# Nikola Tesla – The Creator of the Electric Age

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**Nikola Tesla was one of the greatest inventors of all times. He can be placed along with Faraday and Edison as a prolific inventor who touched on almost every aspect of electricity. In fact he invented electricity as we know it today and hence ushered in the modern age.**

During his long and distinguished career (he died at the age of 86), Tesla invented alternating current, generators and motors to run on it, high voltage Tesla coils, radio, X-rays, highly efficient bladeless steam turbines, radio controlled boats and robots, and fluorescent tubes among others. In addition to his technological inventions he contributed greatly to the field of robotics, ballistics, computer science, nuclear physics and theoretical physics. The visionary nature of Tesla is evident from the fact that most of his major inventions and discoveries were made prior to 1917.

Tesla was a metaphysical genius who had a tremendous ability to pluck inventions or discoveries so to say from the air! Many times he commented that he could visualize the complete working model of his invention including the minutest details and when he got it fabricated, it worked just as he had visualized. It was as if he was getting the knowledge from cyber space. This is a very fascinating aspect of his personality and is the focus of a future article.

## His Early Life

Tesla was born on 10 July 1856, in a small town called Smiljan in the Austria–Hungary border province of modern day Republic of Croatia. His father was a priest and his mother an illiterate housewife but a very talented women. Tesla always gave credit to his mother for being a source of his inventiveness. He was emotionally very close to her. Tesla had one elder brother and

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three sisters. According to Tesla's biography the elder brother was brilliant and died at the age of 12. Nikola Tesla who was 5 years of age at that time came under tremendous pressure from his parents to perform as well as his brother. This expectation seems to have given tremendous inner strength to Tesla.

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Tesla went to school in Karlovac, Croatia and then studied electrical engineering at the Austrian Polytechnic in Graz. While there, he studied the uses of alternating current. Tesla was later persuaded by his father to attend the Charles–Ferdinand branch of the University of Prague. However, his father died soon after and Tesla left the university after completing only one term, the summer term of 1880. In 1881 he moved to Budapest, Hungary, to work for a telegraph company, the American Telephone Company. On the opening in 1881 of the telephone exchange in Budapest, Tesla became the chief electrician to the company, and later engineer for the country's first telephone system. He also developed a device that, according to some, was a telephone repeater or amplifier, but according to others could have been the first loudspeaker.

In 1882 he moved to Paris, France to work as an engineer for the Continental Edison Company (CEC), designing improvements to electric equipment. In the same year Tesla conceived in a flash of intuitive genius the principles of an induction motor and began developing various devices that use rotating magnetic fields (for which he received patents in 1888). One of the administrators of the CEC was Charles Batchelor who was a former assistant and close friend of Thomas Edison. He saw the genius of Tesla and urged him to go to US.

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**Migration to the United States**

In 1884, when Tesla first arrived in the US, he had little besides a letter of recommendation from Charles Batchelor to Thomas Edison. In it, Batchelor wrote, "I know two great men and you are one of them; the other is this young man". Edison hired Tesla to work for his company 'Edison Machine Works'. Tesla's work

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began with simple electrical engineering and quickly progressed to solving the company's most difficult problems. He was offered the task of a complete redesign of the Edison Company's direct current generators.

Tesla wrote (in 1919) that Edison offered him the then-staggering sum of $50,000 (almost $1 million today, adjusted for inflation) if he completed the motor and generator improvements. Tesla said he worked nearly a year to redesign them and gave the Edison Company several enormously profitable new patents in the process. When Tesla inquired about the $50,000, Edison reportedly replied, "Tesla, you don't understand our American humor", and reneged on his promise. Tesla resigned when he was refused a raise to $25 per week. This was in the spring of 1885.

In 1886, Tesla formed his own company, 'Tesla Electric-Light & Manufacturing'. The initial financial investors disagreed with Tesla on his plan for an alternating current (AC) motor and eventually relieved him of his duties at the company. Without any source of income, Tesla worked in New York as a common laborer from 1886 to 1887 to feed himself and to raise capital for his next project. Tesla later remarked that this was the worst time of his life. However during this time by good fortune he came in contact with a patent attorney who helped Tesla to start work on his AC motor and financed in setting up his laboratory. In 1887, he constructed the initial brushless alternating current induction motor, which he demonstrated to the American Institute of Electrical Engineers (AIEE), now IEEE, in 1888. The address at AIEE brought Tesla in contact with George Westinghouse, an American entrepreneur. Westinghouse listened to his fascinating ideas for polyphase power systems which would allow transmission of alternating current over large distances and bought all of his AC patents for a million dollars (one time payment) and agreed to pay royalty of $1/hp produced. In the same year, Tesla developed the principles of the Tesla Coil and began working at Westinghouse Electric & Manufacturing Company's Pittsburgh laboratories. He worked there for a year but did not like the

regimented working conditions. So he quit the job to get back to his laboratory in New York.

