NIKOLA TESLA

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Nikola Tesla was born and raised in the Austrian Empire. Tesla received an advanced education in engineering and physics in the 1870s and gained practical experience in the early 1880s working in telephony and at Continental Edison in the new electric power industry. He emigrated to the United States in 1884, where he would become a naturalized citizen. He worked for a short time at the Edison Machine Works in New York City before he struck out on his own. With the help of partners to finance and market his ideas, Tesla set up laboratories and companies in New York to develop a range of electrical and mechanical devices. His alternating current (AC) induction motor and related polyphase AC patents, licensed by Westinghouse Electric in 1888, earned him a considerable amount of money and became the cornerstone of the polyphase system which that company would eventually market.

Attempting to develop inventions he could patent and market, Tesla conducted a range of experiments with mechanical oscillators/generators, electrical discharge tubes, and early X-ray imaging. He also built a wireless-controlled boat, one of the first ever exhibited. Tesla became well known as an inventor and would demonstrate his achievements to celebrities and wealthy patrons at his lab and was noted for his showmanship at public lectures.

Throughout the 1890s, Tesla pursued his ideas for wireless lighting and worldwide wireless electric power distribution in his high-voltage, high-frequency power experiments in New York and Colorado Springs. In 1893, he made pronouncements on the possibility of wireless communication with his devices. Tesla tried to put these ideas to practical use in his unfinished Wardenclyffe Tower project, an intercontinental wireless communication and power transmitter, but ran out of funding before he could complete it.

After Wardenclyffe, Tesla went on to try to develop a series of inventions in the 1910s and 1920s with varying degrees of success. Having spent most of his money, he lived in a series of New York hotels, leaving behind unpaid bills. Tesla died in New York City in January 1943. His work fell into relative obscurity following his death, but in 1960, the General Conference on Weights and Measures named the SI unit of magnetic flux density the tesla in his honor. There has been a resurgence in popular interest in Tesla since the 1990s. His intellectual achievements and originality have made him named by many a genius.

## Early years

Rebuilt, Tesla's house (parish hall) in Smiljan, now in Croatia, where he was born, and the rebuilt church, where his father served. During the Yugoslav Wars, several of the buildings were severely damaged by fire. They were restored and reopened in 2006.

Nikola Tesla was born an ethnic Serb in the village Smiljan, Lika county, in the Austrian Empire (present day Croatia), on 10 July 1856. His father, Milutin Tesla (1819–1879), was an Eastern Orthodox priest. Tesla's mother, Đuka Tesla (née Mandić; 1822–1892), whose father was also an Orthodox priest, had a talent for making home craft tools and mechanical appliances and the ability to memorize Serbian epic poems. Đuka had never received a formal education. Tesla credited his eidetic memory and creative abilities to his mother's genetics and influence. Tesla's progenitors were from western Serbia, near Montenegro.

Tesla was the fourth of five children. He had three sisters, Milka, Angelina and Marica, and an older brother named Dane, who was killed in a horse riding accident when Tesla was aged five. In 1861, Tesla attended primary school in Smiljan where he studied German, arithmetic, and religion. In 1862, the Tesla family moved to the nearby Gospić, Lika where Tesla's father worked as parish priest. Nikola completed primary school, followed by middle school.

In 1870, Tesla moved far north to Karlovac to attend high school at the Higher Real Gymnasium. The classes were held in German, as it was a school within the Austro-Hungarian Military Frontier.

Tesla would later write that he became interested in demonstrations of electricity by his physics professor. Tesla noted that these demonstrations of this “mysterious phenomena” made him want “to know more of this wonderful force”. Tesla was able to perform integral calculus in his head, which prompted his teachers to believe that he was cheating. He finished a four-year term in three years, graduating in 1873.

In 1873, Tesla returned to Smiljan. Shortly after he arrived, he contracted cholera, was bedridden for nine months and was near death multiple times. Tesla’s father, in a moment of despair, (who had originally wanted him to enter the priesthood) promised to send him to the best engineering school if he recovered from the illness.

In 1874, Tesla evaded conscription into the Austro-Hungarian Army in Smiljan by running away southeast of Lika to Tomingaj, near Gračac. There he explored the mountains wearing hunter's garb. Tesla said that this contact with nature made him stronger, both physically and mentally. He read many books while in Tomingaj and later said that Mark Twain's works had helped him to miraculously recover from his earlier illness.

