Nikola Tesla - Life And Legacy

Nikola Tesla was born a subject of the Austro-Hungarian Empire in 1856 in a mountainous area of the Balkan Peninsula known as Lika. His father Milutin, and his mother Djuka, were both Serbian by origin. Tesla's father was a stern but loving Orthodox priest, who was also a gifted writer and poet. At a young age, Tesla immersed himself in his father's library. Tesla's mother was a hard working woman of many talents who created appliances to help with home and farm responsibilities. One of these was a mechanical eggbeater. Tesla attributed all of his inventive instincts to his mother.

Tesla began his education at home and later attended gymnasium in Carlstadt, Croatia excelling in his studies along the way. An early sign of his genius, he was able to perform integral calculus in his mind, prompting his teachers to think he was cheating. During this period young "Niko" saw a steel engraving of Niagara Falls. In his imagination there appeared a huge water wheel being turned by the powerful cataract. He said to an uncle that he would go to America one day and capture energy in this way. Thirty years later he did exactly that. Despite his early creativity, Tesla did not begin to think of himself as an inventor until he was a young adult.

Passionate about mathematics and sciences, Tesla had his heart set on becoming an engineer but was "constantly oppressed" by his father's insistence that he enter the priesthood. At age seventeen, Tesla contracted cholera and craftily exacted an important concession from his father: the older Tesla promised his son that if he survived, he would be allowed to attend the renowned Austrian Polytechnic School at Graz to study engineering. Tesla's wish became a reality.

At the Polytechnic school Tesla began his studies in mechanical and electrical engineering. One day a physics teacher showed Tesla's class a new Gramme dynamo that—by employing direct current—could be used as both a motor and a generator. After watching it for a time, Tesla suggested it might be possible to do away with a set of inefficient sparking connections known as commutators. This, his amused professor said, would be like building a perpetual motion machine! Not even Tesla could hope to achieve such a feat. For the next several years the challenge obsessed Tesla, who instinctively knew that the solution lay in electric currents that alternated.

It wasn't until age twenty-four, when Tesla was living in Budapest and working for the Central Telephone Exchange, that the answer came to him:

One afternoon, which is ever present in my recollection, I was enjoying a walk with my friend in the city park and reciting poetry. At that age I knew entire books by heart, word for word. One of these was Goethe's *Faust.* The sun was just setting and reminded me of a glorious passage:

The glow retreats, done is the day of toil;
It yonder hastes, new fields of life exploring;
Ah, that no wing can lift me from the soil
Upon its track to follow, follow soaring!

As I uttered these inspiring words the idea came like a flash of lightning and in an instant the truth was revealed. I drew with a stick on the sand the diagram shown six years later in my address before the American Institute of Electrical Engineers.

This was the invention of the induction motor, a technological advance that would soon change the world.

Following his discovery in Budapest, Tesla was hired by electric power companies in Strasbourg and Paris to improve their DC generation facilities. In Germany and France, he attempted to interest investors in his concept for an AC motor, but had no success. It was clear that in order to realize his idea, he would have to meet the greatest electrical engineer in the world—Thomas Alva Edison.

At age 28, Nikola Tesla arrived in New York City and was shocked by what he discovered. "What I had left was beautiful, artistic and fascinating in every way; what I saw here was machined, rough and unattractive. It [America] is a century behind Europe in civilization." The Serbian immigrant had four cents in his pocket, some mathematical computations, a drawing of an idea for a flying machine, and a letter of introduction from Charles Batchelor, one of Edison's business associates in Europe.

Electricity was first introduced to New York in the late 1870s. Edison's incandescent lamp had created an astonishing demand for electric power. And his DC power station on Pearl Street in lower Manhattan was quickly becoming a monopoly. On the streets, single poles carried dozens of crooked crossbeams supporting sagging wires, and the exposed electrical wiring was a constant danger. Unsuspecting children would scale the poles only to meet an untimely electrical demise. The residents of Brooklyn became so accustomed to dodging shocks from electric trolley tracks that their baseball team was called the *Brooklyn Dodgers*. In spite of the perils, wealthy New Yorkers rushed to have their homes wired, the most important being the banker, J.P. Morgan, who had invested heavily in Edison.

