

## The Lost Inventions of Nikola Tesla

TESLA, Nikola (1856-1943), electrical inventor. Tesla was famous at the turn of the century for inventing the alternating current system still in use today. But his later inventions, documented in some 30 U.S. patents between 1890 and 1921, have never been utilized as Tesla intended despite their obvious potential for advancing in fundamental ways the technology of modern civilization. Among these lost inventions: the disk-turbine rotary engine, the Tesla coil, electric energy magnifier, high-frequency lighting systems, the magnifying transmitter, wireless power, and the free-energy receiver. Born Yugoslavia, 1856. Educated at the polytechnic school at Graz and at University of Prague. Worked as telephone engineer in Prague and Paris. Conceived new type of electric motor having no commutator, as direct current motors have, but works on principle of rotating magnetic field produced by poly phase alternating currents. Constructed prototype. Found nobody interested in Europe. Emigrated to U.S. (1884). Worked briefly and unhappily with Thomas Edison.

Established own lab and obtained patents on poly phase motors, dynamos, transformers for a complete alternating current power system. Formed alliance with George Westinghouse, who bought poly phase patents for \$1 million plus royalty. With Westinghouse, engaged in struggle against Edison to convince public of efficiency and safety of AC over DC, and succeeded in getting Alternating Current accepted as the electric power system worldwide.

Also with Westinghouse, lit the Chicago World's Fair, built Niagara Falls hydropower plant, and installed AC - Alternating Current - systems at Colorado silver mines, and other industries. By turn of the century was lifted to celebrity status comparable to Edison's as media promoted him along with the expanding electric power industry. Experimenting independently in Manhattan lab, developed and patented electric devices based on superior capabilities of high-potential, high-frequency currents: Tesla coil, radio, high-frequency lighting, x-rays, electrotherapy. Suffered lab fire. Rebuilt, and continued. Moved lab to Colorado Springs for about one year (1899). Built huge magnifying transmitter. Experimented with wireless power, radio, and earth resonance. Studied lightning. Created lightning. Returned to New York. With encouragement of financier J.P. Morgan, promoted a World System of radio broadcasting utilizing magnifying transmitters. Built huge tower for magnifying transmitter at Wardencllyffe, Long Island as first station in World System. Received enough from Morgan to bring station within sight of completion, then funds cut off, project collapsed.

Continued to invent into the 1920's, but flow of patents meager compared to earlier torrent, which amounted to some 700 patents worldwide. High-frequency inventions ignored by established technology, as were disk turbine, free energy receiver, and other inventions. Shut out by media except for birthday press conferences. At these conferences, predicted microwaves, TV, beam technologies, cosmic-ray motor, interplanetary communications, and wave-interference devices that since have been named the Tesla howitzer and the Tesla shield. In the 1930's, he was involved in wireless power projects in Quebec. Last birthday media appearance in 1940.

Died privately and peacefully at 87 in New York hotel room from no apparent cause in particular. Personal papers, including copious lab notes, impounded by U.S. Government, surfaced many years later at the "Tesla Museum", in Belgrade, Yugoslavia. Of these notes, only a fragment, "Colorado Springs Notes", has been published by the Museum.

the inventions:

### 1. Disk-Turbine Rotary Engine

Tesla called it a powerhouse in a hat. One version developed 110 h.p. at 5000 RPM and was less than ten inches in diameter. Tesla believed larger turbines could achieve 1000 HP. The disk-turbine rotary engine runs vibration free. It is cheap to manufacture because nothing but the rotor bearings needs to be fitted to close tolerances. It requires little maintenance. If necessary, the rotor can be replaced with ease. The turbine can run on steam, compressed air, gasoline, or oil.

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### How it works

Unlike conventional turbines that use blades or buckets to catch the flow, Tesla's uses a set of rigid metal disks that, instead of battling the propelling stream at steep angles, runs with smooth efficiency in parallel with the flow. What drives the disks is a peculiar adhesion that exists between the surface of a body and any moving fluid. This adhesion, is, in Tesla's words, caused by the shock of the fluid against the asperities of the solid substance (simple resistance) and from internal forces opposing molecular separation (a sticking phenomenon).

The propellant enters the intake and is directed through a nozzle onto the disks at their perimeter. It travels over the spinning disks in a spiral fashion, exiting at the disks' central openings and is exhausted from the casing. Tesla notes in his patent that, in an engine driven by a fluid, changes in the velocity and direction of movement of the fluid should be as gradual as possible. This, he observes, is not the case, though, in existing engines where sudden changes, shocks, and vibrations are unavoidable. The use of pistons, paddles, vanes and blades, notes Tesla, necessarily introduces numerous defects and limitations and adds to the complication, cost of production, and maintenance of the machines.

We who are stuck with the piston engine know this all too well. The Tesla turbine is vibration-free because the propelling fluid moves in natural paths or stream lines of least resistance, free from constraint and disturbance. Conducting the propellant through the intake valve on the other side easily reverses the turbine.

### Internal combustion

A hollow casting is bolted to the top of the turbine for the internal combustion mode. A glow plug or spark plug screws into the top of this chamber. Sticking out of the sides are the intake valves. Interesting thing about these valves, there are no moving parts. They work on a fluidic principle. The Tesla turbines' only moving part is its rotor. Imagine, a powerful internal combustion engine with only one moving part.

### Fluidics

The fluidic valve, which Tesla calls a valvular conduit, allows easy flow in one direction but in the other the flow gets hung up in dead-end chambers (buckets) where it gets spun around 360 degrees, thus forming eddies, or countercurrents that stop the flow as surely as if a mechanical valve were moved into the shut position. The spinning rotor creates plenty of suction to pull fuel and air into the combustion chamber. Tesla notes that after a short lapse of time the chamber becomes heated to such a degree that the ignition device may be shut off without disturbing the established regime. In other words; it diesels. The disk-turbine motor principle in reverse becomes a very efficient pump. (Tesla's Patent No. 1,061,142)

### Fluid drive

The disk turbine principle is employed in the speedometer, which presents the problem of having to turn the rotary motion of a vehicles wheels to angular motion in order to push a spring-loaded indicator needle over a short arc. Tesla's solution: the speedometer cable connects to a disk which spins in interface with a second disk, imparting spin to the fluid in between and, hence, to the second disk which moves the needle. Interface two disks of different sizes in a fluid medium and any desired ratio between speeds of rotation may be obtained by proper selection of the diameters of the disks, observes Tesla in his patent, thus anticipating in 1911 the fluid-drive automatic transmission.

Tesla First worked on his turbine early in his career, believing it would be a good prime mover for his alternating-current dynamos, far superior to the reciprocal steam engines that were the workhorses of that era. But he did not get down to perfecting and patenting it until after the collapse of his global broadcasting scheme (1909). By this time the internal-combustion piston engine was firmly rooted in

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Western power mechanics. Tesla referred to organized opposition to his attempts to introduce the superior engine, and so have others who have made the attempt since. But Tesla still saw a glorious future for his turbine. To his friend, Yale engineering professor Charles Scott, Tesla predicted, "My turbine will scrap all the heat engines in the world." Replied Scott, "That would make quite a pile of scrap."

### 2. Spark-Gap Oscillator:

Tesla was central in establishing the 60 cycle alternating current power system still in use today. Yet he suspected that the more striking phenomena resided in the higher frequencies of electric vibration. To reach these heights, he first tried dynamos spun at higher speeds and having a greater number of poles than any that had existed before. One having as an armature a flat, radially grooved copper disk achieved 30,000 cycles, but Tesla wanted to go into the millions of cycles.

It occurred to him that this vibratory capability was to be found in the capacitor. With a capacitor circuit, the spark-gap oscillator, he did indeed achieve the higher frequencies, and he did so by non mechanical means. The circuit was promising enough for him to patent it as A Method of and Apparatus for Electrical Conversion and Distribution, for Tesla saw in it the possibility of a whole new system of electric lighting by means of high frequencies. Though it was quickly succeeded by the Tesla coil and is not numbered among the more famous of the lost inventions, the spark-gap oscillator is pivotal for Tesla as the invention that launched him into his career in high frequencies.

#### How it works

The capacitor. There are only a few basic building blocks of electrical circuitry. The capacitor is one of them. Tesla didn't invent it, it had been around for some time, arguably for millennia, but he did improve upon it in three of his patents. Also called condenser, the common capacitor is just a sandwich of conductive and nonconductive layers that serves the purpose of storing electrical charge. The simplest capacitor has just two conductive sheets separated by a single sheet of insulation. In the capacitor shown, the conductive elements are two metal plates.

The insulation between them is oil. In the official vocabulary, the plates are indeed called plates and the insulative layer (oil, glass, mica, or whatever) is called the dielectric. Connect the two terminals of a capacitor into a circuit where there is plus-minus electrical potential, and charge builds on the plates, positive on one, negative on the other. Let this charge build for a while, and then connect the two plates through some resistance, a coil, say, and the capacitor discharges very suddenly. Tesla said, The explosion of dynamite is only the breath of a consumptive compared with its discharge. He went on to say that the capacitor is the means of producing the strongest current, the highest electrical pressure, the greatest commotion in the medium.