In 1875, Tesla enrolled at Austrian Polytechnic in Graz, Austria, on a Military Frontier scholarship. During his first year, Tesla never missed a lecture, earned the highest grades possible, passed nine exams (nearly twice as many as required), started a Serb cultural club, and even received a letter of commendation from the dean of the technical faculty to his father, which stated, “Your son is a star of first rank.” During his second year, Tesla came into conflict with Professor Poeschl over the Gramme dynamo, when Tesla suggested that commutators were not necessary.

Tesla claimed that he worked from 3 a.m. to 11 p.m., no Sundays or holidays excepted. He was “mortified when [his] father made light of those hard-won honors.” After his father’s death in 1879, Tesla found a package of letters from his professors to his father, warning that unless he were removed from the school, Tesla would die through overwork. At the end of his second year, Tesla lost his scholarship and became addicted to gambling. During his third year, Tesla gambled away his allowance and his tuition money, later gambling back his initial losses and returning the balance to his family. Tesla said that he “conquered his passion then and there,” but later in the U.S. he was again known to play billiards. When examination time came, Tesla was unprepared and asked for an extension to study but was denied. He did not receive grades for the last semester of the third year and he never graduated from the university.

In December 1878, Tesla left Graz and severed all relations with his family to hide the fact that he dropped out of school. His friends thought that he had drowned in the nearby Mur River. Tesla moved to Maribor, where he worked as a draftsman for 60 florins per month. He spent his spare time playing cards with local men on the streets.

In March 1879, Tesla’s father went to Maribor to beg his son to return home, but he refused. Nikola suffered a nervous breakdown around the same time. On 24 March 1879, Tesla was returned to Gospić under police guard for not having a residence permit.

On 17 April 1879, Milutin Tesla died at the age of 60 after contracting an unspecified illness. Some sources say that he died of a stroke. During that year, Tesla taught a large class of students in his old school in Gospić.

In January 1880, two of Tesla's uncles put together enough money to help him leave Gospić for Prague, where he was to study. He arrived too late to enroll at Charles-Ferdinand University; he had never studied Greek, a required subject; and he was illiterate in Czech, another required subject. Tesla did, however, attend lectures in philosophy at the university as an auditor and he did not receive grades for the courses.

### Working at Budapest Telephone Exchange

In 1881, Tesla moved to Budapest, Hungary, to work under Tivadar Puskás at a telegraph company, the Budapest Telephone Exchange. Upon arrival, Tesla realized that the company, then under construction, was not functional, so he worked as a draftsman in the Central Telegraph Office instead. Within a few months, the Budapest Telephone Exchange became functional, and Tesla was allocated the chief electrician position. During his employment, Tesla made many improvements to the Central Station equipment and claimed to have perfected a telephone repeater or amplifier, which was never patented nor publicly described.

## Working at Edison

In 1882, Tivadar Puskás got Tesla another job in Paris with the Continental Edison Company. Tesla began working in what was then a brand new industry, installing indoor incandescent lighting citywide in the form of an electric power utility. The company had several subdivisions and Tesla worked at the Société Electrique Edison, the division in the Ivry-sur-Seine suburb of Paris in charge of installing the lighting system. There he gained a great deal of practical experience in electrical engineering. Management took notice of his advanced knowledge in engineering and physics and soon had him designing and building improved versions of generating dynamos and motors. They also sent him on to troubleshoot engineering problems at other Edison utilities being built around France and in Germany.

### A move to the US

In 1884, Edison manager Charles Batchelor, who had been overseeing the Paris installation, was brought back to the US to manage the Edison Machine Works, a manufacturing division situated in New York City, and asked that Tesla be brought to the US as well. In June 1884, Tesla emigrated to the United States. He began working almost immediately at the Machine Works on Manhattan's Lower East Side, an overcrowded shop with a workforce of several hundred machinists, laborers, managing staff, and 20 “field engineers” struggling with the task of building the large electric utility in that city. As in Paris, Tesla was working on troubleshooting installations and improving generators. Historian W. Bernard Carlson notes Tesla may have met company founder Thomas Alva Edison only a couple of times. One of those times was noted in Tesla’s autobiography where, after staying up all night repairing the damaged dynamos on the ocean liner SS *Oregon*, he ran into Batchelor and Edison, who made a quip about their “Parisian” being out all night. After Tesla told them he had been up all night fixing the *Oregon* Edison commented to Batchelor that “this is a damned good man.” One of the projects given to Tesla was to develop an arc lamp-based street lighting system. Arc lighting was the most popular type of street lighting but it required high voltages and was incompatible with the Edison low-voltage incandescent system, causing the company to lose contracts in cities that wanted street lighting as well. Tesla's designs were never put into production, possibly because of technical improvements in incandescent street lighting or because of an installation deal that Edison cut with an arc lighting company.