It was into this state of affairs that the 6'4" immigrant from Eastern Europe entered Edison's office. Thrilled and terrified to meet his hero, Tesla handed Edison his letter of recommendation: It read: "My Dear Edison: I know two great men and you are one of them. The other is this young man!" Tesla proceeded to describe the engineering work he had done, and his plans for an alternating current motor.

Edison knew little of alternating current and did not care to learn more about it. In short, AC power sounded like competition to Edison. But there was something different about Tesla, and Edison immediately hired him to make improvements in his DC generation plants. Tesla claimed that Edison promised him $50,000 if he succeeded, perhaps thinking it an impossible undertaking. But the potential of so much money appealed mightily to the impoverished immigrant.

Both Tesla and Edison shared a common trait of genius in that neither of them seemed to need much sleep. Edison could go for days, taking occasional catnaps on a sofa in his office. Tesla claimed that his working hours at the Edison Machine Works were 10:30 a.m. till 5 a.m. the next day. Even into old age Tesla said he only slept two or three hours a night.

That's where the similarity ended. Tesla relied on moments of inspiration, perceiving the invention in his brain in precise detail before moving to the construction stage. Edison was a trial and error man who described invention as five percent inspiration and 95 percent perspiration. Edison was self-taught. Tesla had a formal European education.

It was only a matter of time until their differences would lead to conflict.

Several months after Edison employed him, Tesla announced that his work was successfully completed. When Tesla asked to be paid, however, Edison seemed astonished. He explained that the offer of $50,000 had been made in jest. "When you become a full-fledged American you will appreciate an American joke," Edison said. Shocked and disgusted, Tesla immediately resigned.

Word began to spread that a foreigner of unusual talent was digging ditches to stay alive. Investors approached Tesla and asked him to develop an improved method for arc lighting. Although this was not the opportunity he had hoped for, the group was willing to finance the Tesla Electric Light Company. The proud new owner set to work and invented a unique arc lamp of beautiful design and efficiency. Unfortunately, all of the money earned went to the investors and all Tesla got was a stack of worthless stock certificates.

But his luck was about to change. Mr. A.K. Brown of the Western Union Company, agreed to invest in Tesla's idea for an AC motor. In a small laboratory just a short distance from Edison's office, Tesla quickly developed all the components for the system of AC power generation and transmission that is used universally throughout the world today. "The motors I build there," said Tesla, "were exactly as I imagined them. I made no attempt to improve the design, but merely reproduced the pictures as they appeared to my vision and the operation was always as I expected." The battle to produce his motor was over. But the struggle to introduce it commercially was only just beginning.

In November and December of 1887, Tesla filed for seven U.S. patents in the field of polyphase AC motors and power transmission. These comprised a complete system of generators, transformers, transmission lines, motors and lighting. So original were the ideas that they were issued without a successful challenge, and would turn out to be the most valuable patents since the telephone.

An adventurous Pittsburgh industrialist named George Westinghouse, inventor of railroad air brakes, heard about Tesla's invention and thought it could be the missing link in long-distance power transmission. He came to Tesla's lab and made an offer, purchasing the patents for $60,000, which included $5,000 in cash and 150 shares of stock in the Westinghouse Corporation. He also agreed to pay royalties of $2.50 per

horsepower of electrical capacity sold. With more inventions in mind, Tesla quickly spent half of his newfound wealth on a new laboratory.

With the breakthrough provided by Tesla's patents, a full-scale industrial war erupted. At stake, in effect, was the future of industrial development in the United States, and whether Westinghouse's alternating current or Edison's direct current would be the chosen technology.

It was at this time that Edison launched a propaganda war against alternating current. Westinghouse recalled:

I remember Tom [Edison] telling them that direct current was like a river flowing peacefully to the sea, while alternating current was like a torrent rushing violently over a precipice. Imagine that! Why they even had a professor named Harold Brown who went around talking to audiences... and electrocuting dogs and old horses right on stage, to show how dangerous alternating current was.
Meanwhile, a murderer was about to be executed in the first electric chair at New York's Auburn State Prison. Professor Brown had succeeded in illegally purchasing a used Westinghouse generator in order to demonstrate once and for all the extreme danger of alternating current. The guinea pig was William Kemmler, a convicted ax-murderer, who died horribly on August 6, 1890, in "an awful spectacle, far worse than hanging." The technique was later dubbed "Westinghousing."

