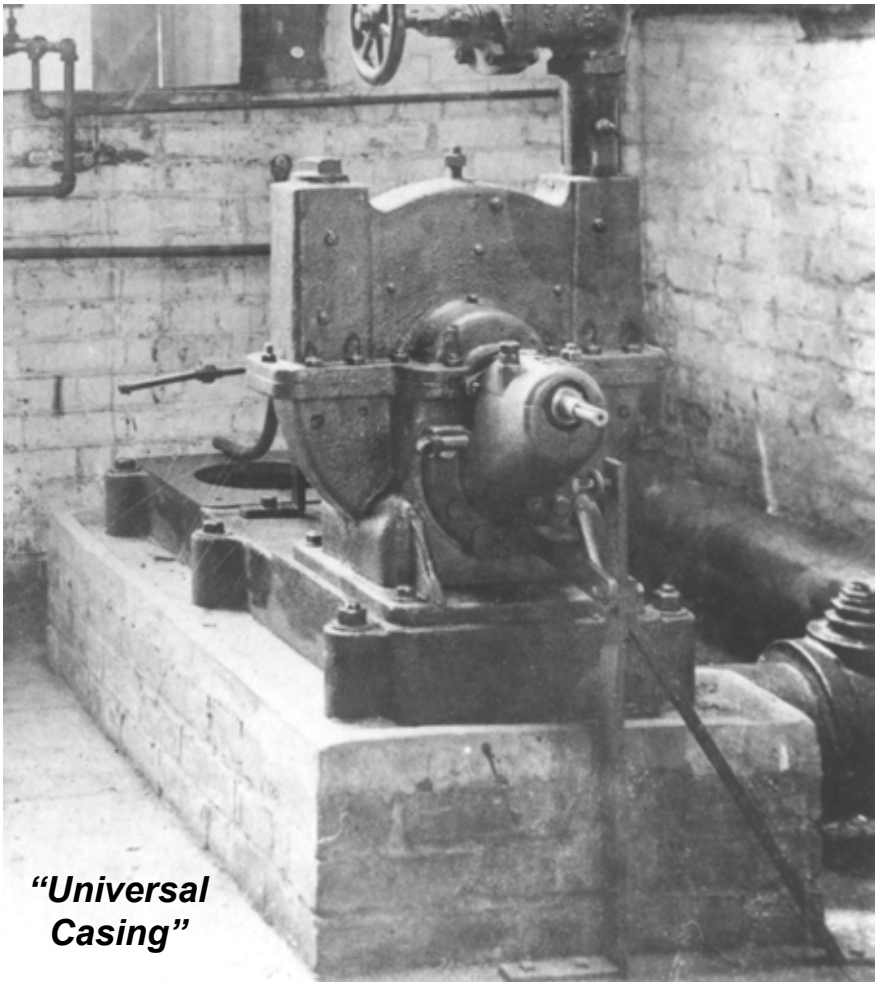
See Also p.34

Designed by Tesla for the American Pipe and Construction Company. Capacity 3,500 G.P.M. Manufactured by the American and British Manufacturing Company and sold to the Corliss Steam Engine Works foundary in Providence R.I.