The capacitor's discharge is not necessarily a single event. If it discharges into a suitable resistance, there is a rush of current outward, then back again, as if it were bouncing off the resistance, then out, and back and so forth until it peters out. The discharge is oscillatory, a vibration. The vibration can be sustained by recharging the capacitor at appropriate intervals. When Tesla talks of the capacitor's discharge causing commotion in the medium, he means a vibration or mix of vibrations. The character of this vibration is determined in part by the capacity of the capacitor, that is, how much charge it will hold. This is a function of its size, the distance between plates, and the composition of the dielectric. Upon discharge there would be, typically, a fundamental vibration, some harmonics, and perhaps other commotion, maybe musical, maybe not. Additional circuitry can tame the vibration to a pure tone.

#### The medium

When Tesla speaks of commotion in the medium, what is the medium? In Tesla's time it was an article of faith that there existed a unified field that permeated all being called the ether. The ether as the electric medium still is an article of faith in some circles, but in official science its existence is presumed

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to have been disproved in the laboratory. Nevertheless, this conviction about an ether ran very deep, not only among scientists but among all thinkers, until only about forty-some years ago when particle theory,  $E=MC^2$ , and, finally Hiroshima firmly established the new faith. Tesla said the electron did not exist.

The materialistic concept of these little particles running through conductors is alien to Tesla electric theory. Here is the Quaker writer Rufus Jones on the ether in 1920: An intangible substance which we call ether - luminiferous (light-bearing) aether - fills all space, even the space occupied by visible objects, and this ether which is capable of amazing vibrations, billions of times a second, is set vibrating at different velocities by different objects. These vibrations bombard the minute rods of the retina... It is responsible also for all the immensely varied phenomena of electricity, probably, too of cohesion and gravitation...

The dynamo and the other electrical mechanisms, which we have invented do not make or create electricity. They merely let it come through, showing itself now as light, now as heat, now again as motive power. But always it was there before, unnoted, merely potential, and yet a vast surrounding ocean of energy there behind, ready to break into active operation when the medium was at hand for it. Jones, who was not a scientist but a religious thinker and communicator, was making a point about the nearness of God's power and could do so by invoking the physics of his time. This would be difficult using the Einsteinian physics in fashion today, which W. Gordon Allen has called atheistic science.

Although the ether is intangible, it is assumed to have elastic properties, so that Tesla can say a circuit with a large capacity behaves as a slack spring, whereas one with a small capacity acts as a stiff spring vibrating more vigorously. This elastic character of the ether, which you experience palpably when you play with a pair of magnets, is due to the medium's lust for equilibrium. Distorted by electrical charge (or by magnetism or by the gravity of a material body), the ether seeks to restore a perfect balance between the polarities of positive-negative, plus/minus, yang/yin.

Voltage is the measure of ether strain or imbalance, called potential difference, or just potential. Balance is not restored from this strained condition in one swing-back. As we have seen with the capacitor, the disturbed electric medium, like a plucked guitar string, over-swings the centerline of equilibrium to one side, then to the other, again and again, and this we know as vibration. In this way of looking at nature, vibration is energy; energy is vibration. So you could say that the commotion in the medium caused by the capacitors discharge is energy itself.

Thus, you can speak of the capacitor as an energy magnifier. Even though a feeble potential may charge it, the sudden blast of the capacitor's release plucks the medium mightily. The capacitor is common in modern circuitry, but Tesla used it with much greater emphasis on its capability as an energy magnifier and on a scale almost unheard of today. It's difficult to find commercial capacitors that meet Tesla specifications. Builders of tesla coils and other high-voltage devices usually must construct their own capacitors. Fortunately, this can be done using readily available materials.

## How it works

The spark gap: A simple way to discharge a capacitor is through a spark gap. The spark-gap oscillator is just a capacitor firing into a circuit load (lamps or whatever) through the spark gap. The opening between the spark-gap electrodes determines when the capacitor will fire. This setting is one determinant of the frequency of the circuit.

The others are capacity and the reactance, or bounce characteristics, of the load. The potential needed to bridge the gap is in the tens of thousands of volts. It takes a potential of about 20,000 volts to break down the resistance of just a quarter of an inch of air. The gap doesn't necessarily have to be air. Tesla has referred to a gap consisting of a film of insulation. A spark gap is a switching device, a semiconductor in fact. But the spark gap is problematic, particularly the common two-electrode air-gap version. Heating and ionizing of the air cause irregularities in conduction and premature firing.

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This arcing must be quenched. It can be to a great degree by using a series of small gaps instead of one larger one, or by using a rotary gap. Tesla also immersed the gap in flowing oil, used an air blowout, and even found that a magnetic field helps to quench. For the gap Tesla substituted high-speed rotary switches, which he called circuit controllers. One has a rotor that dips into a pool of mercury, and another uses mercury jets to make contact. You can operate a spark gap without a capacitor by connecting it directly to a source of sufficient voltage.

This is, of course, how our automotive spark plugs work, directly off the coil. (The capacitor in that circuit is used to juice the ignition coil primary.) The auto distributor, incidentally, is a rotary gap, pure Tesla. Early radio amateurs used spark-gap oscillators as transmitters. The capacitor was, more often than not, left out of the circuit, but with it the transmitter could create a greater commotion in the medium.

### 3. Tesla Coil

Tesla's best-known invention takes the spark-gap oscillator and uses it to vibrate vigorously a coil consisting of few turns of heavy conductor. Inside of this primary coil sits another secondary coil with hundreds of turns of slender wire. In the Tesla coil there is no iron core as in the conventional step-up transformer, and this air-core transformer differs radically in other ways. Recounting the birth of this invention, Tesla wrote, Each time the condenser was discharged the current would quiver in the primary wire and induce corresponding oscillations in the secondary. Thus, a transformer or induction coil on new principles was evolved. Electrical effects of any desired character and of intensities undreamed of before are now easily producible by perfected apparatus of this kind. Elsewhere Tesla wrote, There is practically no limit to the power of an oscillator.

The conventional step-up transformer (short primary winding, long secondary on an iron core) boosts voltage at the expense of amperage. This is not true of Tesla's transformer. There is a real gain in power. Writing of the powerful coils he experimented with at his Colorado Springs lab, coils with outputs in excess of 12 million volts, Tesla wrote, It was a revelation to myself to find out that ... a single powerful streamer breaking out from a well insulated terminal may easily convey a current of several hundred amperes! The general impression is that the current in such a streamer is small.

#### How it works

A Tesla coil secondary has its own particular electrical character determined in part by the length of that slender coiled wire. Like a guitar string of a particular length, it wants to vibrate at a particular frequency. The secondary is inductively plucked by the primary coil. The primary circuit consists of a pulsating high-voltage source (a generator or conventional step-up transformer), a capacitor, a spark gap, and the primary coil itself. This circuit must be designed so that it vibrates at a frequency compatible with the frequency at which the secondary wants to vibrate.

The primary circuit's frequency is determined by the frequency and voltage of the source, the capacity of the capacitor, the setting of the spark gap, and the character of the primary coil, determined in part by the length of its winding. Now when all these primary-circuit components are tuned to work in harmony with each other, and the circuit's resulting frequency is right for plucking the secondary in a compatible rhythmic manner, the secondary becomes at its terminal end maximally excited and develops huge electrical potentials, which if not put to work, boil off as a corona of bluish light or as sparks and streamers that jump to nearby conductors with crackling reports.

Unlike the conventional iron-core step-up transformer, whose core has the effect of damping vibrations, the secondary of the Tesla transformer is relatively free to swing unchecked. The pulsing from the primary coil has the effect of pushing a child in a swing. If it's done in a rhythmic manner at just the right moment at the end of a cycle, the swing will oscillate up to great heights. Similarly, with the right timing, the electrical vibration of the secondary can be made to swing up to tremendous amplitudes, voltages in the millions. This is the power of resonance.

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### Manmade earthquake

Tesla was fascinated with the power of resonance and experimented with it not only electrically but on the mechanical plane as well. In his Manhattan lab he built mechanical vibrators and tested their powers. One experiment got out of hand.

Tesla attached a powerful little vibrator driven by compressed air to a steel pillar. Leaving it there, he went about his business. Meanwhile, down the street, a violent quaking built up, shaking down plaster, bursting plumbing, cracking widows, and breaking heavy machinery off its anchorage. Tesla's vibrator had found the resonant frequency of a deep sandy layer of subsoil beneath his building, setting up an earthquake.

Soon Tesla's own building began to quake, and, just at the moment the police burst into the lab, Tesla was seen smashing the device with a sledgehammer, the only way he could promptly stop it. In a similar experiment, on an evening walk through the city, Tesla attached a battery-powered vibrator, described as being the size of an alarm clock, to the steel framework of a building under construction and, adjusting it to a suitable frequency, set the structure into resonant vibration. The structure shook, and so did the earth under his feet.