In spite of the bad press, good things were happening for Westinghouse and Tesla. The Westinghouse Corporation won the bid for illuminating The Chicago World's Fair, the first all-electric fair in history. The fair was also called the Columbian Exposition — in celebration of the 400th Anniversary of Columbus discovering America. Up against the newly formed General Electric Company (the company that had taken over the Edison Company), Westinghouse undercut GE's million-dollar bid by half. Much of GE's proposed expenses were tied to the amount copper wire necessary to utilize DC power. Westinghouse's winning bid proposed a more efficient, cost-effective AC system.

The Columbian Exposition opened on May 1, 1893. That evening, President Grover Cleveland pushed a button and a hundred thousand incandescent lamps illuminated the fairground's neoclassical buildings. This "City of Light" was the work of Tesla, Westinghouse and twelve new thousand-horsepower AC generation units located in the Hall of Machinery. In the Great Hall of Electricity, the Tesla polyphase system of alternating current power generation and transmission was proudly displayed. For the twenty-seven million people who attended the fair, it was dramatically clear that the power of the future was AC. From that point forward more than 80 percent of all the electrical devices ordered in the United States were for alternating current.

The Niagara Falls Power Project was an act of pure technological optimism. Americans had dreamed of pressing the Falls into "an honest day's work" since the first pioneer sawmill had been built there in 1725. But schemes for extracting power had never been adequately conceived.

Since his childhood, Tesla himself had dreamed of harnessing the power of the great natural wonder. And in late 1893, his dream became a reality, when Westinghouse was awarded the contract to create the powerhouse.

The contract came as a result of a failed competition spearheaded by the international Niagara Falls Commission. The commission, charged with planning the power project, had solicited proposals from experts around the world only to reject them all. The schemes ranged from a system using pneumatic pressure to one requiring ropes, springs and pulleys. And there were proposals to transmit DC electricity, one endorsed by Edison. At the head of the commission was Lord Kelvin, the famous British physicist, who had been as opposed to alternating current as Edison until he attended the Chicago Exposition. Now, a strong convert to AC, Kelvin and his commission asked Westinghouse to use alternating current to harness the power of the falls.

The construction period was traumatic for engineers, mechanics and workers, but it weighed most heavily on investors. Project backers included several of the wealthiest men in America and Europe, including: J. P. Morgan, John Jacob Astor, Lord Rothschild, and W. K. Vanderbilt. After a five-year nightmare of doubt and financial crises, the project approached completion. Tesla had not doubted the results for a moment. The investors, however, were not at all sure the system would work. While the machines were running smoothly

in Tesla's three-dimensional imagination, they were still unproved and expensive.

But the worries were unwarranted. When the switch was thrown, the first power reached Buffalo at midnight, November 16, 1896. The *Niagara Falls Gazette* reported that day, "The turning of a switch in the big powerhouse at Niagara completed a circuit which caused the Niagara River to flow uphill." The first one thousand horsepower of electricity surging to Buffalo was claimed by the street railway company, but already the local power company had orders from residents for five thousand more. Within a few years the number of generators at Niagara Falls reached the planned ten, and power lines were electrifying New York City. Broadway was ablaze with lights; the elevated, street railways, and subway system rumbled; and even the Edison systems converted to alternating current.

But there were complications. Both the Westinghouse and General Electric corporations were morally and financially drained by the War of the Currents. Years of litigation, the absorption of Edison's company and others by professional managers at GE, and the financial teetering of Westinghouse all contributed to a takeover. This was the era of the Robber Barons, and one of the biggest was ready to make his move. J. P. Morgan, hoping to bring all U.S. hydroelectric power under his control, proceeded to manipulate stock market forces with the intention of starving out Westinghouse and buying the Tesla patents. Thanks in part to Tesla, this did not happen.

Westinghouse called on the inventor, pleading for an escape from the initial contract that gave Tesla generous royalties. In a magnanimous and history-making gesture, Tesla said he tore up the contract. He was, after all, grateful to the one man who had believed in his invention. And he was convinced that greater inventions lay ahead. The Westinghouse Electric Company was saved for future triumphs. Tesla, although sharing the glory, was left forever afterward in recurring financial difficulties.