Tesla had been working at the Machine Works for a total of six months when he quit. What event precipitated his leaving is unclear. It may have been over a bonus he did not receive, either for redesigning generators or for the arc lighting system that was shelved. Tesla had previous run-ins with the Edison company over unpaid bonuses he believed he had earned. In his own biography, Tesla stated the manager of the Edison Machine Works offered a $50,000 bonus to design “twenty-four different types of standard machines” “but it turned out to be a practical joke”. Later versions of this story have Thomas Edison himself offering and then reneging on the deal, quipping “Tesla, you don't understand our American humor.” The size of the bonus in either story has been noted as odd since Machine Works manager Batchelor was stingy with pay and the company did not have that amount of cash (equivalent to $12 million today) on hand. Tesla’s diary contains just one comment on what happened at the end of his employment, a note he scrawled across the two pages covering December 7, 1884, to January 4, 1885, saying “Good bye to the Edison Machine Works”.

## Tesla Electric Light & Manufacturing

Soon after leaving the Edison company, Tesla was working on patenting an arc lighting system, possibly the same one he had developed at Edison. In March 1885, he met with patent attorney Lemuel W. Serrell, the same attorney used by Edison, to obtain help with submitting the patents. Serrell introduced Tesla to two businessmen, Robert Lane and Benjamin Vail, who agreed to finance an arc lighting manufacturing and utility company in Tesla's name, the Tesla Electric Light & Manufacturing. Tesla worked for the rest of the year obtaining the patents that included an improved DC generator, the first patents issued to Tesla in the US, and building and installing the system in Rahway, New Jersey Tesla's new system gained notice in the technical press, which commented on its advanced features.

The investors showed little interest in Tesla’s ideas for new types of alternating current motors and electrical transmission equipment. After the utility was up and running in 1886, they decided that the manufacturing side of the business was too competitive and opted to simply run an electric utility. They formed a new utility company, abandoning Tesla’s company and leaving the inventor penniless. Tesla even lost control of the patents he had generated, since he had assigned them to the company in exchange for stock. He had to work at various electrical repair jobs and as a ditch digger for $2 per day. Later in life Tesla would recount that part of 1886 as a time of hardship, writing “My high education in various branches of science, mechanics and literature seemed to me like a mockery”.

## AC and the induction motor

In late 1886, Tesla met Alfred S. Brown, a Western Union superintendent, and New York attorney Charles F. Peck. The two men were experienced in setting up companies and promoting inventions and patents for financial gain. Based on Tesla’s new ideas for electrical equipment, including a thermo-magnetic motor idea, they agreed to back the inventor financially and handle his patents. Together they formed the Tesla Electric Company in April 1887, with an agreement that profits from generated patents would go 1/3 to Tesla, 1/3 to Peck and Brown, and 1/3 to fund development. They set up a laboratory for Tesla at 89 Liberty Street in Manhattan, where he worked on improving and developing new types of electric motors, generators, and other devices.

In 1887, Tesla developed an induction motor that ran on alternating current (AC), a power system format that was rapidly expanding in Europe and the United States because of its advantages in long-distance, high-voltage transmission. The motor used polyphase current, which generated a rotating magnetic field to turn the motor (a principle that Tesla claimed to have conceived in 1882). This innovative electric motor, patented in May 1888, was a simple self-starting design that did not need a commutator, thus avoiding sparking and the high maintenance of constantly servicing and replacing mechanical brushes.

Along with getting the motor patented, Peck and Brown arranged to get the motor publicized, starting with independent testing to verify it was a functional improvement, followed by press releases sent to technical publications for articles to run concurrent with the issue of the patent. Physicist William Arnold Anthony (who tested the motor) and *Electrical World* magazine editor Thomas Commerford Martin arranged for Tesla to demonstrate his AC motor on 16 May 1888 at the American Institute of Electrical Engineers. Engineers working for the Westinghouse Electric & Manufacturing Company reported to George Westinghouse that Tesla had a viable AC motor and related power system – something Westinghouse needed for the alternating current system he was already marketing. Westinghouse looked into getting a patent on a similar commutator-less, rotating magnetic field-based induction motor developed in 1885 and presented in a paper in March 1888 by Italian physicist Galileo Ferraris, but decided that Tesla's patent would probably control the market.