In April of 1887, Tesla began investigating what would later be called X-rays using his own single node vacuum tubes. This was much before Roentgen's discovery. This device differed from other early X-ray tubes in that they had no target electrode. The modern term for the phenomenon produced by this device is *bremsstrahlung* (or *braking radiation*). We now know that this device worked by emitting electrons from the single electrode through a combination of field and thermionic emissions. Once liberated, electrons are strongly repelled by the high electric field near the electrode during negative voltage peaks from the oscillating HV output of the Tesla coil, generating X-rays as they collide with the glass envelope.

On July 30, 1891, he became a naturalized citizen of the United States at the age of 35. Tesla established his 35 S. Fifth Avenue laboratory in New York during the same year. Later, Tesla would establish his Houston Street laboratory in New York at 46 E. Houston Street. He lit vacuum tubes wirelessly at both of the New York locations, providing evidence for the potential of wireless power transmission.

When Tesla was 36 years old, the first patents concerning the polyphase power system were granted. He continued research of the system and rotating magnetic field principles. Tesla served from 1892 to 1894 as the vice president of AIEE, the forerunner (along with the Institute of Radio Engineers) of the modern-day IEEE. From 1893 to 1895, he investigated high frequency alternating currents. He generated AC of one million volts using a conical Tesla coil and investigated the *skin effect* in conductors, designed tuned circuits, invented a machine for inducing sleep and cordless gas discharge lamps, and transmitted electromagnetic energy without wires, effectively building the first radio transmitter. In 1890 he showed for the first time the heating effect of high frequency current in meat tissue. This invention was the

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forerunner of microwave cooking! At St Louis, Missouri, Tesla made a demonstration related to radio communication in 1893. Addressing the Franklin Institute in Philadelphia, Pennsylvania and the National Electric Light Association, he described and demonstrated in detail its principles.

At the 1893 World's Fair, the World's Columbian Exposition in Chicago, an international exposition was held which for the first time devoted a building to electrical exhibits. It was a historic event as Tesla and George Westinghouse introduced visitors to AC power by using it to illuminate the Exposition. This was the first plant producing electricity using Tesla's AC system. On display were Tesla's fluorescent lights and single node bulbs. Tesla also explained the principles of the *rotating magnetic field* and *induction motor* by demonstrating how to make an egg made of copper stand on end in his demonstration of the device he constructed known as the "Egg of Columbus". In 1896 the world's first large-scale power plant producing AC power was set up at Niagara Falls. Both these systems clearly demonstrated the superiority of AC power over Edison's DC power.

**Conflict with Edison**

In the late 1880s, Tesla and Edison became adversaries in part due to Edison's promotion of direct current (DC) for electric power distribution over the more efficient alternating current (AC) advocated by Tesla and Westinghouse. Until Tesla invented the induction motor, AC's advantages for long distance high voltage transmission were counterbalanced by the failure to operate motors on AC. As a result of the "War of Currents", Edison and Westinghouse went nearly bankrupt. So in 1897, Tesla released Westinghouse from contract obligations, providing Westinghouse a break from Tesla's patent royalties. In doing so Tesla gave away nearly 12 million dollars in royalty that he would have received. In 1894, he was given honorary doctoral degrees by Columbia and Yale Universities and the Elliot Cresson Medal by the Franklin Institute. In 1934, the city of Philadelphia awarded him the

John Scott Medal for his polyphase power system. He was an honorary member of the National Electric Light Association and a fellow of the American Association for the Advancement of Science.

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In 1896, when Tesla was 41 years old, he filed the first radio patent. This was well before Marconi's invention. A year later, he demonstrated a radio-controlled boat to the US military. In 1898, a radio-controlled boat was demonstrated to the public during an electrical exhibition at Madison Square Garden. These devices had an innovative coherer and a series of logic gates. In the same year, Tesla devised an "electric igniter" or spark plug for internal combustion gasoline engines. Tesla lived in Gerlach Hotel, later renamed The Radio Wave building, at 49 W 27th St. (between Broadway and Sixth Avenue), Lower Manhattan, before the end of the century where he conducted the radio wave experiments. A commemorative plaque was placed on the building in 1977 to honor his work.

**Colorado Springs**

In 1899, Tesla on the invitation of L E Curtis decided to move and began research in Colorado Springs, Colorado, where he would have room for his high voltage, high frequency experiments. Upon his arrival he told reporters that he was conducting wireless telegraphy experiments transmitting signals from Pikes Peak to Paris. Tesla's diary contains explanations of his experiments concerning the ionosphere and the ground's telluric currents via transverse and longitudinal waves. At his laboratory, Tesla proved that the Earth was a conductor, and he produced artificial lightning (with discharges consisting of millions of volts, and up to 135 feet long). Tesla also investigated atmospheric electricity, observing lightning signals via his receivers. Reproductions of Tesla's receivers and coherer circuits show an unpredictable level of complexity (e.g., distributed high-Q helical resonators, radio frequency feedback, crude heterodyne effects, and regeneration techniques). Tesla stated that he observed stationary

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waves during this time. In the Colorado Springs laboratory, he "recorded" what he believed were extraterrestrial radio signals, though his announcements and data were rejected by the scientific community. He noted measurements of repetitive signals from his receiver which were substantially different from the signals he had noted from storms and "earth noise". Specifically, he later recalled that the signals appeared in groups of one, two, three, and four clicks. In 1996 Corum and Corum published an analysis of Jovian plasma torus signals which indicated that Tesla's highly sensitive instrument may have detected them. This was the first such attempt towards radio astronomy.