After the success of Niagara, Tesla resumed his favorite work—experimentation. Back at his laboratory on Grand Street in New York City, Tesla engrossed himself in the exploration of high frequency electricity.

A number of scientific breakthroughs had already shed light on the high-frequency phenomenon. In 1873, James Clerk Maxwell, in England, had proven mathematically that light was electromagnetic radiation—light was electricity, vibrating at an extremely high frequency. In 1888, Heinrich Hertz of Germany confirmed experimentally that an electric spark propagates electromagnetic waves into space. These discoveries identified radio waves and prompted intense speculation about new possibilities for electricity.

Tesla began to search for a device that could transport him to this unexplored territory. He knew that higher frequencies would have many technical advantages: lamps could glow brighter, energy could be transmitted more efficiently, and this would all be less dangerous because the energy could pass harmlessly across the body.

Tesla's initial goal was to approximate the frequency of sunlight and create lamps of revolutionary brightness and configuration. This, he hoped, would eliminate Edison's incandescent lamp, which utilized only five percent of the available energy.

Tesla began his high frequency investigations by building rotary AC generators that could run at higher speeds; but as he approached twenty thousand cycles per second, the machines began to fly apart, leaving him far short of his goal. The answer came with a remarkable device still known today as a Tesla coil. Patented in 1891, this invention took ordinary sixty-cycle per second household current and stepped it up to extremely high frequencies—into the hundreds of thousands of cycles per second. In addition to high frequencies, the coil could also generate extremely high voltages.

With high frequencies, Tesla developed some of the first neon and fluorescent illumination. He also took the first x-ray photographs. But these discoveries paled when compared to his discovery of November 1890, when he illuminated a vacuum tube wirelessly—having transmitted energy through the air.

This was the beginning of Tesla's lifelong obsession—the wireless transmission of energy.

With his newly created Tesla coils, the inventor soon discovered that he could transmit and receive powerful radio signals when they were tuned to resonate at the same frequency. When a coil is tuned to a signal of a particular frequency, it literally magnifies the incoming electrical energy through resonant action. By early 1895, Tesla was ready to transmit a signal 50 miles to West Point, New York... But in that same year,

disaster struck. A building fire consumed Tesla's lab, destroying his work.

The timing could not have been worse. In England, a young Italian experimenter named Guglielmo Marconi had been hard at work building a device for wireless telegraphy. The young Marconi had taken out the first wireless telegraphy patent in England in 1896. His device had only a two-circuit system, which some said could not transmit "across a pond." Later Marconi set up long-distance demonstrations, using a Tesla oscillator to transmit the signals across the English Channel.

Tesla filed his own basic radio patent applications in 1897. They were granted in 1900. Marconi's first patent application in America, filed on November 10, 1900, was turned down. Marconi's revised applications over the next three years were repeatedly rejected because of the priority of Tesla and other inventors.

The Patent Office made the following comment in 1903:

Many of the claims are not patentable over Tesla patent numbers 645,576 and 649,621, of record, the amendment to overcome said references as well as Marconi's pretended ignorance of the nature of a "Tesla oscillator" being little short of absurd... the term "Tesla oscillator" has become a household word on both continents [Europe and North America].

But no patent is truly safe, as Tesla's career demonstrates. In 1900, the Marconi Wireless Telegraph Company, Ltd. began thriving in the stock markets—due primarily to Marconi's family connections with English aristocracy. British Marconi stock soared from $3 to $22 per share and the glamorous young Italian nobleman was internationally acclaimed. Both Edison and Andrew Carnegie invested in Marconi and Edison became a consulting engineer of American Marconi. Then, on December 12, 1901, Marconi for the first time transmitted and received signals across the Atlantic Ocean.

Otis Pond, an engineer then working for Tesla, said, "Looks as if Marconi got the jump on you." Tesla replied, "Marconi is a good fellow. Let him continue. He is using seventeen of my patents."

But Tesla's calm confidence was shattered in 1904, when the U.S. Patent Office suddenly and surprisingly reversed its previous decisions and gave Marconi a patent for the invention of radio. The reasons for this have never been fully explained, but the powerful financial backing for Marconi in the United States suggests one possible explanation.