600 HP Tesla Turbo-Pump



Tesla Single Disc Hydraulic Speed Feedback Pump



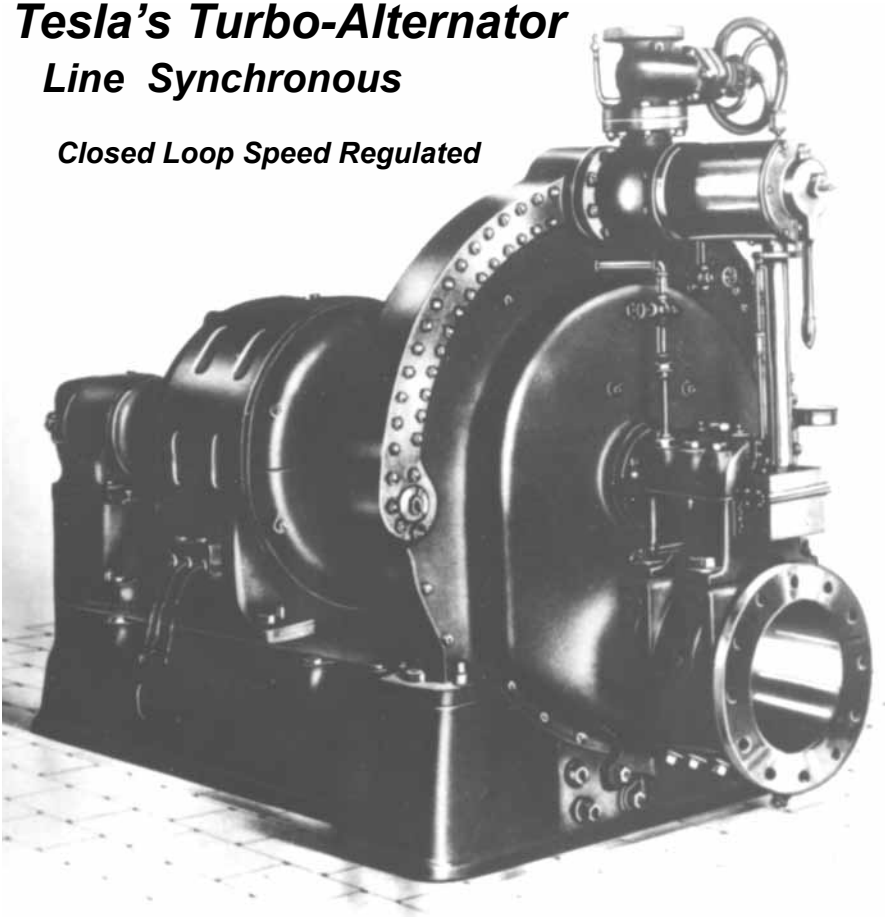
***Original Tesla
Turbine or Pump***

Transformed, by the activation of a lever, into a turbine or pump by changing case geometries

Tesla's Turbo-Alternator

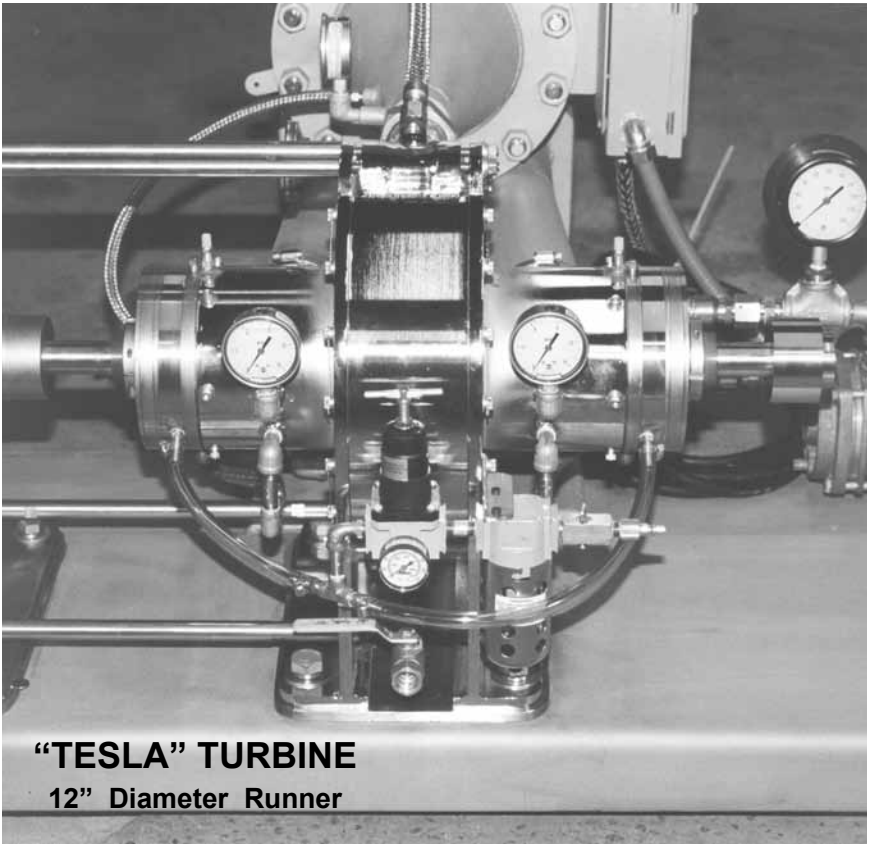
Line Synchronous

Closed Loop Speed Regulated



All attempts to considerably extend the range have failed chiefly because of the inability of bucket strutures to withstand the action of intense heat.