Later Tesla boasted that he could shake down the Empire State Building with such a device, and, as if this claim were not extravagant enough, he went on to state that a large-scale resonant vibration was capable of splitting the Earth in half. No details of Tesla's vibrators are available, but they probably resembled one of Tesla's reciprocating engines (such as Patent No. 511,916). These exploited the elasticity of gases, just as his electrical vibrators, like the Tesla coil, exploit the elasticity of the electric medium.

### A new power system

Tesla invented his resonant transformer, as the Tesla coil is sometimes called, to power a new type of high-frequency lighting system, as his 1891 patent drawing shows. This was the first Tesla coil patent. There followed a series of other patents developing the device. All of these are for bipolar coils: both ends of the secondary are connected to the working circuit (usually lamps), as opposed to the mono polar format favored by today's basement builders in which the top is connected to a ball or other terminal capacitor, the bottom to ground. The mono polar format emerges later in patents for radio and wireless power, including Tesla's magnifying transmitter.

The 1896 patent drawing shows an evolved bipolar coil using tandem chokes to store energy for sudden release into the capacitor, enabling the device to be powered by relatively modest inputs. Chokes are coils wound on iron cores. They store energy as magnetism. When the charging current is interrupted, the magnetic field collapses inducing current in the coils, which rushes in to charge the capacitors.

### Superconductivity

Alternating currents can be sent over long distances with relatively low losses. This is why Tesla's early 60-cycle system triumphed over Edison's direct current. The high frequency, high-potential output of a Tesla coil can travel over relatively light conductors for vastly greater distances than conventional 60-cycle AC. Losses occur to some degree from corona discharge but hardly at all from ohmic resistance. This type of current also renders conductive materials that are normally nonconductive, rarefied gases, for example. You might say these currents make a medium superconductive.

Although super-magnetism is not in the picture because high-frequency vibrations would be severely damped by an electromagnet's iron core, it is revealing to reflect upon the unexploited superconductivity of Tesla energy these days when science is congratulating itself on new advances in the field. Prior to recent breakthroughs, superconductivity and super magnetism were low-temperature (cryogenic) phenomena, occurring when circuits were cooled down to near absolute zero. The new

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superconductivity at less drastically reduced temperatures developed out of the cryogenic work of the last twenty years, and this may be in debt to Tesla, who patented a similar idea way back in 1901.

Tesla's patent shows that the deep cooling of conductors with agents like liquid air results in an extraordinary magnification of the oscillation in the resonating circuit. Imagine the performance of a super cooled Tesla coil. No electrocution. Since we tend to associate high voltage with possibly fatal electric shock it may be puzzling to learn that the output of a well-tuned Tesla coil, though in the millions of volts, is harmless. This is customarily thought to be because the amperage is low (it's not) or it's explained in terms of something called the skin effect, which means that the current travels over you instead of through. But the real reason is a matter of human frequency response. Just as your ears cannot respond to vibrations over about 30,000 cycles, or the eyes to light vibrations at or above ultra violet, your nervous system cannot be shocked by frequencies over about 2,000 cycles.

## Electrotherapy

Now that you know it's harmless, would you believe these currents are even good for you? Fact is that a whole branch of medicine was founded on the healing effects of certain Tesla coil frequencies. Tesla understood the therapeutic value of high-frequency vibrations. He never patented in the area but did announce his findings to the medical community, and a number of devices were patented and marketed by others.

Patients, by focusing certain frequencies on afflicted areas, or, in some cases, just sitting in the vicinity of vibrations from a device like the Lakhovsky Multi wave Oscillator, which produced a blend of specific frequencies, were said to have experienced relief from rheumatism and other painful conditions. It was even considered a cure for certain types of paralysis. Such radiation's increase the supply of blood to the area with a warming effect (diathermy). They enhance the oxygenation and nutritive value of the blood, increase various secretions, and accelerate the elimination of waste products in the blood. All this promotes healing. Electrotherapists even spoke of broadcasting vitamins to the body. Reversals of cancer tumor growths have been documented. Lakhovsky predicated science will discover, some day, not only the nature of microbes by the radiation they produce, but also a method of killing disease within the body by radiation.

Electrotherapy devices were sold directly to the public via ads in popular magazines and in the Sears catalogs. Self-treatment was widespread. This easy access to treatment of all sorts of conditions led to the eventual suppression of the technology by the medical establishment. Electrotherapy, however, is making a big comeback. In chiropractic and sports medicine, low-frequency AC and DC pulses are being used to kill pain and exercise muscles. High-frequency electrotherapy is coming back in alternative healing practices. There is an increasing appreciation of the electrical nature of biological functioning and that some electric vibrations in the environment are harmful while others are healing. Reprints of Lakhovsky's works are widely read. There is a growing conviction that cancer can be effectively treated with high-frequency therapies.

In his experimenting over an eight-year period, Tesla made no fewer than 50 types of oscillating coils. He experimented with lighting and other vacuum effects, including x-rays. He also experimented with novel shapes for the normally cylindrical coils, getting satisfying results from cone shapes and flat spirals. At Colorado Springs Tesla achieved phenomenally increased outputs by using a third coil resonantly tuned to the secondary. Observing the tremendous magnification this achieved, he gave much of his attention to integrating this extra coil, as he called it, into an evolved outsize tesla coil called the magnifying transmitter.

## 4. Magnifying Transmitters; Wireless Power

In 1893 Tesla told a meeting of the National Electric Light Association that he believed it practical to disturb, by means of powerful machines, the electrostatic conditions of the earth, and thus transmit intelligible signals, and, perhaps, power. He said, It could not require a great amount of energy to produce a disturbance perceptible at a great distance, or even all over the surface of the earth. The

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ultimate powerful machine for these tasks is Tesla's magnifying transmitter.

### How it works

An extra coil gives the resonant boost of a Tesla coil secondary but has the advantage of being more independent in its movement. A secondary, being closely slaved to the primary, is inhibited somewhat by it, its oscillations slightly damped. The extra coil is able to swing more freely. Extra coils, writes Tesla, enable the obtainment of practically any EMF, the limits being so far remote that I would not hesitate to produce sparks of thousands of feet in this manner.

The engineering challenge of the magnifying transmitter, then, becomes one of containing and properly radiating its immense electrical activities, measured in the tens and even hundreds of thousands of horsepower, as Tesla put it. Containment and effective radiation of this power is the whole point of the design shown, for which Tesla applied for patent in 1902. The heavy primary is wound on top of the secondary at the base of the tower. The extra coil extends upward through a hooded connection to a conductive cylinder.

The antenna is a toroid, a donut-shaped geometry that allows for a maximum of surface area with a comparative minimum of electrical capacity. Since this is a high-frequency device, a relatively low capacity is desirable. To increase the area of the radiating surface, the outside of the toroid is covered with half-spherical metal plates. A subtlety of the design is that the conductive cylinder is of larger radius than the radius of curvature of these plates, since a tighter curve would allow escape of energy. The cylinder is polished to minimize losses through irregularities in the surface. At the center of the top surface sits a pointy plate that serves as a safety valve for overloads so the powerful discharge may dart out there and lose itself harmlessly in the air.

Tesla advises bringing the power up slowly and carefully so pressure does not build at some point below the antenna, in which case a ball of fire might break out and destroy the support or anything else in the way, an event that may take place with inconceivable violence. Current in the antenna could build to an incredible 4000 amperes.

### A.C. / D.C.

Wireless power transmission via the magnifying transmitter was the ultimate development of the inventor who had earlier brought alternating-current power to the world with his poly phase system. The predecessor of A.C. was a direct-current system developed, manufactured, and marketed chiefly by Thomas Edison. Direct current was adequate for serving small areas but was unworkable for long distance transmission. By contrast, A.C. could be transmitted for long distances over lighter wires and its voltage could be stepped up for transmission and down for consumption by means of transformers. Tesla invented from scratch a new kind of motor (poly phase) that could utilize A.C., and he greatly evolved earlier concepts of dynamos to generate A.C. as well as transformers to step voltage up and down. Whereas Edison's D.C. would have been suitable for a society of small, autonomous communities, the evolving system of industrial rule wanted centralized power and needed A.C.'s long distance capability to serve huge sprawling populations.

George Westinghouse, an inventor (the air brake) who, like Edison, turned industrialist (having found that to profit from an invention one must undertake manufacturing and marketing as well) saw the promise in Tesla's poly phase inventions and formed an alliance with the young prodigy. Westinghouse paid Tesla one million dollars and contracted to pay a royalty of one dollar per horsepower for the poly phase inventions. Later Westinghouse was forced to renege on the royalty.

Together, Westinghouse and Tesla triumphed over Edison's D.C. system and installed the first A.C. power facilities, the most notable being the hydra plant at Niagara Falls. Tesla believed in hydropower. His ultimate energy-magnifying, wireless power system would have been hydro-based. The centralized A.C. electric power system we have today was forced into existence on a colossal scale by utility

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magnates of that era, the most prominent being Samuel Insull, who became infamous in some circles for his massive bilking of the investing public and famous in others for hammering together the electric power complex now in place. This complex has developed into a federally protected monopoly with greater capital wealth than any other industry in the U. S. In the order of energy sources used, Tesla's hydropower has been left well behind the burning of fossil fuels, a process that dumps 24 million tons of pollutants into the nation's air supply each year.