Tesla was embroiled in other problems at the time, but when Marconi won the Nobel Prize in 1911, Tesla was furious. He sued the Marconi Company for infringement in 1915, but was in no financial condition to litigate a case against a major corporation. It wasn't until 1943—a few months after Tesla's death— that the U.S. Supreme Court upheld Tesla's radio patent number 645,576. The Court had a selfish reason for doing so. The Marconi Company was suing the United States Government for use of its patents in World War I. The Court simply avoided the action by restoring the priority of Tesla's patent over Marconi.

Tesla wanted an extraordinary way to demonstrate the potential of his system for wireless transmission of energy [radio]. In 1898, at an electrical exhibition in the recently completed Madison Square Garden, he made a demonstration of the world's first radio-controlled vessel. Everyone expected surprises from Tesla, but few were prepared for the sight of a small, odd-looking, iron-hulled boat scooting across an indoor pond (specially built for the display). The boat was equipped with, as Tesla described, "a borrowed mind."

"When first shown... it created a sensation such as no other invention of mine has ever produced," wrote Tesla. As happened fairly often with his inventions, many of those present were unsure how to react, whether to laugh or take flight. He had cleverly devised a means of putting the audience at ease, encouraging onlookers to ask questions of the boat. For instance, in response to the question "What is the cube root of 64?" lights on the boat flashed four times. In an era when only a handful of people knew about radio waves, some thought that Tesla was controlling the small ship with his mind. In actuality, he was sending signals to the mechanism using a small box with control levers on the side.

Tesla's U.S. patent number 613,809 describes the first device anywhere for wireless remote control. The working model, or "teleautomaton," responded to radio signals and was powered with an internal battery.

Tesla did not limit his method to boats, but generalized the invention's potential to include vehicles of any sort and mechanisms to be actuated for any purpose. He envisioned one operator or several operators

simultaneously directing fifty or a hundred vessels or machines through differently tuned radio transmitters and receivers.

When a New York Times writer suggested that Tesla could make the boat submerge and carry dynamite as a weapon of war, the inventor himself exploded. Tesla quickly corrected the reporter: "You do not see there a wireless torpedo, you see there the first of a race of robots, mechanical men which will do the laborious work of the human race."

Tesla's device was literally the birth of robotics, though he is seldom recognized for this accomplishment. The inventor was trained in electrical and mechanical engineering, and these skills merged beautifully in this remote-controlled boat. Unfortunately, the invention was so far ahead of its time that those who observed it could not imagine its practical applications.

By the end of the 1890s, Tesla had come to the conclusion that it might be possible to transmit electrical power without wires at high altitudes. There the air was thinner, and therefore more conductive.

A friend and patent lawyer, Leonard E. Curtis, on being advised of Tesla's work, offered to find land and provide power for the research from the El Paso Power Company of Colorado Springs. The next supporter to come forward was Colonel John Jacob Astor. With $30,000 from Astor, the inventor prepared at once to move to Colorado and begin building a new experimental station near Pikes Peak. Joining Tesla were several assistants who were not fully informed of the inventor's plans.

Arriving at Colorado Springs in May 1899, Tesla went to inspect the acreage. It was some miles out in the prairie. He told reporters that he intended to send a radio signal from Pikes Peak to Paris, but furnished no details.

In the midst of Colorado's own incredible electrical displays, Tesla would sit taking measurements. He soon found the earth to be "literally alive with electrical vibrations." Tesla came to think that when lightning struck the ground it set up powerful waves that moved from one side of the earth to the other. If the earth was indeed a great conductor, Tesla hypothesized that he could transmit unlimited amounts of power to any place on earth with virtually no loss. But to test this theory, he would have to become the first man to create electrical effects on the scale of lightning.

The laboratory that rose from the prairie floor was both wired and weird, a contraption with a roof that rolled back to prevent it from catching fire, and a wooden tower that soared up eighty feet. Above it was a 142-foot metal mast supporting a large copper ball. Inside the strange wooden structure, technicians began to assemble an enormous Tesla coil, specially designed to send powerful electrical impulses into the earth.

On the evening of the experiment, each piece of equipment was first carefully checked. Then Tesla alerted his mechanic, Czito, to open the switch for only one second. The secondary coil began to sparkle and crack and an eerie blue corona formed in the air around it. Satisfied with the result, Tesla ordered Czito to close the switch until told to cease. Huge arcs of blue electricity snaked up and down the center coil. Bolts of man-made lightning more than a hundred feet in length shot out from the mast atop the station. Tesla's experiment burned out the dynamo at the El Paso Electric Company and the entire city lost power. The power station manager was livid, and insisted that Tesla pay for and repair the damage.