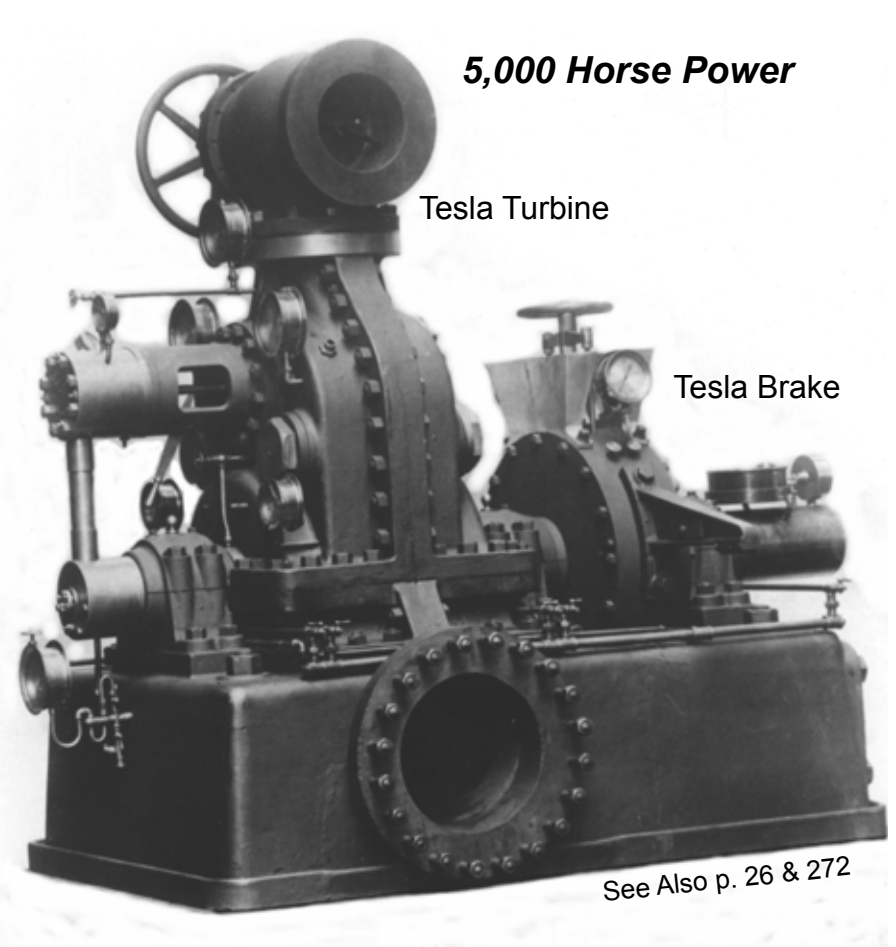
Nikola Tesla



"TESLA" TURBINE
12" Diameter Runner

"The most economical of the present prime movers is the Diesel engine. But, quite apart of many practical and commercial drawbacks, inseparable from this type, it is entirely dependent on comparatively expensive oil, so that the Tesla Gas Turbine, working with much cheaper fuel, would have the better in competition even if its efficiency as a thermodynamic transformer were appreciably lower, all the more so in view of its greater mechanical perfection."