Hydropower even runs way behind the nukes in kilowatt-hours produced. So went another Tesla dream. Tesla was a celebrity in his poly phase heyday, but today his celebrity is as an underground cult figure known for his radically progressive energy-magnifying, free-energy, and wireless power inventions, which, of course, have no place in the established system.

### Power by wire

Prior to his wireless power inventions, Tesla patented in 1897 a high frequency system that transmitted power by wire. The system used previously unheard of levels of electric potential. He notes that at these voltages, conventional power would destroy the equipment, but that his system not only contains this energy but is harmless to handle while in use. This system is not a circuit in the usual sense but a single wire without return. It employs the familiar Tesla coil configurations at both sending and receiving ends. The primary circuit (power source, capacitor, spark gap) is represented in the drawing by the generator symbol. The secondary coil is a flat spiral. An advantage in this coil design is that the voltage adjacent to the primary, where arcing across could occur, is at zero and soars to high values as the coil spirals inward. The same patent also shows a cone-shaped secondary in which the primary is at the base of the cone, which is at zero potential.

### Wireless power

The drawing for Tesla's wireless power patent looks like the earlier power-by-wire patent except now spherical antennas replace the transmission lines, which are dropped out of the picture almost as if they were redundant. The ball antenna is peculiarly Tesla, as is the toroid, and you wonder why nothing like them have appeared since. In this 1900 patent, wireless power is not represented as an earth-resonant system. Here Tesla talks about transmission through elevated strata. The patent contains much discussion of how rarefied gases in the upper atmosphere became quite conductive when there is applied many hundred thousand or millions of volts. Balloons are suggested to send the antennas aloft. Appreciate that Tesla in this patent has invented nothing less than the principles of radio.

Tesla recognizes only a quantitative difference between sending radio signals and broadcasting electric power. Both involve sending and receiving stations tuned to one another by means of tesla coil circuits. Tesla's wireless power would be the ultimate centralized electric system, a capitalist dream, but for the fact that the technology is too simple. Just raising an antenna, planting a ground, and connecting simple Tesla coil circuitry in between could achieve reception of power.

Although Tesla himself patented a couple of electric meters for high frequencies, it would be all too easy for consumers to tune in for free, just as many today bootleg pay TV signals using illicit equipment far more sophisticated. It is no wonder, then, that the electric power establishment didn't welcome this invention. This was one problem. Another was that the established electric power system would have to be relegated to another great pile of scrap, and maybe the established system of political power as well.

Tesla's announced dream was to use hydra sources where available and through wireless power broadcast that energy around the planet, thus liberating the world from poverty. Such a scheme would not be readily embraced by powers that sustain their rule by keeping populations poor and weak. Centralized control of energy, as well as other resources, is, of course, believed to be essential to civilized rule, at least as far as thinking on that subject has progressed in this era. Moreover, no multinational political system was in existence, or is now for that matter, that could implement a technology of such global implications. Tesla was blind to such considerations.

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His commitment, his overriding priority as a technological purist, was to take machine possibilities to their logical conclusions. Today, if wireless power were seriously proposed, there would no doubt be at least one political problem that would not have arisen in Tesla's time: resistance from environmentalists. What would an environmental impact report have to say about biologic hazards? A Navy submarine communication system that uses extremely low frequency (ELF) waves, down to below 10 cycles, has been challenged by environmentalists, as have microwave and 60 cycle high-voltage transmission lines.

## Engineering details

Patents normally don't give many quantitative specifics, but Tesla's wireless power patent does give some about the big prototype power-transmission Tesla coil (which was, incidentally, used to conduct a demonstration before skeptical patent examiners). A 50,000-volt transformer charged a capacitor of .004 mfd., which discharged through a rotary gap that gave 5,000 breaks per second. The eight-foot diameter primary had just one turn of stout stranded cable. The secondary was 50 turns of heavily insulated No. 8 wire wound as a flat spiral. It vibrated at 230-250,000 cycles and produced 2 to 4 million volts. This coil evolved into the huge experimental magnifying transmitter

Tesla describes in his Colorado Springs notes. Housed in a specially built lab 110 feet square, the device used a 50,000 volt Westinghouse transformer to charge a capacitor that consisted of a galvanized tub full of salt water as an electrolyte, into which he placed large glass bottles, themselves containing salt water. The salt water in the tub was one plate of this capacitor, the salt water inside the bottles the other plate, and the bottle glass the dielectric. Various capacities were tried, incremental changes being made by connecting more or fewer bottles. A variable tuning coil of 20 turns was connected to the primary, which consisted of two turns of heavy insulated cable that ran around the base of the huge fence like wooden secondary framework. The secondary had 24 turns of No. 8 wire on a diameter of 51 feet. Various extra coils were tried, the final version being 12 feet high, 8 feet in diameter, and having 100 turns of No. 8 wire.

The antenna was a 30-inch conductive ball adjustable for height on a 142-foot mast. The huge transmitter could vibrate from 45 to 150 kilocycles. Even with the big transformer, this bill of materials does not seem inaccessible to enterprising people, and the technology does not seem so abstruse, so it is no wonder that people have gotten together to build magnifying transmitters and experiment with wireless power without support from corporations or government.

One such group was the People's Power Project in central Minnesota in the late 70's. This group, largely farmers, objected to high voltage power lines trespassing on their land and set out to build an alternative. Limited by the sketchy information then available, the project was not successful. Another attempt, called Project Tesla, is being set up in Colorado. Endowed with more precise calculations and more experienced personnel, Project Tesla will try to repeat Tesla's wireless-power experiment and verify his theory by taking measurements at various remote locations.

## Earth resonance

Among the appealing features of Colorado Springs for Tesla was the region's frequent and sensational electrical storms. For Tesla, lightning was a joyous phenomenon. Biographers report that, during storms back East, Tesla would throw open the windows of his New York lab and recline on a couch for the duration, muttering to himself ecstatically. In Colorado Springs he tuned in and tracked lightning storms using rudimentary radio receiving equipment. He thereby determined that lightning was a vibratory phenomenon, which set up standing waves bouncing within the earth at a frequency resonantly compatible with the earth's electrical capacity. This earth-resonant frequency, he reasoned, was the ideal frequency for wireless power transmission, and he tuned his ultimate magnifying transmitter accordingly.

The literature contains various reports on exactly what this frequency is. Some say 150 kilocycles, which would be at the upper range of the Colorado Springs transmitter. Others give frequencies considerably lower, 11.78 cycles, 6.8 cycles, frequencies Tesla's transmitter may have achieved

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harmonically. With reinforcement from the earth resonance, the power would actually increase in the process of transmission.

In one memorable experiment with the Colorado Springs transmitter, Tesla shot from the antenna ball veritable lightning bolts of 135 feet, producing thunder heard 15 miles distant, and, in the process, pulled so many amperes that he burned out the municipal generator. In another experiment he lit up wirelessly, at a distance of 26 miles from the lab, a bank of 10,000 watts worth of incandescent bulbs. Two years after Colorado Springs, Tesla applied for patent for the far more refined magnifying transmitter shown at the opening of this chapter, a patent that was not granted until a dozen years later.

In this patent he no longer speaks of energy broadcast through the upper strata of the atmosphere but of a grounded resonant circuit. Tesla predicted that his magnifying transmitter would prove most important and valuable to future generations, that it would bring about an industrial revolution and make possible great humanitarian achievements. Instead, as we shall see, the magnifying transmitter became Tesla's Waterloo.

### 5. Magnifying Transmitter II ; Grounded Radio:

With the backing of J. P. Morgan, Tesla began, soon after returning from Colorado Springs, the construction of a magnifying transmitter tower at Wardencllyffe, near Shoreham, Long Island. Though closely related to a wireless power propagator and intended for further experimentation in that area, the tower was built specifically as the first station in Tesla's proposed World System of broadcasting. The system was to carry programming for the general public as well as private communications.

Tesla was the first to suggest the broadcasting of news and entertainment to the public; only point-to-point signaling had been experimented with up to then. The fully realized World System was to serve as a multi-frequency wireless interconnects for all existing telephone, telegraph, and stock ticker services around the planet. Exclusivity and noninterference of priority private communications was to be assured by multiplex techniques. The giant transmitter was also to carry a universal time register, navigation beacons, and facsimile transmissions. This was in 1902. As we shall see, Tesla's massive contribution to radio is still largely unrecognized.

The Wardencllyffe tower's rugged wooden structure, designed by Stanford White, stood at 187 feet. It was topped by a mushroom-like terminal 68 feet in diameter. A separate brick building at the foot housed generating and other equipment. The entire project was to cover 200 acres and include housing for 2,000 employees of the facility. Tesla estimated that the tower would emit a wave complex of a total maximum activity of 10 million horsepower. The top of the tower was outfitted with a platform that may have been intended to accommodate powerful ultraviolet lamps, which Tesla could have used for an experimental beam system of electric power transmission that was on his mind. The tower structure and building beneath were built and partially equipped, but they never saw operation.