For nine months Tesla conducted experiments at Colorado Springs. Though he kept a day-to-day diary that was rich in detail, the results of his experiments are not clear. One question has never been definitively answered: Did Tesla actually transmit wireless power at Pikes Peak?

There are some reports that he did transmit a signal several miles powerful enough to illuminate vacuum tubes planted in the ground. But this can be attributed to conductive properties in the ground at Colorado Springs.

Another approach pursued by Tesla was to transmit extra-low-frequency signals through the space between the surface of the earth and the ionosphere. Tesla calculated that the resonant frequency of this area was approximately 8-hertz. It was not until the 1950s that this idea was taken seriously and researchers were surprised to discover that the resonant frequency of this space was indeed in the range of 8-hertz.

A third approach for wireless power transmission was to transmit electrical power to the area 80-kilometers

above the earth known as the ionosphere. Tesla speculated that his region of the atmosphere would be highly conductive and again his suspicions were correct. What he needed was the technical means to send electrical power to such a high altitude.

One night in his laboratory, Tesla noticed a repeating signal being picked-up by his transmitter. To his own amazement, he believed that he was receiving a signal from outer space. Tesla was widely ridiculed when he announced this discovery, but it is possible that he was the first man to detect radio waves from space.

A great deal of mystery still surrounds Tesla's work at Colorado Springs. It is not clear from his notes or his comments exactly how he intended to transmit wireless power. But it is clear that he returned back to New York City fully convinced that he could accomplish it.

When Tesla returned from Colorado Springs to New York, he wrote a sensational article for *Century Magazine*. In this detailed, futuristic vision he described a means of tapping the sun's energy with an antenna. He suggested that it would be possible to control the weather with electrical energy. He predicted machines that would make war an impossibility. And he proposed a global system of wireless communications. To most people the ideas were almost incomprehensible, but Tesla was a man who could not be underestimated.

The article caught the attention of one of the world's most powerful men, J. P. Morgan. A frequent guest in Morgan's home, Tesla proposed a scheme that must have sounded like science fiction: a "world system" of wireless communications to relay telephone messages across the ocean; to broadcast news, music, stock market reports, private messages, secure military communications, and even pictures to any part of the world. "When wireless is fully applied the earth will be converted into a huge brain, capable of response in every one of its parts," Tesla told Morgan.

Morgan offered Tesla $150,000 to build a transmission tower and power plant. A more realistic sum would have been $1,000,000, but Tesla took what was available and went to work immediately. In spite of what he told his investor, Tesla's actual plan was to make a large-scale demonstration of electrical power transmission without wires. This turned out to be a fatal mistake.

For his new construction project, Tesla acquired land on the cliffs of Long Island Sound. The site was called Wardenclyffe. By 1901 the Wardenclyffe project was under construction, the most challenging task being the erection of an enormous tower, rising 187 feet in the air and supporting on its top a fifty-five-ton sphere made of steel. Beneath the tower, a well-like shaft plunged 120 feet into the ground. Sixteen iron pipes were driven three hundred feet deeper so that currents could pass through them and seize hold of the earth. "In this system that I have invented," Tesla explained, "it is necessary for the machine to get a grip of the earth, otherwise it cannot shake the earth. It has to have a grip... so that the whole of this globe can quiver."

As the tower construction slowly increased, it became evident that more funds were sorely needed. But Morgan was not quick to respond. Then on December 12, 1901, the world awoke to the news that Marconi had signaled the letter "S" across the Atlantic from Cornwall, England to Newfoundland. Tesla, unruffled by the accomplishment, explained that the Italian used 17 Tesla patents to accomplish the transmission. But Morgan began to doubt Tesla. Marconi's system not only worked, it was also inexpensive.

Tesla pleaded with Morgan for more financial support, but the investor soundly refused. To make matters worse, the stock market crashed and prices for the tower's materials doubled. High prices combined with Tesla's inability to find enough willing investors eventually led to the demise of the project.