The breadth of his inventions is further demonstrated by his patent for a bladeless steam turbine which Tesla demonstrated in 1906 producing 200 hp (150 kW) at 16,000 rpm.

Since the Nobel Prize in Physics was awarded to Marconi for radio in 1909, Thomas Edison and Tesla were mentioned as potential laureates to share the Nobel Prize of 1915 in a press dispatch, leading to one of several Nobel Prize controversies. Some sources have claimed that due to their animosity towards each other neither was given the award, despite their enormous scientific contributions, and that each sought to minimize the other's achievements and right to win the award, that both refused to ever accept the award if the other received it first, and that both rejected any possibility of sharing it. In the events which followed after the rumors, neither Tesla nor Edison ever won the prize.

In 1917 Tesla was awarded the Edison Medal, the most coveted prize of IEEE. He reluctantly accepted it since he hated Edison. In his speech presenting Tesla with the Edison medal, Vice President Behrend of the Institute of Electrical Engineers eloquently expressed the following: "Were we to seize and eliminate from our industrial world the result of Mr. Tesla's work, the wheels of industry would cease to turn, our electric cars and trains would stop, our towns would be dark and our mills would be idle and dead. His name marks an epoch in the advance of electrical science". Behrend ended his speech with a paraphrase of Pope's

lines on Newton: "Nature and nature's laws lay hid by night. God said 'Let Tesla Be', and all was light". In August 1917, Tesla propounded the principles for the first primitive RADAR. In 1934, Emile Girardeau, working with the first French RADAR system, stated that he was building RADAR systems "conceived according to the principles stated by Tesla".

On Tesla's seventy-fifth birthday in 1931, the *Time* magazine put him on its cover. The caption noted his contribution to electrical power generation. Tesla received his last patent in 1928 for an apparatus for aerial transportation which was the first proposal for a vertical take off light (VTOL) aircraft.

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Tesla worked on plans for a directed-energy weapon which he called "death ray", between the early 1900s till the time of his death. In 1937, Tesla composed a treatise entitled *The Art of Projecting Concentrated Non-dispersive Energy through the Natural Media* concerning charged particle beams. Tesla published the document in an attempt to expound on the technical description of a "super weapon that would put an end to all war". This treatise on the particle beam is currently in the Nikola Museum archive in Belgrade. It described an open ended vacuum tube with a gas jet seal that allowed particles to exit, a method of charging particles to millions of volts, and a method of creating and directing non-dispersive particle streams (through electrostatic repulsion).

His records on this subject indicate that this device was based on a narrow stream of atomic clusters of liquid mercury or tungsten accelerated by high voltage (akin to his magnifying transformer). Tesla gave the following colorful description regarding the particle gun's operation; "The nozzle would send concentrated beams of particles through the free air, of such tremendous energy that they will bring down a fleet of 10,000 enemy airplanes at a distance of 200 miles from a defending nation's border and will cause armies to drop dead in their tracks".

Tesla tried to interest the US War Department in the device. He

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also offered this invention to European countries. None of the governments purchased a contract to build the device.

Tesla died of heart failure in the New Yorker Hotel (where he was living alone), some time between the evening of January 5 and the morning of January 8, 1943, at the age of 86. Immediately after his death all his papers were seized and sealed by FBI marking them "top secret". Despite creating and patenting a large number of inventions, Tesla was essentially a destitute and died with significant debts. Later that year the US Supreme Court upheld Tesla's patent on radio, in effect recognizing him as the inventor of radio. The recognition came after 47 years and robbed him of the Nobel Prize.

The world has now recognized the genius of Tesla. The SI unit measuring magnetic flux density or magnetic induction (commonly known as the magnetic field $B$) was called Tesla, in his honor in 1960. The United States Postal Service honored Tesla with a commemorative stamp in 1983. The Nikola Tesla Award given by IEEE is one of the most distinguished honors in the field of electrical engineering. The award has been given annually since 1976. The year 2006 was celebrated by UNESCO as the 150th anniversary of the birth of Nikola Tesla.

Tesla worked alone. He did not have assistants. He was a perfectionist and hence did not file a patent till he had a working device. This meant that many of his brilliant ideas never saw the light of day.

## Suggested Reading


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