In July 1888, Brown and Peck negotiated a licensing deal with George Westinghouse for Tesla’s polyphase induction motor and transformer designs for $60,000 in cash and stock and a royalty of $2.50 per AC horsepower produced by each motor. Westinghouse also hired Tesla for one year for the large fee of $2,000 ($54,500 in today's dollars) per month to be a consultant at the Westinghouse Electric & Manufacturing Company’s Pittsburgh labs.

During that year, Tesla worked in Pittsburgh, helping to create an alternating current system to power the city’s streetcars. He found it a frustrating period because of conflicts with the other Westinghouse engineers over how best to implement AC power. Between them, they settled on a 60-cycle AC system that Tesla proposed (to match the working frequency of Tesla’s motor), but they soon found that it would not work for streetcars, since Tesla’s induction motor could run only at a constant speed. They ended up using a DC traction motor instead.

### Market turmoil

Tesla’s demonstration of his induction motor and Westinghouse's subsequent licensing of the patent, both in 1888, came at the time of extreme competition between electric companies. The three big firms, Westinghouse, Edison, and Thompson-Houston, were trying to grow in a capital-intensive business while financially undercutting each other. There was even a “War of Currents” propaganda campaign going on with Edison Electric trying to claim their direct current system was better and safer than the Westinghouse alternating current system. Competing in this market meant Westinghouse would not have the cash or engineering resources to develop Tesla’s motor and the related polyphase system right away.

Two years after signing the Tesla contract, Westinghouse Electric was in trouble. The near collapse of Barings Bank in London triggered the financial panic of 1890, causing investors to call in their loans to W.E. The sudden cash shortage forced the company to refinance its debts. The new lenders demanded that Westinghouse cut back on what looked like excessive spending on acquisition of other companies, research, and patents, including the per motor royalty in the Tesla contract. At that point, the Tesla induction motor had been unsuccessful and was stuck in development. Westinghouse was paying a $15,000-a-year guaranteed royalty even though operating examples of the motor were rare and polyphase power systems needed to run it were even rarer. In early 1891, George Westinghouse explained his financial difficulties to Tesla in stark terms, saying that, if he did not meet the demands of his lenders, he would no longer be in control of Westinghouse Electric and Tesla would have to “deal with the bankers” to try to collect future royalties. The advantages of having Westinghouse continue to champion the motor probably seemed obvious to Tesla and he agreed to release the company from the royalty payment clause in the contract. Six years later Westinghouse would purchase Tesla's patent for a lump sum payment of $216,000 as part of a patent-sharing agreement signed with General Electric (a company created from the 1892 merger of Edison and Thompson-Houston).

## New York laboratories

The money Tesla made from licensing his AC patents made him independently wealthy and gave him the time and funds to pursue his own interests. In 1889, Tesla moved out of the Liberty Street shop Peck and Brown had rented and for the next dozen years would work out of a series of workshop/laboratory spaces in Manhattan. These included a lab at 175 Grand Street (1889–1892), the fourth floor of 33–35 South Fifth Avenue (1892–1895), and sixth and seventh floors of 46 & 48 East Houston Street (1895–1902). Tesla and his hired staff would conduct some of his most significant work in these workshops.

### Tesla coil

*Main article: Tesla coil*

In the summer of 1889, Tesla traveled to the 1889 Exposition Universelle in Paris and learned of Heinrich Hertz' 1886–88 experiments that proved the existence of electromagnetic radiation, including radio waves. Tesla found this new discovery “refreshing” and decided to explore it more fully. In repeating, and then expanding on, these experiments, Tesla tried powering a Ruhmkorff coil with a high-speed alternator he had been developing as part of an improved arc lighting system but found that the high frequency current overheated the iron core and melted the insulation between the primary and secondary windings in the coil. To fix this problem Tesla came up with his Tesla coil with an air gap instead of insulating material between the primary and secondary windings and an iron core that could be moved to different positions in or out of the coil.

### Citizenship

On 30 July 1891, aged 35, Tesla became a naturalized citizen of the United States. In the same year, he patented his Tesla coil.

### Wireless lighting

Tesla demonstrating wireless lighting by “electrostatic induction” during an 1891 lecture at Columbia College via two long Geissler tubes (similar to neon tubes) in his hands.