From: A MUSEUM AT WARDENCLYFFE - THE CREATION OF A MONUMENT TO NIKOLA TESLA

The year was 1900 and following 9 productive months of wireless propagation research in Colorado, Nikola Tesla was anxious to put a mass of new found knowledge to work. His vision focused on the development of a prototype wireless communications station and research facility and he needed a site on which to build. In 1901 he cast his eyes some 60 miles eastward to the north shore village of Woodville Landing. Only six years before the north branch of the Long Island Railroad had opened, reducing travel time to the locality from a horse drawn five hours to less than two. Seeing an opportunity in land development a western lawyer and banker by the name of James S. Warden had purchased 1400 acres in the area and started building an exclusive summer resort community known as Wardencllyffe-On-Sound. With an opportunity for further development in mind, Warden offered Tesla a 200 acre section of this parcel lying directly to the south of the newly laid track. It was anticipated that implementation of Tesla's system would eventually lead to the establishment of a "Radio City" to house the thousands of employees needed for operation of the facility. The proximity to Manhattan and the

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fairly short travel time between the two, along with the site's closeness to a railway line must surely have been attractive features and Tesla accepted the offer.

The Wardenclyffe World Wireless facility as envisioned by Tesla was to have been quite different from present day radio broadcasting stations. While there was to be a great similarity in the apparatus employed, the method in which it was to be utilized would have been radically different. Conventional transmitters are designed so as to maximize the amount of power radiated from the antenna structure. Such equipment must process tremendous amounts of power in order to counteract the loss in field strength encountered as the signal radiates out from its point of origin. The transmitter at Wardenclyffe was being configured so as to minimize the radiated power. The energy of Tesla's steam driven Westinghouse 200 kW alternator was to be channeled instead into an extensive underground radial structure of iron pipe installed 120 feet beneath the tower's base. This was to be accomplished by superposing a low frequency baseband signal on the higher frequency signal coursing through the transmitter's helical resonator. The low frequency current in the presence of an enveloping corona-induced plasma of free charge carriers would have pumped the earth's charge. It is believed the resulting ground current and its associated wave complex would have allowed the propagation of wireless transmissions to any distance on the earth's surface with as little as 5% loss due to radiation. The terrestrial transmission line modes so excited would have supported a system with the following technical capabilities:

Establishment of a multi-channel global broadcasting system with programming including news, music, etc;

Interconnection of the world's telephone and telegraph exchanges, and stock tickers;

Transmission of written and printed matter, and data;

World wide reproduction of photographic images;

Establishment of a universal marine navigation and location system, including a means for the synchronization of precision timepieces;

Establishment of secure wireless communications services.

The plan was to build the first of many installations to be located near major population centers around the world. If the program had moved forward without interruption, the Long Island prototype would have been followed by additional units the first of which being built somewhere along the coast of England. By the Summer of 1902 Tesla had shifted his laboratory operations from the Houston Street Laboratory to the rural Long Island setting and work began in earnest on development of the station and furthering of the propagation research. Construction had been made possible largely through the backing of financier J. Pierpont Morgan who had offered Tesla \$150,000 towards the end of 1900. By July 1904, however, this support had run out and with a subsequent major down turn in the financial markets Tesla was compelled to pursue alternative methods of financing. With funds raised through an unrecorded mortgage against the property, additional venture capital, and the sale of X-ray tube power supplies to the medical profession he was able to make ends meet for another couple of years. In spite of valiant efforts to maintain the operation, income dwindled and his employees were eventually dropped from the payroll. Still, Tesla was certain that his wireless system would yield handsome rewards if it could only be set into operation and so the work continued as he was able. A second mortgage in 1908 acquired again from the Waldorf-Astoria proprietor George C. Boldt allowed some additional bills to be paid, but debt continued to mount and between 1912 and 1915 Tesla's financial condition disintegrated. The loss of ability to make additional payments was accompanied by the collapse of his plan for high capacity trans-Atlantic wireless communications. The property was foreclosed, Nikola Tesla honored the agreement with his debtor and title on the property was signed over to Mr. Boldt. The plant's abandonment sometime around 1911-1912 followed by demolition and salvaging of the tower in 1917 essentially brought an end to this era. Tesla's April 20, 1922 loss on appeal of the judgment completely closed the door to any further chance of his developing the site.

Tesla; the Father of Radio?

As we have seen, Tesla's earliest oscillators were dynamos, but, having determined that he could not reach the higher frequencies by this means, he went on to develop the spark gap oscillator, the Tesla coil, and the magnifying transmitter. But did any of these devices become the first to be used for

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overseas radio transmission? No, ironically, the first commercial overseas transmitter was a 21.8 kilocycle GE Alexanderson alternator operated by RCA, a design evolved straight out of Tesla's early dynamos. Such was Tesla's luck in radio.

Official histories often credit Tesla with the poly phase system and either ignore his later inventions altogether or dismiss them as the work of a crackpot. But among those who have published honest research on the subject, there is one hundred percent consensus that Tesla was cheated out of his rightful place in history, particularly his status as the leading inventor of radio technology.

## Radio simplified

Early radio devices are fascinating and worthy of study if only because they remind us that powerful radio technologies can be so simple and accessible to anyone, the present-day micro complexity notwithstanding. As we have seen, the earliest transmitters in wide use by amateurs were not alternators but spark-gap oscillators. To get on the air all you needed was a battery, a telegraph key, an induction coil, a spark gap, a length of wire as an antenna, and a ground. Of course, the addition of a capacitor juiced it up considerably.

The very earliest experiments in radio receiving used spark gaps as receivers. When you saw an arc across the gap, this was the detection of a disturbance in the medium. This evolved into a detector called a coherer. This is just a horizontal glass tube loosely filled with metal chips (iron, nickel). It is placed in series with a battery and a telegraph sounder, and one side of the coherer goes to the antenna, the other to ground.

The coherer is a switch (a semiconductor, really) that conducts when there is a disturbance of the medium. The more easily conducted radio-frequency energy triggers conduction of this almost conductive material. To get the coherer back to a non conducting state requires a tap that can be accomplished manually or by mechanical linkage to the telegraph sounder. Tesla comes into the technology about here. He improves the coherer by putting it into continual rotation (rotating coherer) so it didn't need a tap to reset.

## Tuned radio

The spark gap transmitter was indiscriminate as to the frequency of the disturbance. It put out a dirty complex of frequencies consisting of a rough fundamental determined by width of gap, together with parasitic oscillations, harmonics splatter what-have-you. The coherer was set off by any disturbance. In Colorado Springs, Tesla used a rotating coherer to track electrical storms. The celebrated Marconi units employed nothing more evolved than this crash method of signaling.

So why is Marconi so famous? It is because, like Edison and Westinghouse, he built up an industry around the invention and made himself famous in the course of promoting his enterprise. Marconi's company was ultimately incorporated into RCA (now incorporated into General Electric). It owed much of its technological development to ideas lifted from the likes of Tesla. Tesla's contribution was nothing less than selective tuning. He set forth the principle of resonantly tuned circuits in his Tesla coil patent of 1896, and the principles of transmitter-receiver tuned circuits a year later in his wireless power patent.

The Tesla coil is a powerful and simple radio transmitter. If the primary circuit is smoothly vibrating well above the audio range, its signal can even be modulated for voice transmission by varying some circuit element.

Tesla's few published notes on modulation describe crude ways of varying spark gaps, but, conceivably, an inductance core mechanically linked to a loudspeaker transducer might modulate the signal with some fidelity. Tesla and his supporters waged a fight for recognition of Tesla as the founder of radio. The struggle was finally won in the Supreme Court, but this did not happen until shortly after Tesla's death.

Tesla was not a theoretician by calling, but he made plenty of observations on the electrical nature of the universe that put him at odds with official theory. In fashion then (and even now) was the theory of Heinrich Hertz, an interpreter of the physics of James Maxwell. Hertz explained radio propagation as transverse waves akin to light. Tesla was convinced that radio disturbances were standing waves in the ether akin to sound. When you drop a pebble into water, the disturbances you see in the form of concentric circles are standing waves.

Both Tesla and Hertz assumed the existence of an aetheric medium, but differed as to its energy transmitting properties. Tesla believed that the ether was a gas like medium, that electric propagation was very much like that of sounds in air, alternate compression's and rarefaction's of the medium, and that Hertzian waves could only take place in a solid medium. Tesla once said that Hertz waves are radiation and that no energy could be economically transmitted to a distance by any such agency. He said, In my system, the process is one of true conduction which can be effected at the greatest distance without appreciable loss.