Nikola Tesla



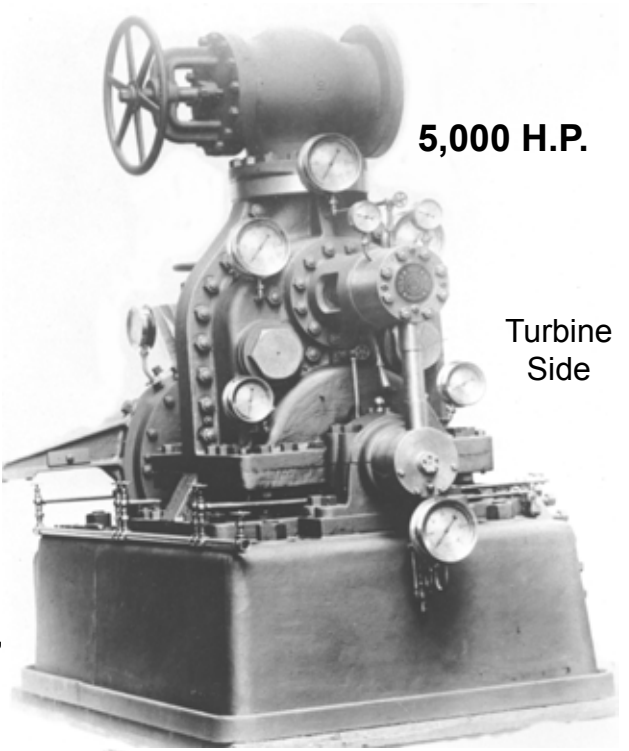
See Also p. 26 & 272

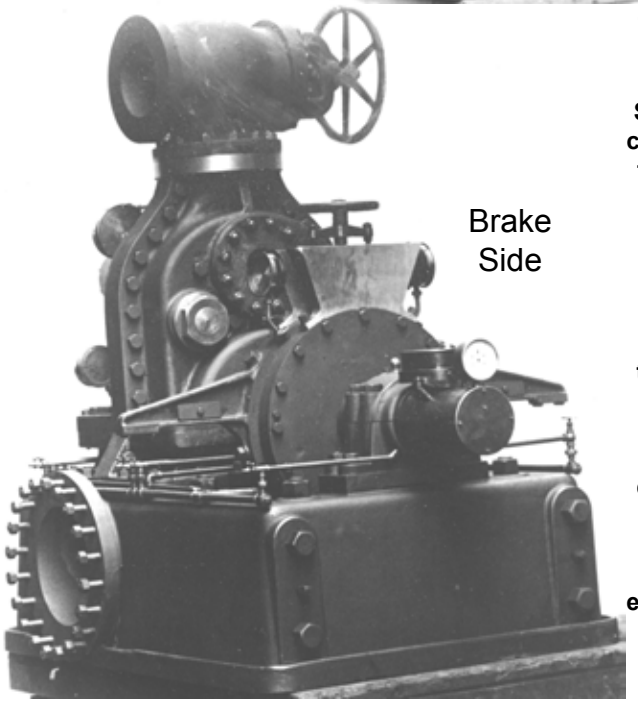
THE TESLA STEAM TURBINE

Working circuit diameter of 25 inches, 5,000 HP, designed especially for demonstration at the German Patent Bureau. The turbine was manufactured in the workshop of De La Vergne Company in New York, the whole project financed by Bergmann Elektricitats Werke in Berlin Ca. 1916

"Although its practical introduction has been delayed by the force of circumstances, a number of years have been spent in exhaustive investigations and experiments on the basis of which the performance in any given case can be closely calculated. The first public tests were made before the outbreak of the war (WWI) at the Waterside Station of the New York Edison Company where several machines, ranging from 100 to 5,000 h.p., were installed and operated with satisfactory results."

Nikola Tesla





The Tesla Brake is a unique form of Torque Converter. Similar in nature to conventional bladed torque converters, which have made the automatic transmission possible, having a primary set of blades (turbine), transferring power to a secondary set of blades (pump), In Tesla's device blades now become primary and secondary set of discs with elimination of all the disadvantages of the blades.

See Page 329

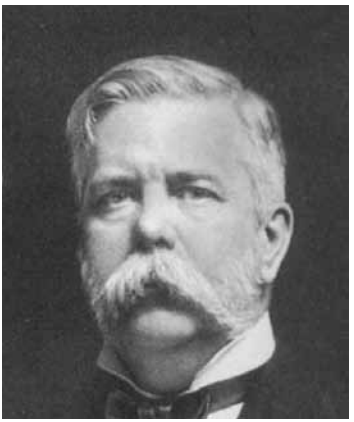
September 20, 1924 ELECTRICAL WORLD

EARLY DAYS IN THE WESTINGHOUSE SHOPS

Making the acquaintance of alternating current and its apparatus—How Stanley, Shallenberger, Tesla, Lamme and Westinghouse himself impressed a young engineer in 1888