After 1890, Tesla experimented with transmitting power by inductive and capacitive coupling using high AC voltages generated with his Tesla coil. He attempted to develop a wireless lighting system based on near-field inductive and capacitive coupling and conducted a series of public demonstrations where he lit Geissler tubes and even incandescent light bulbs from across a stage. He would spend most of the decade working on variations of this new form of lighting with the help of various investors but none of the ventures succeeded in making a commercial product out of his findings.

In 1893 at St. Louis, Missouri, the Franklin Institute in Philadelphia, Pennsylvania and the National Electric Light Association, Tesla told onlookers that he was sure a system like his could eventually conduct “intelligible signals or perhaps even power to any distance without the use of wires” by conducting it through the Earth.

Tesla served as a vice-president of the American Institute of Electrical Engineers from 1892 to 1894, the forerunner of the modern-day IEEE (along with the Institute of Radio Engineers).

### Steam-powered oscillating generator

Trying to come up with a better way to generate alternating current, Tesla developed a steam powered reciprocating electricity generator. He patented it in 1893 and introduced it at the Chicago World's Columbian Exposition that year. Steam would be forced into the oscillator and rush out through a series of ports, pushing a piston up and down that was attached to an armature. The magnetic armature vibrated up and down at high speed, producing an alternating magnetic field. This induced alternating electric current in the wire coils located adjacent. It did away with the complicated parts of a steam engine/generator, but never caught on as a feasible engineering solution to generate electricity.

### Polyphase System and the Columbian Exposition

At the beginning of 1893, Westinghouse engineer Benjamin Lamme had made great progress developing an efficient version of Tesla’s induction motor, and Westinghouse Electric started branding their complete polyphase AC system as the “Tesla Polyphase System”. They believed that Tesla’s patents gave them patent priority over other AC systems.

Westinghouse Electric asked Tesla to participate in the 1893 World’s Columbian Exposition in Chicago where the company had a large space in a building devoted to electrical exhibits. Westinghouse Electric won the bid to light the Exposition with alternating current and it was a key event in the history of AC power, as the company demonstrated to the American public the safety, reliability, and efficiency of a fully integrated alternating current system. Tesla showed a series of electrical effects related to alternating current as well as his wireless lighting system, using a demonstration he had previously performed throughout America and Europe; these included using high-voltage, high-frequency alternating current to light a wireless gas-discharge lamp.

An observer noted:

Within the room were suspended two hard-rubber plates covered with tin foil. These were about fifteen feet apart and served as terminals of the wires leading from the transformers. When the current was turned on, the lamps or tubes, which had no wires connected to them, but lay on a table between the suspended plates, or which might be held in the hand in almost any part of the room, were made luminous. These were the same experiments and the same apparatus shown by Tesla in London about two years previous, “where they produced so much wonder and astonishment”.

Tesla also explained the principles of the rotating magnetic field in an induction motor by demonstrating how to make a copper egg stand on end, using a device that he constructed known as the *Egg of Columbus* and introduced his new steam powered oscillator AC generator.

### Consulting on Niagara

In 1893, Edward Dean Adams, who headed up the Niagara Falls Cataract Construction Company, sought Tesla’s opinion on what system would be best to transmit power generated at the falls. Over several years, there had been a series of proposals and open competitions on how best to use power generated by the falls. Among the systems proposed by several US and European companies were two-phase and three-phase AC, high-voltage DC, and compressed air. Adams pumped Tesla for information about the current state of all the competing systems. Tesla advised Adams that a two-phased system would be the most reliable, and that there was a Westinghouse system to light incandescent bulbs using two-phase alternating current. The company awarded a contract to Westinghouse Electric for building a two-phase AC generating system at the Niagara Falls, based on Tesla’s advice and Westinghouse’s demonstration at the Columbian Exposition that they could build a complete AC system. At the same time, a further contract was awarded to General Electric to build the AC distribution system.

### The Nikola Tesla Company

In 1895, Edward Dean Adams, impressed with what he saw when he toured Tesla’s lab, agreed to help found the Nikola Tesla Company, set up to fund, develop, and market a variety of previous Tesla patents and inventions as well as new ones. Alfred Brown signed on, bringing along patents developed under Peck and Brown. The board was filled out with William Birch Rankine and Charles F. Coaney. It found few investors; the mid-1890s was a tough time financially, and the wireless lighting and oscillators patents it was set up to market never panned out. The company would handle Tesla’s patents for decades to come.