When quantum physics and particle theory came into vogue, the aetheric medium was dropped out of electric theory altogether, but Hertz's theory was more compatible with the new concepts of propagation and therefore survived. By way of rubbing this in, the unit of frequency, formerly cycles per second (cps), was renamed in honor of Hertz (Hz), while only an obscure unit of magnetic flux density remembers Tesla. It is in respect to Tesla that I have reverted to the old unit in this book. Hertzian radio is straight-line, light-like radiation's that bounce off hills and mountains. Long distance Hertzian transmissions are explained in terms of radiation's bouncing off a radio reflective upper layer called the ionosphere. Tesla thought this was all nonsense and declared in 1919 that Hertzian thinking has stifled creative effort in the wireless art and retarded it for 25 years. Hertzian radio is aerial.

Most of us are conditioned to thinking in terms of aerial radio; the air waves, on the air. Tesla's radio is grounded; the lower end of the energized coil is rooted in the earth. Pure Hertzian radio has no such natural load. Tesla doesn't speak of antennas as such; the element he places aloft is an elevated capacity. Tesla said radio devices should be designed with due regard to the physical properties of this planet and the electrical conditions obtaining in same. Grounded radio is indeed more powerful than the Hertzian aerial. But this is true particularly for the frequencies Tesla was using. The higher frequencies do behave in a Hertzian manner. Yet grounding is all but a lost concept in consumer electronics. Up through the 1940's, AM radio receivers customarily had a terminal one was encouraged to connect to a cold water pipe or other deep earth connection. Ground the chassis of any of today's receivers, and, unless there is some kind of interference coming up through the ground (from fluorescent circuits, light dimmers, which are oscillators, or from the local Tesla coil), you will usually improve signal strength and range.

Among Tesla's contributions to radio was remote control. Tesla demonstrated a radio-controlled boat before crowds at Madison Square Gardens and sent another robot craft 25 miles up the Hudson River. Grounded radio works particularly well through water. Tesla's basic radio tuning tank circuit for receiving (coil plus capacitor between antenna and ground) was, and is, all by itself, a powerful signal amplifier, and a beautifully simple one, at that. But as radio developed over the years, the tank circuit shrank in size and the result was a loss in gain. This was compensated for by the addition of stage upon stage of complex amplification circuitry.

Tesla watched this development with bewilderment. Tesla knew that the most efficient long-distance radio took place in the lower frequencies, especially those close to the earth-resonant frequency. Frequencies well below the AM broadcast band were the favored ham frequencies in the early days prior to World War I. In fact, waves of 600 meters (500 kc) were considered short while considered fairly long were the waves of 1200 meters (25 kc). Like a lot of good real estate, many of these more radio-effective frequencies below the AM broadcast band have been appropriated for military use, but also for navigation beacons, weather stations, and time registers.

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The mind conditioned by Hertzian aerial radio concepts has trouble grasping the idea that signaling can take place without any above-surface antenna, totally through the ground. James Harris Rogers, taking a cue from Tesla, circa World War I, built a radio system in which both sending and receiving antennas were sunk completely into the ground or submerged in bodies of water. He found this system far more effective and far less vulnerable to interference than any aerial radio. Signal strength has been said to be 5,000 times stronger.

The military is on to this, as evidenced in the Navy's ELF and by a U. S. Air Force project underway called Ground Wave Emergency Network. GWEN is a low-frequency communications system designed for use during a nuclear war. The network will have a cross-continent series of 600-foot diameter underground copper screens connected to 300-foot towers reminiscent of Tesla's Wardencllyffe.

Among the advantages of the system is its invulnerability to the effects of the electric pulse sent out by nuclear blasts. Such a pulse fries at one stroke any and all solid-state electronics within its extensive range. (Strong electric vibrations from a Tesla coil or magnifying transmitter have a similar effect on solid state and will scramble or disable such circuitry temporarily or even dud it permanently.) It's revealing that for last-ditch doomsday communications, the government reverts to Tesla's grounded radio.

### J. P. Morgan sinks Tesla

Tesla's ambitious World System came to an end when its principal financier, J. P. Morgan pulled the plug on funding. Morgan, the financial giant behind the formation of many monopolies in railroads, shipping, steel, banking, etc., was a major conduit of European capital into U. S. industrial development in the Robber Baron era. He looms large in Tesla's life. Morgan money was in the Niagara Falls project. He backed Edison, too. It was Morgan's pressure on Westinghouse, whom he also financed, that caused the cancellation of Tesla's dollar-a-horsepower contract and the loss of millions in royalties to Tesla for his poly phase.

When Tesla's lab burned down (arson was suspected), one of Morgan's men promptly arrived with aid, as well as with the offer of a partnership with Morgan interests. Acceptance would have put Tesla firmly under Morgan's control. Tesla refused. And Tesla succeeded in preserving his autonomy until he became possessed with overwhelming ardor to fulfill the dream of his World system. Tesla was ready to sell his soul to finance Wardencllyffe, and J. P. Morgan was right there to buy it.

In 1901, Tesla signed over to Morgan controlling interest in the patents he still owned, as well as all future ones, in lighting and radio. Morgan then put about \$150,000 startup funding into Wardencllyffe. Later he invested more, just enough to bring the project within sight of completion. Morgan then became elusive. Tesla tried desperately to communicate with the investor, but to no avail. When word was out on Wall Street that Morgan had withdrawn support, no one would touch the project. This finished Tesla as a functioning inventor. Work on the Wardencllyffe tower came to a halt. Left to dereliction, the tower remained only as a curiosity to passersby. During World War I, the tower was unceremoniously dynamited to the ground.

## 6. Lighting

In 1891 Tesla said that existing methods of lighting were very wasteful, that some better methods must be invented, some more perfect apparatus devised. Tesla went and did just that. Yet, here we are today, in a world lit predominantly by the same Edison bulb! Edison's bulb burns with six percent efficiency, the rest going off as heat, while the high resistance filament cooks at 4,000 degrees and eventually breaks without warning. Today's fluorescent tube, though inspired by Tesla, is no model of efficiency either.

Its inner surfaces are stimulated to phosphorescence by energy-consuming filament-like cathodes that also burn out, and the lit-up tube would present a dead short to the current if it were not for the so-called

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ballast transformer, an inductance placed in the circuit to oppose and thus eat up yet more current. What sent Tesla into an exploration of high frequency phenomena was his conviction that these rapid vibrations held the key to a superior mode of lighting. The explorations were not Tesla's first venture into lighting. His very first U. S. patent (1885) is for an improvement in the arc lamp. He used an electromagnet to feed carbons to the arc at a uniform rate to produce a steadier light (No. 335,785).

Early arc lamps produced a brilliant blue-white light, good for street lighting but not for the home, and they emitted noxious fumes. Home lighting was by gas. Street arc lighting used series circuits. Edison introduced the parallel circuit, and designed his lamp for such a circuit. Edison introduced the big scale production and sale of electric power itself on the model of gas lighting, a major industry at the time. He wanted to be first in the business and announced to the press that he had an operable bulb before he actually had a bulb that worked. When Tesla's a.c. system was established, it was grafted on to Edison's, greatly extending its range and efficiency. But, essentially, it was still Edison's parallel circuit, high consumption, incandescent lighting system, and this is what we have to live with today.

### A better way

Tesla patented both his spark-gap oscillator and his Tesla coil specifically as power sources for a new lighting system that used currents of high frequency and high potential. Lest you get the impression that a lone genius named Tesla invented this new form of lighting out of the blue, you should know that others before him had used high frequencies to stimulate light, and others, like Sir William Crookes, had done the same with high potentials, but Tesla was the first on record to put the two together.

In Jules Verne's 1872 novel *A Journey to the Center of the Earth*, the narrator tells of a brilliant portable battery lamp used by the underground explorers. The device was powered by a Ruhmkorf coil; a high voltage buzzer-type induction coil (step-up transformer) popular among early electrical experimenters. The Ruhmkorf coil stimulated a lamp (type unspecified but probably a gas tube), which produced the light of an artificial day. The lamp had such a low current draw that the battery lasted throughout the subterranean adventure. Verne evidently was drawing, at least in part, on experimental knowledge of his day for what he calls this ingenious application of electricity to practical purposes.

Perhaps somebody should reinvent such a high potential lamp to replace today's flashlight, which seems to exist for the purpose of enriching the Eveready division of Union Carbide. Modern neon lighting is high potential at 2,000 to 15,000 volts. (Neon sign transformers are good for powering tesla coils, but a low-frequency, high voltage device: caution.) Neon, as well as its cousin, 7,500-volt cold cathode (filament's) fluorescent, which is used in some industrial lighting, is as close as we get to Tesla lighting today.

Circa 1900, Tesla experimented with luminous tubes bent into alphabetic characters and other shapes. Although today's neon is simplistic Tesla, being driven by 60-cycle high-voltage transformer power alone without the benefits of high-frequency excitation, it should suggest to us the amazing efficiency of high-potential lighting, since a single 15,000-volt neon transformer drawing only 230 watts can light up a tube extending up to 120 feet. How superior is the economy of Tesla high potential, high frequency lighting over Edison incandescent? Tesla says certainly 20 times, if not more light is obtained for the same expenditure of energy.