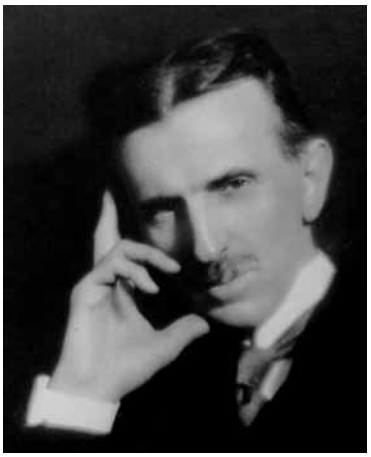
by Charles F. Scott

Professor of Electrical Engineering, Yale University



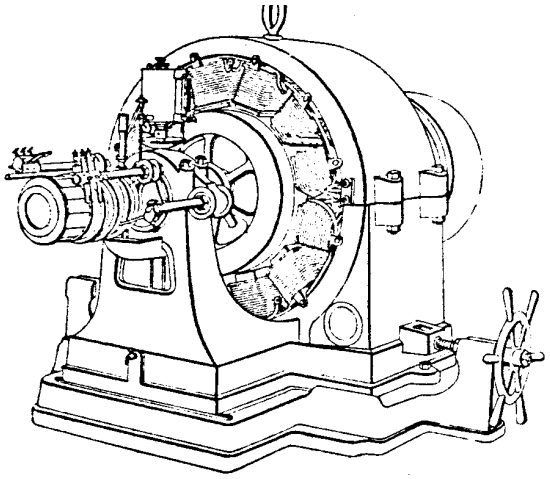
George Westinghouse

The request to tell of the early days in the Westinghouse shops awakens a flood of precious memories. To the youthful newcomer who knew far less of industry and of electricity then he then realized, the incidents and experiences and associates of those days meant much, although they may now seem of trivial consequence to others. But those were the days when electrical engineering was in its beginning. The alternator, the transformer, the polyphase motor—the elements which soon became the controlling factors in shaping the trend of electric power development—were then truly in their infancy, and their cradle was the Westinghouse shops.



Nikola Tesla

In the summer of 1887 I first saw an alternator and a transformer and learned that there was such a thing as an alternating current. I had been graduated from college two years earlier, and I wondered why I had not heard of these things from my professor. Later I learned why; the Gaulard and Gibbs "secondary generators" (transformers) were first brought to this country by Mr. Westinghouse less than two years earlier (September, 1885). The apparatus had been tested, the system had been changed from series connection of primary



Earliest Alternating-Current Generator

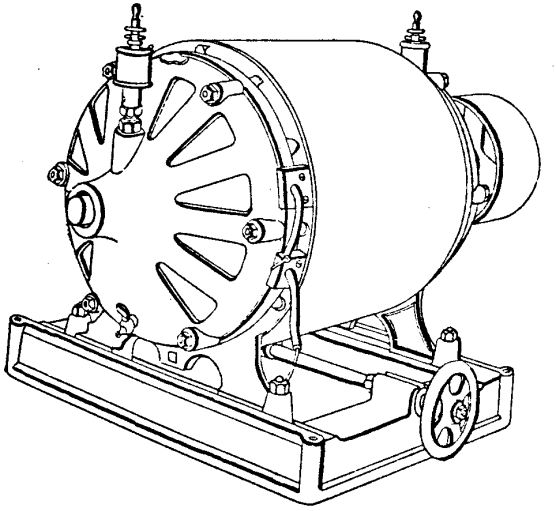
coil to parallel connection, transformers and alternators of radically new form had been designed and constructed, and numerous plants were in operation when I got a job as wireman at the Baldwin Locomotive Works, where a plant with four 35-kw., 1,000-volt alternators was being installed. I was unable to find out very much about the principles involved in the new system until I read in the ELECTRICAL WORLD a few months later an article by William Stanley. His simple story of alternations and induction and lag and power factor was fascinating, and for me it was the key to many mysteries.

In the following summer (1888) I reached my mecca—the Westinghouse shops. They were on the Allegheny River, about ten minutes' walk from the Pennsylvania station, and there were, I presume, about three or four hundred employees. The principal products were alternators and transformers and accessories for equipping central stations for supplying incandescent lighting. The three-wire direct-current system, with its limited radius of distribution of a half mile or so, was well established in the centers of cities, but could not reach the outlying districts. Unelectrified towns naturally preferred the alternating system, which could supply the whole area. Hence a bitter commercial competition with violent attacks on the alternating system and dire predictions as to its future.

I began as helper in the testing room at night, keeping the field current adjusted on the alternator during its full-load run and measuring the temperature about daybreak. Incidentally there were oil cups to keep filled, brass work to be polished and floors to be swept. The most prevalent alternator was the "750-light" size (35 kw.), and there were others twice as large and occasionally one four times the size which appeared for test. The output averaged a little more than one machine per day, as I now recall, or an annual kilowatt output about equivalent to one medium-sized turbo-generator of today. These machines had cast-iron poles and

rotating armatures with smooth cores on which there was a single layer of wire held in place by band wires.

Transformers were of various sizes up to a maximum of forty lights, or 2 kw. The East End station in Pittsburgh was portrayed as a "model lighting plant." A row of single-acting non-condensing engines was belted to a row of alternators. The switchboard had bare bus bars for 1,000 volts, with exposed jaw switches, and there was no insulation except wood. The branch blocks and fuse blocks for house wiring were made of wood. Porcelain insulation and carbon brushes and slotted armatures had not yet arrived.