### Lab fire

In the early morning hours of March 13, 1895, the South Fifth Avenue building that housed Tesla’s lab caught fire. It started in the basement of the building and was so intense Tesla’s 4th floor lab burned and collapsed into the second floor. The fire not only set back Tesla's ongoing projects, it destroyed a collection of early notes and research material, models, and demonstration pieces, including many that had been exhibited at the 1893 Worlds Colombian Exposition. Tesla told *The New York Times* “I am in too much grief to talk. What can I say?” After the fire Tesla moved to 46 & 48 East Houston Street and rebuilt his lab on the 6th and 7th floors.

### X-ray experimentation

X-ray of a hand, taken by Tesla

Starting in 1894, Tesla began investigating what he referred to as radiant energy of “invisible” kinds after he had noticed damaged film in his laboratory in previous experiments (later identified as “*Roentgen rays”* or “X-Rays”). His early experiments were with Crookes tubes, a cold cathode electrical discharge tube. Tesla may have inadvertently captured an X-ray image—predating, by a few weeks, Wilhelm Röntgen’s December 1895 announcement of the discovery of x-rays—when he tried to photograph Mark Twain illuminated by a Geissler tube, an earlier type of gas discharge tube. The only thing captured in the image was the metal locking screw on the camera lens.

In 1898, Tesla demonstrated a radio-controlled boat which he hoped to sell as a guided torpedo to navies around the world.

In March 1896, after hearing of Wilhelm Röntgen’s discovery of X-ray and X-ray imaging (radiography), Tesla proceeded to do his own experiments in X-ray imaging, developing a high energy single terminal vacuum tube of his own design that had no target electrode and that worked from the output of the Tesla Coil (the modern term for the phenomenon produced by this device is *bremsstrahlung* or *braking radiation*). In his research, Tesla devised several experimental setups to produce X-rays. Tesla held that, with his circuits, the “instrument will enable one to generate Roentgen rays of much greater power than obtainable with ordinary apparatus.”

Tesla noted the hazards of working with his circuit and single-node X-ray-producing devices. In his many notes on the early investigation of this phenomenon, he attributed the skin damage to various causes. He believed early on that damage to the skin was not caused by the Roentgen rays, but by the ozone generated in contact with the skin, and to a lesser extent, by nitrous acid. Tesla incorrectly believed that X-rays were longitudinal waves, such as those produced in waves in plasmas. These plasma waves can occur in force-free magnetic fields.

On 11 July 1934, the *New York Herald Tribune* published an article on Tesla, in which he recalled an event that would occasionally take place while experimenting with his single-electrode vacuum tubes; a minute particle would break off the cathode, pass out of the tube, and physically strike him:

Tesla said he could feel a sharp stinging pain where it entered his body, and again at the place where it passed out. In comparing these particles with the bits of metal projected by his “electric gun,” Tesla said, “The particles in the beam of force... will travel much faster than such particles... and they will travel in concentrations.”

### Radio remote control

In 1898, Tesla demonstrated a boat that used a coherer-based radio control—which he dubbed “telautomaton”—to the public during an electrical exhibition at Madison Square Garden. The crowd that witnessed the demonstration made outrageous claims about the workings of the boat, such as magic, telepathy, and being piloted by a trained monkey hidden inside. Tesla tried to sell his idea to the U.S. military as a type of radio-controlled torpedo, but they showed little interest. Remote radio control remained a novelty until World War I and afterward, when a number of countries used it in military programs. Tesla took the opportunity to further demonstrate “Teleautomatics” in an address to a meeting of the Commercial Club in Chicago, while he was travelling to Colorado Springs, on 13 May 1899.

## Wireless power

Tesla sitting in front of a spiral coil used in his wireless power experiments at his East Houston St. laboratory

From the 1890s through 1906, Tesla spent a great deal of his time and fortune on a series of projects trying to develop the transmission of electrical power without wires. It was an expansion of his idea of using coils to transmit power that he had been demonstrating in wireless lighting. He saw this as not only a way to transmit large amounts of power around the world but also, as he had pointed out in his earlier lectures, a way to transmit worldwide communications.

At the time Tesla was formulating his ideas, there was no feasible way to wirelessly transmit communication signals over long distances, let alone large amounts of power. Tesla had studied radio waves early on and came to the conclusion that part of existing study on them, by Hertz, was incorrect. Also, this new form of radiation was widely considered at the time to be a short-distance phenomenon that seemed to die out in less than a mile. Tesla noted that, even if theories on radio waves were true, they were totally worthless for his intended purposes since this form of “invisible light” would diminish over distance just like any other radiation and would travel in straight lines right out into space, becoming “hopelessly lost.”