### "Pure" light

Tesla invented a variety of lamps, not all of which show up in his patents. He lit up solid bodies like carbon rods in vacuum bulbs, or in bulbs containing various inert gases at low pressure (rarefied). He noted that tubes devoid of any electrodes may be used, and there is no difficulty in producing by their means light to read by. But he noted that the effect is considerably increased by the use of phosphorescent bodies, such as yttrium, uranium glass, etc. Here Tesla lays the foundation for fluorescent lighting. Applied to such lamps were currents at potentials ranging from a lower limit of 20,000 volts up to voltages in the millions and vibrations of 15,000 cycles per second and up.

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Tesla dreamed of creating what he called pure light or cold light by generating electric vibrations at frequencies that equaled those of visible light itself. Light produced by this direct and efficient means would require vibrations of 350 to 750 billion cycles, but Tesla believed such oscillations, far above those attainable by his coils, would someday be achieved. Even so, his rarefied gas-tube lamps produced a light that more closely approximated natural daylight than any other artificial source. Tesla's light is like the full-spectrum light that is coming to be recognized as far more healthful than Edison incandescent and particularly more healthful than conventional fluorescent. Full-spectrum lighting is believed by some health practitioners actually to have healing properties.

## No sudden burnout

Tesla's gas tube lamps burn indefinitely, as do today's neon tubes, for there is nothing within to be consumed. Tesla's lamps that contain electrodes like carbon rods, however, do undergo some deterioration. In Tesla's words, a very slow destruction and gradual diminution in size always occurs, as in incandescent filaments; but there is no possibility of sudden and premature disabling which occurs in the latter by the breaking of the filament, especially when incandescent bodies are in the shape of blocks. In vacuum lamps, the life of the bulb depends upon the degree of exhaustion, which can never be made perfect. Also, the higher the frequency applied to such a lamp the slower the deterioration. Electrodes glow at high temperatures, and this raises the problem of how to conduct energy to them since wires or other metallic elements will melt. The problem must be addressed in lamp design. For example, in the incandescent lamp shown at the opening of this chapter, the lead-in wires connect to the hot electrodes via bronze powder contained in a refractory cup. Tesla may have designed his capacitor-base bulbs to help address this same problem.

## High heat

Tesla's search for the ideal electrode is reminiscent of Edison's search for the long lasting filament: The production of a small electrode capable of withstanding enormous temperatures, said Tesla, is regarded as the greatest importance in the manufacture of light. One of the electrodes he tried was a small button of carbon, which he placed in a near vacuum. Tesla regarded the high incandescence of the button to be a necessary evil. For lighting purposes, it was the incandescence of the gas remaining in the mostly evacuated chamber that was important. But the carbon-button lamp proved to have some remarkable properties beyond its use for illumination. When the voltage was turned up, the lamp produced such tremendous heat that the carbon button rapidly vaporized. Tesla experimented extensively with this fascinating phenomenon. For the button of carbon he substituted zirconium, the most refractory substance available at the time. It fused instantly. Even rubies vaporized. Diamonds, and, to a greater degree, carborundum, endured the best, but these could also be vaporized at high potentials.

Tesla worked on the problem of heating. I have read that he contributed to the development of a high-frequency induction heating. Did Tesla work on the problem of space heating? Certainly the huge current draw of conventional electric heaters, which use resistive elements, argues for some inventiveness in this area. Tesla did observe that the discharges from a tesla coil resembled flames escaping under pressure and were indeed hot. He reflected that a similar process must take place in the ordinary flame, that this might be an electric phenomenon. He said that electric discharges might be a possible way of producing by other than chemical means a veritable flame which would give light and heat without material consumed. The behavior of the carbon-button lamp suggests that a new heating mode might be found in the effects of high-frequency currents in a vacuum.

## Lighting up the sky

Hold a fluorescent tube near a Tesla coil and it will light up in your hand. This is true of any tube or bulb with vacuum or rarefied gas. A more efficient way is to ground one end of the tube and put a length of wire as a sort of antenna on the other. Better yet, put a coil of wire that resonates with the secondary in series with the tube and ground and you have the optimal wireless power arrangement.

Tesla conducted many experiments with different arrangements like this, using on some occasions the

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widely available Edison filament incandescent, which lighted up more brilliantly than usual because of the effects of high frequencies on the bulbs rarefied interior. Inside his New York lab Tesla strung a wire connected to a tesla coil around the perimeter of the room. Wherever he needed light he hung a gas tube in the vicinity of this high frequency conductor.

Tesla had a bold fantasy whereby he would use the principle of rarefied gas luminescence to light up the sky at night. High frequency electric energy would be transmitted, perhaps by an ionizing beam of ultraviolet radiation, into the upper atmosphere, where gases are at relatively low pressure, so that this layer would behave like a luminous tube. Sky lighting, he said, would reduce the need for street lighting, and facilitate the movement of ocean going vessels. The aurora borealis is an electrical phenomenon that works on this principle, the effects of cosmic eruptions such as those from the sun being the source of electric stimulation. I, for one, am grateful that this particular Tesla fantasy never materialized since it is difficult enough to see the stars with existing light pollution, and there might be undesirable biological impacts as well.

## Rotating brush

Tesla took an evacuated incandescent type lamp globe, suspended within it at dead center a conductive element, stimulated that element with high voltage currents from an induction coil, and thus created a beam-like emanation, a brush discharge that was so eerily sensitive to disturbances in its environs that it seemed to be endowed with an intelligent life of its own. The device works best if there is no lead-in wire. In the bulb shown, every measure has been taken to construct it so it is free from its own electrical influence. The bulb could be stimulated inductively by applying energy to metal foil wrapped around its neck. Thus excited, an intense phosphorescence then spreads at first over the globe, but soon gives place to a white misty light, observes Tesla. The glow then resolves into a directional brush or beam that will spin around the central element. So responsive is it to any electrostatic or magnetic changes in its vicinity that the approach of an observer at a few paces from the bulb will cause the brush to fly to the opposite side. A small, inch-wide permanent magnet will affect it visibly at a distance of two meters, slowing down or accelerating the rotation according to how it is held relatively to the brush.

Tesla never patented the rotating brush or used it in any practical application, but he believed it could have practical applications. He saw one use in radio where the device could conceivably be adapted to being a most sensitive detector of disturbances in the medium. The rotating brush appears to be a precursor of the plasma globe toys now in fashion; these are sometimes called Tesla globes. Tesla's new lighting was famous in its time. Tesla, the promoter, saw to it. He conducted demonstrations at lectures before the electric industry associations, before large audiences in rented halls, and before select groups of influential New Yorkers in his Manhattan lab.

His articles about the new lighting were published in the popular scientific press and it was reported in the newspapers. Still, it did not catch on with the powers-that-be who no doubt saw in it Tesla's perennial pile-of scrap problem. But, I wonder, would the whole electric distribution system have to be scrapped to implement the efficiencies of Tesla lighting? Conceivably, the new lighting could be run off of local oscillators at the consumer end, the old power distribution system remaining intact. This is still a possibility, as it has been for about one hundred years.

## 7. Transportation

Tesla speculated, that, perhaps the most valuable application of wireless energy, will be the propulsion of the flying machine, which will carry no fuel and be free from any limitations of the present airplanes and dirigibles. The possibility of electric flight intrigued Tesla, though he never did patent an electric aircraft. But he did patent an electric railway using his high frequency, high-potential electricity in a by-wire mode, and also patented a radical aircraft that, while not electric, did have an advanced power plant: his disk turbine. Tesla's railway and aircraft can be numbered among the lost inventions. The closest transport technology has come to putting any of Tesla into actual practice is with diesel-electric power using Tesla poly phase motors, an early and notable example of which was the ocean liner Normandy. In the field of transport, Tesla is more commonly identified with antigravity flight and

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UFOs. Although this identification is based upon nothing more than a few public utterances, his suggestions charge the imagination with possibilities.

## High-frequency railway

Tesla's high-frequency, high-potential railway picks up its power inductively without the use of the rolling or sliding contacts used in conventional trolley or third-rail systems. A pickup bar travels near a cable carrying the oscillating energy. This cable, which Tesla specifically invented to carry such currents, is the precursor of the grounded shielded cable used today to carry TV and other high-frequency signals. But unlike today's cables, which carry energy only of signal strength and shield by means of a continuous grounded static screen of fine braided copper wire, Tesla's high voltage cable uses metal pipe or screen that is broken up into short lengths, very much shorter, says Tesla in his patent, than the wave lengths of the current used. This feature reduces loss. Since the shielding must not be interrupted, the short sections are made to overlap but are insulated from one another. To further reduce loss to ground, an inductance of high ohmic resistance or a small capacity is placed in the ground line.