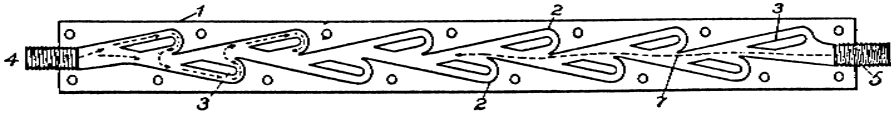
Tesla Starting Motor

The alternating system began with two commercial handicaps—it had no house meter and no motor. The Shallenberger induction meter and the Tesla polyphase motor appeared in the spring of 1888. Both were theoretically difficult but mechanically simple. The first was soon in service on the 133-cycle circuits which were then standard. The motor did not respond to the effort to adapt it to single-phase and high frequency and was a disappointment, but presently the situation was reversed as phases were increased and frequency was lowered to meet the needs of the motor. Today, practically all power is generated and transmitted and nearly all is used as low-frequency polyphase alternating current, as prescribed by the Tesla motor.

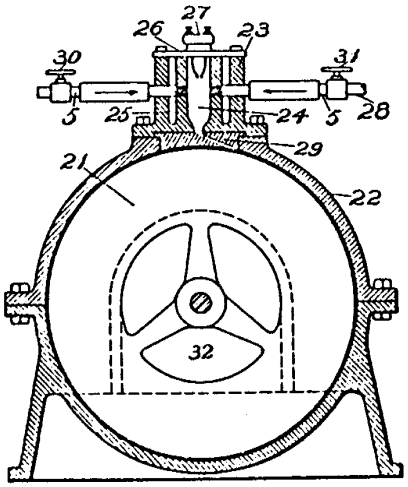
Measuring Instruments

In those early years of alternating-current development there were two laboratory measuring instruments, the Siemens electrodynamometer for current and the Cardew voltmeter. The latter indicated the elongation of a fine wire when heated by current—it took a quarter of an ampere or more for full deflection. Power and power factor involved the simultaneous reading of three dynamometers one with "split connection," which was liable to instrumental errors and did not inspire confidence.

Tesla Engine Valves have No Moving Parts!



The Tesla turbine can be used as a combustion engine, employing individual explosions, in a similar fashion to those that occur in our common piston engines today. This process, in either case, involves bringing air and fuel into a chamber and then igniting it. The chamber must be sealed so that the expansive energy of the explosion is not dissipated but is instead directed against the piston or in the case of the Tesla engine, into the runner. In the conventional piston engine, this is accomplished using valves that mechanically open and close. This system requires a complicated mechanical or electrical actuation system. It is usually done mechanically using a camshaft, push rods, rocker arms, gears etc. Timing is, of course, a critical factor that introduces other mechanisms and complications.



In the Tesla engine the valve system is completely passive with NO moving parts or timing considerations. The combustion chamber is sealed using a one way, one piece, "Valvular Conduit" with a rectangular housing.

The unique geometry of this conduit, pictured, allows flow to travel easily from right to left but not from left to right. Reverse flow, created by the pressure of an explosion, is turned against itself and "checked."

The valvular conduit has recently been built and tested, performing just as Tesla described, as have preliminary combustion system tests. Unlike conventional check valves, the larger the explosion, the better the action.

Seattle Post - Intelligencer ***Page 1*** ***October 16, 1996***

From an Obscure Genius Comes a Tiny Pump for Computer Age

by Tom Paulson

Engineers at the University of Washington have created a microchip-sized pump with no moving parts, exploiting a 75-year-old patent held by an eccentric Serbian American inventor whose celebrity status was once the equal of Thomas Edison and Albert Einstein.

His name was Nikola Tesla.

Many people, today, scientists and engineers included, have never heard of Tesla. Yet those who do know his work contend he may have had a more profound effect on the modern world than Edison, if not Einstein.

"His impact on the 20th century was phenomenal," said Martin Afromowitz, a UW professor of electrical engineering.

This tiny pump - the size and composition of a computer chip - has no moving parts. It was built by University of Washington engineers using a design patented 75 years ago by the eccentric Serbian American inventor Nikola Tesla.

Most of our electrical power system - based on alternating current - was Tesla's creation. He invented fluorescent light bulbs, held the first patent on radio and in the early part of this century predicted future technologies that sound like cellular phones and the Internet. A basic unit of electromagnetic power is named for him. And that's just the beginning. Tesla's name is on more than 700 U.S. patents.