By the mid-1890s, Tesla was working on the idea that he might be able to conduct electricity long distance through the Earth or the atmosphere and began working on experiments to test this idea including setting up a large resonance transformer magnifying transmitter in his East Houston Street lab. Seeming to borrow from a common idea at the time that the Earth’s atmosphere was conductive, he proposed a system composed of balloons suspending, transmitting, and receiving, electrodes in the air above 30,000 feet (9,100 m) in altitude, where he thought the lower pressure would allow him to send high voltages (millions of volts) long distances.

### Colorado Springs

To further study the conductive nature of low pressure air, Tesla set up an experimental station at high altitude in Colorado Springs during 1899. There he could safely operate much larger coils than in the cramped confines of his New York lab, and an associate had made an arrangement for the El Paso Power Company to supply alternating current free of charge. To fund his experiments he convinced John Jacob Astor IV to invest $100,000 to become a majority shareholder in the Nikola Tesla Company. Astor thought he was primarily investing in the new wireless lighting system. Instead, Tesla used the money to fund his Colorado Springs experiments. Upon his arrival, he told reporters that he planned to conduct wireless telegraphy experiments, transmitting signals from Pikes Peak to Paris.

A multiple exposure picture of Tesla sitting next to his “magnifying transmitter” generating millions of volts. The 7-metre (23 ft) long arcs were not part of the normal operation, but only produced for effect by rapidly cycling the power switch.

There he conducted experiments with a large coil operating in the megavolts range, producing artificial lightning (and thunder) consisting of millions of volts and up to 135 feet (41 m) long discharges and, at one point, inadvertently burned out the generator in El Paso, causing a power outage. The observations he made of the electronic noise of lightning strikes, led him to (incorrectly) conclude that he could use the entire globe of the Earth to conduct electrical energy.

During his time at his laboratory, Tesla observed unusual signals from his receiver which he speculated to be communications from another planet. He mentioned them in a letter to a reporter in December 1899 and to the Red Cross Society in December 1900. Reporters treated it as a sensational story and jumped to the conclusion Tesla was hearing signals from Mars. He expanded on the signals he heard in a 9 February 1901 *Collier's Weekly* article “Talking With Planets” where he said it had not been immediately apparent to him that he was hearing “intelligently controlled signals” and that the signals could come from Mars, Venus, or other planets. It has been hypothesized that he may have intercepted Guglielmo Marconi’s European experiments in July 1899—Marconi may have transmitted the letter S (dot/dot/dot) in a naval demonstration, the same three impulses that Tesla hinted at hearing in Colorado—or signals from another experimenter in wireless transmission.

Tesla had an agreement with the editor of *The Century Magazine* to produce an article on his findings. The magazine sent a photographer to Colorado to photograph the work being done there. The article, titled “The Problem of Increasing Human Energy”, appeared in the June 1900 edition of the magazine. He explained the superiority of the wireless system he envisioned but the article was more of a lengthy philosophical treatise than an understandable scientific description of his work, illustrated with what were to become iconic images of Tesla and his Colorado Springs experiments.

Tesla’s Wardenclyffe plant on Long Island in 1904. From this facility, Tesla hoped to demonstrate wireless transmission of electrical energy across the Atlantic.

Tesla made the rounds in New York trying to find investors for what he thought would be a viable system of wireless transmission, wining and dining them at the Waldorf-Astoria’s Palm Garden (the hotel where he was living at the time), The Players Club, and Delmonico’s. In March 1901, he obtained $150,000 ($4,412,400 in today's dollars) from J. Pierpont Morgan in return for a 51% share of any generated wireless patents, and began planning the Wardenclyffe Tower facility to be built in Shoreham, New York, 100 miles (161 km) east of the city on the North Shore of Long Island.