## Motor mystery

A conundrum raised by Tesla's railway patent is that the vehicle is powered by an electric motor, but nowhere among Tesla's inventions is to be found an electric motor that runs off of high-frequency currents. Was Tesla planning to use a lower frequency here, something under 1,000 cycles? Did he have a converter in mind that could bring the frequency down? Or did Tesla invent a high-frequency motor that never made it into patent, an invention that may be among his unpublished notes? Anyway, Tesla proceeds in many of his discussions of high-frequency power as if this problem were solved. I've seen references post-Tesla to the existence of such a motor. Free-energy inventor, Hermann Plauson, (next chapter) refers to high-frequency motors. These motors have magnetic cores made of very thin laminations insulated from each other, a design that would limit damping effects.

## Turbine aircraft

Tesla's only patented aircraft is a vertical takeoff and landing (VTOL) plane that he intended as an improvement upon the helicopter, already invented at this time (1921): The helicopter type of flying machine, especially with large inclination angle of the propeller axis to the horizontal, at which it is generally expected to operate, is quite unsuitable for speedy aerial transport; it is incapable of proceeding horizontally along a straight line under prevailing air conditions; it is subject to dangerous plunges and oscillations ... and it is almost certainly doomed to destruction in case the motive power gives out. Advances in helicopter design may have mitigated some of these problems, but at least the last one still holds true: Tesla's craft, which has a large wing area, is powered by two disk turbines, rotating in opposite directions. The engineering problem of swinging the pilot and passengers around 90 degrees after takeoff, is solved at least to Tesla's satisfaction. There have been some experimental VTOL's but nothing in production.

## Electric flight

Tesla's dream electric aircraft would be powered by means of magnifying transmitters: Aerial machines will be propelled around the earth without a stop. Also, in 1900, he predicted a cold coal battery with such output that a practical flying machine would be possible. Such a battery also would enormously enhance the introduction of the automobile. Tesla fantasized a personal aerial taxi which could be folded into a six-foot cube, and would weigh under 250 lb.: It can be run through the streets and put in a garage, if desired, just like an automobile.

Explaining how his earth-resonant wireless-power system could energize vehicles aloft, he said, power can be readily supplied without ground connection, for, although the flow is confined to earth, an electromagnetic field is created in the atmosphere surrounding it. Tesla believed such a system to be the

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ultimate method of man-made flight: With an industrial plant of great capacity, sufficient power can be derived in this manner to propel any kind of aerial machine. This I have always considered the best and permanent solution to the problems of flight. No fuel of any kind will be required as the propulsion will be accomplished by light electric motors operated at great speed.

## Antigravity

Tesla wrote in 1900 of an antigravity motor: Imagine a disk of some homogeneous material turned perfectly true and arranged to turn in friction less bearings on a horizontal shaft above the ground. Now, it is possible that we may learn how to make such a disk rotate continuously and perform work by the force of gravity. To do so, he said, we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one-half of the disk, and rotation of the latter would follow.

Does it not follow then, that such a gravity screen could also be used to levitate a vehicle? Tesla held no patent on such a device or on any other antigravity device, and there are no published notes on experimentation in the area. Nevertheless, Tesla inevitably pops up in the literature of antigravity and UFOs. This may be because Tesla was a prominent exponent of a physics in which antigravity seems more feasible because gravity is better explained.

A researcher-theorist of today, Thomas Bearden, allows for gravity control in the physics he calls the new Tesla electromagnetic. Scalar (standing) waves in time itself can be produced electrically and this becomes a magic tool capable of directly affecting and altering anything that exists in time, including gravitational fields, says Bearden. In 1931 the editor of Science And Mechanics, Hugo Gernsback reported, It is believed by many scientists today that the force of gravitation is merely another manifestation of electromagnetic waves. Edward Farrow, a New York inventor, reported in 1911 an antigravity effect produced by a ring of spark gaps. When the gaps were fired, the device, called a condensing dynamo, lost one-sixth of its weight. T. Henry Moray wrote, Frequencies may be developed which will balance the force of gravity to a point of neutralization. Antigravity researcher Richard Lefors Clark places the frequency of gravity's vibrations right at Nature's neutral center in the radiant energy spectrum, above radar and below infrared, at 1012 cycles per second.

## 8. Free-Energy Receiver

For starters, think of this as a solar-electric panel. Tesla's invention is very different, but the closest thing to it in conventional technology is in photovoltaic. One radical difference is that conventional solar-electric panels consist of a substrate coated with crystalline silicon; the latest use amorphous silicon. Conventional solar panels are expensive, and, whatever the coating, they are manufactured by esoteric processes. But Tesla's solar panel is just a shiny metal plate with a transparent coating of some insulating material, which today could be a spray plastic. Stick one of these antenna-like panels up in the air, the higher the better, and wire it to one side of a capacitor, the other going to a good earth ground. Now the energy from the sun is charging that capacitor. Connect across the capacitor some sort of switching device so that it can be discharged arrhythmic intervals, and you have an electric output. Tesla's patent is telling us that it is that simple to get electric energy. The bigger the area of the insulated plate, the more energy you get. But this is more than a solar panel because it does not necessarily need sunshine to operate. It also produces power at night Of course; this is impossible according to official science.

For this reason, you could not get a patent on such an invention today. Many an inventor has learned this the hard way. Tesla had his problems with the patent examiners, but today's free-energy inventor has it much tougher. Tesla's free-energy receiver was patented in 1901 as An Apparatus for the Utilization of Radiant Energy. The patent refers to the sun, as well as other sources of radiant energy, like cosmic rays. That the device works at night is explained in terms of the nighttime availability of cosmic rays.

Tesla also refers to the ground as a vast reservoir of negative electricity. Tesla was fascinated by radiant energy and its free-energy possibilities. He called the Crooke's radiometer (a device which has vanes that spin in a vacuum when exposed to radiant energy) a beautiful invention. He believed that it would

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become possible to harness energy directly by connecting to the very wheelwork of nature. His free-energy receiver is as close as he ever came to such a device in his patented work. But on his 76th birthday at the ritual press conference, Tesla (who was without the financial wherewithal to patent but went on inventing in his head) announced a cosmic-ray motor. When asked if it was more powerful than the Crooke's radiometer, he answered, thousands of times more powerful.

### how it works

From the electric potential that exists between the elevated plate (plus) and the ground (minus), energy builds in the capacitor, and, after a suitable time interval, the accumulated energy will manifest itself in a powerful discharge which can do work. The capacitor, says Tesla should be of considerable electrostatic capacity and its dielectric made of the best quality mica, for it has to with stand potentials that could rupture a weaker dielectric.

Tesla gives various options for the switching device. One is a rotary switch that resembles a Tesla circuit controller. Another is an electrostatic device consisting of two very light, membranous conductors suspended in a vacuum. These sense the energy buildup in the capacitor, one going positive, the other negative, and, at a certain charge level, are attracted, touch, and thus fire the capacitor. Tesla also mentions another switching device consisting of a minute air gap or weak dielectric film, which breaks down suddenly when a certain potential is reached. The above is about all the technical detail you get in the patent.

### Plauson's converter

Tesla's invention may have helped to inspire the many other inventors who have worked in the field of free energy. At least a dozen are on record. Let's look at one in particular. In 1921 Hermann Plauson, a German experimenter, succeeded in obtaining patents, including one in the U. S., for Conversion of Atmospheric Electric Energy. In school, every introduction to electricity touches on the phenomenon of so-called static (or electrostatic) electricity, and this is what Plauson means by atmospheric. Static electricity is built-up charge, electricity in a raw state, and it comes easy in Nature, as evidenced by lightning and the aurora borealis.

If you have ever seen a frictional static machine in operation, it's not difficult to imagine the tremendous potential in artificially produced static. A rotating disk type of static machine or the silk belt type, as in the Van de Graff generator, produces discharges like those from a tesla coil. Unfortunately, in school, the subject of static electricity is briefly touched upon and then abruptly dropped, never to be mentioned again. Electrical power sources thereafter are limited to the battery or the wall socket.

### How it works

In the Plauson drawing the free energy converter on the left interfaces with a disk type static machine via special pick up combs. When the static collecting disk is rotated, the combs pick up the charge, one comb going positive, and the other negative. The combs, in turn, charge up their respective capacitors until sufficiently high potential builds to jump the spark gap. The oscillatory discharge is induced into the transformer primary. This is high-voltage, high frequency electric energy. The familiar spark-gap oscillator has turned charge into dynamic energy.

The transformer steps down the vibrating high voltage to practical levels to power lighting, heating, and special high-frequency motors. The Plauson patent drawing shows a device that works on the same principle but collects energy by means of an antenna, as does Tesla's receiver. Since the higher the antenna the better, and the more area the better, Plauson favors big metallic helium balloons. Plauson says the safety gap, which has three times the resistance of the working gap, is absolutely necessary for collecting large quantities of charge. The capacitors across the gaps in the series safety gap allow for uniform sparking. Plauson's device suggests that Tesla's might be explained in terms of electrostatics.

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Tesla, at the press conference honoring his 77th birthday in 1933 declared that electric power was everywhere present in unlimited quantities and could drive the worlds machinery without the need of coal, oil, gas, or any other fuels. A reporter asked if the sudden introduction of his principle wouldn't upset the present economic system...

Tesla replied, "It is badly upset already."

END