By July 1901, Tesla had expanded his plans to build a more powerful transmitter to leap ahead of Marconi's radio-based system, which Tesla thought was a copy of his own system. He approached Morgan to ask for more money to build the larger system but Morgan refused to supply any further funds. In December 1901, Marconi successfully transmitted the letter S from England to Newfoundland, defeating Tesla in the race to be first to complete such a transmission. A month after Marconi's success, Tesla tried to get Morgan to back an even larger plan to transmit messages and power by controlling “vibrations throughout the globe”. Over the next five years, Tesla wrote more than 50 letters to Morgan, pleading for and demanding additional funding to complete the construction of Wardenclyffe. Tesla continued the project for another nine months into 1902. The tower was erected to its full 187 feet (57 m). In June 1902, Tesla moved his lab operations from Houston Street to Wardenclyffe.

Investors on Wall Street were putting their money into Marconi’s system, and some in the press began turning against Tesla’s project, claiming it was a hoax. The project came to a halt in 1905, and in 1906, the financial problems and other events may have led to what Tesla biographer Marc J. Seifer suspects was a nervous breakdown on Tesla’s part. Tesla mortgaged the Wardenclyffe property to cover his debts at the Waldorf-Astoria, which eventually mounted to $20,000 ($488,600 in today's dollars). He lost the property in foreclosure in 1915, and in 1917 the Tower was demolished by the new owner to make the land a more viable real estate asset.

## Later years

After Wardencyiffe closed, Tesla continued to write to Morgan; after “the great man” died, Tesla wrote to his son Jack Morgan, trying to get further funding for the project. In 1906, Tesla opened offices at 165 Broadway in Manhattan, trying to raise further funds by developing and marketing his patents. He went on to have offices at the Metropolitan Life Tower from 1910 to 1914; rented for a few months at the Woolworth Building, moving out because he could not afford the rent; and then to office space at 8 West 40th Street from 1915 to 1925. After moving to 8 West 40th Street, he was effectively bankrupt. Most of his patents had run out and he was having trouble with the new inventions he was trying to develop.

### Living circumstances

Since 1900, Tesla had been living at the Waldorf Astoria in New York running up a large bill. In 1922, he moved to St. Regis Hotel and would follow a pattern from then on of moving to a new hotel every few years leaving behind unpaid bills.

Tesla would walk to the park every day to feed the pigeons. He took to feeding them at the window of his hotel room and bringing the injured ones in to nurse back to health. He said that he had been visited by a specific injured white pigeon daily. Tesla spent over $2,000, including building a device that comfortably supported her so her bones could heal, to fix her broken wing and leg. Tesla stated:

*I have been feeding pigeons, thousands of them for years. But there was one, a beautiful bird, pure white with light grey tips on its wings; that one was different. It was a female. I had only to wish and call her and she would come flying to me. I loved that pigeon as a man loves a woman, and she loved me. As long as I had her, there was a purpose to my life.*

Tesla’s unpaid bills, and complaints about the mess from his pigeon-feeding, forced him to leave the St. Regis in 1923, the Hotel Pennsylvania in 1930, and the Hotel Governor Clinton in 1934. At one point, he also took rooms at the Hotel Marguery.

In 1934, Tesla moved to the Hotel New Yorker, and Westinghouse Electric & Manufacturing Company began paying him $125 per month as well as paying his rent, expenses the Company would pay for the rest of Tesla’s life. Accounts of how this came about vary. Several sources say Westinghouse was worried (or warned) about potential bad publicity surrounding the impoverished conditions under which their former star inventor was living. The payment has been described as being couched as a “consulting fee” to get around Tesla’s aversion to accept charity, or by one biographer Marc Seifer as a type of unspecified settlement.

## Death

On 7 January 1943, at the age of 86, Tesla died alone in Room 3327 of the New Yorker Hotel. His body was later found by maid Alice Monaghan after she had entered Tesla's room, ignoring the “do not disturb” sign that Tesla had placed on his door two days earlier. Assistant medical examiner H.W. Wembley examined the body and ruled that the cause of death had been coronary thrombosis.

Two days later the Federal Bureau of Investigation ordered the Alien Property Custodian to seize Tesla’s belongings, even though Tesla was an American citizen. John G. Trump, a professor at M.I.T. and a well-known electrical engineer serving as a technical aide to the National Defense Research Committee, was called in to analyze the Tesla items, which were being held in custody. After a three-day investigation, Trump’s report concluded that there was nothing which would constitute a hazard in unfriendly hands, stating:

Tesla’s thoughts and efforts during at least the past 15 years were primarily of a speculative, philosophical, and somewhat promotional character often concerned with the production and wireless transmission of power; but did not include new, sound, workable principles or methods for realizing such results.

In a box purported to contain a part of Tesla’s “death ray”, Trump found a 45-year-old multidecade resistance box.