In 1905, after some amazing electrical displays, Tesla and his team had to abandon the project forever. The newspapers called it, "Tesla's million dollar folly."

Humiliated and defeated, Tesla experienced a complete nervous breakdown. "It is not a dream," he protested. "It is a simple feat of scientific electrical engineering, only expensive... blind, faint-hearted, doubting world."

In 1909, Guglielmo Marconi was awarded a Nobel Prize for his development of radio. From this point on, the history books began to refer to him as "the father of radio." In fact, radio had many inventors, not the least of which was Nikola Tesla. But Marconi was now a wealthy man and Tesla was penniless.

"My enemies have been so successful in portraying me as a poet and a visionary," said Tesla, "that I must put out something commercial without delay."

In 1912, Tesla tested a revolutionary new kind of turbine engine. Both Westinghouse Manufacturing and the General Electric Company had spent millions developing bladed turbine designs, which were essentially powerful windmills in a housing. Tesla's design was something altogether different. In it, a series of closely spaced discs were keyed to a shaft. With only one moving part, Tesla's design was of ideal simplicity, much like the AC motor he had invented years earlier. Fuels such as steam or vaporized gas were injected into the spaces between the discs, spinning the motor at a high rate of speed. In fact, the turbine operated at such high revolutions to the minute that the metal in the discs distorted from the heat. Eventually, Tesla abandoned the project.

With no great prospects to speak of, Tesla began visiting the local parks more often, rescuing injured pigeons, and often taking them back to his hotel room to nurse them. Years later, when he lived at the Hotel New Yorker, he had the hotel chef prepare a special mix of seed for his pigeons, which he hoped to sell commercially. Naturally, this prompted speculation about his mental well-being. His aversion to germs also heightened in this period, and he began to wash his hands compulsively and would eat only boiled foods.

In spite of his growing eccentricity, fruitful ideas continued to spring from his imagination. At the beginning of World War I, Tesla described a means for detecting ships at sea. His idea was to transmit high-frequency radio waves that would reflect off the hulls of vessels and appear on a fluorescent screen. The idea was too far ahead of its day, but it was one of the first descriptions of what we now call radar. Tesla was also the first to warn of an era when flying vehicles without wings could be remotely controlled to land with an explosive charge on an unsuspecting enemy.

In 1922, at sixty-five years of age, Tesla still dressed impeccably. Yet friends observed that his clothing, like his scientific theories, now appeared old-fashioned. He managed to make a living by working as a consulting engineer, but more often than not he delivered plans that his clients deemed impractical.

During this period, Tesla spoke out vehemently against the new theories of Albert Einstein, insisting that energy is not contained in matter, but in the space between the particles of an atom.

In the late 1920s, Tesla began to develop a friendship with George Sylvester Viereck, a well-known German poet and mystic. Though nearly a recluse, Tesla occasionally attended dinner parties held by Viereck and his wife. Competitive by nature, Tesla wrote a strange poem that he dedicated to his friend. It was called "Fragments of Olympian Gossip" and poked vitriolic fun at the scientific establishment of the day.

Tesla's business with the U. S. Patent Office was still not finished. In 1928, at the age of seventy-two, he received his last patent, number 6,555,114, "Apparatus For Aerial Transportation." This brilliantly designed flying machine resembled both a helicopter and an airplane. According to the inventor, the device would weigh eight-hundred pounds. It would rise from a garage, a roof, or a window as desired, and would sell at $1,000 for both military and consumer uses. This novel invention was the progenitor of today's tiltrotor or VSTOL (vertical short takeoff and landing) plane. Unfortunately, Tesla never had the money to build a prototype.

Tesla inherited from his father a deep hatred of war. Throughout his life, he sought a technological way to end warfare. He thought that war could be converted into, "a mere spectacle of machines."

In 1931 Tesla announced to reporters at a press conference that he was on the verge of discovering an entirely new source of energy. Asked to explain the nature of the power, he replied, "The idea first came upon me as a tremendous shock... I can only say at this time that it will come from an entirely new and unsuspected source."

War clouds were again darkening Europe. On 11 July 1934 the headline on the front page of the *New York Times* read, "TESLA, AT 78, BARES NEW 'DEATH BEAM.'" The article reported that the new invention "will 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 250 miles..." Tesla stated that the death beam would make war impossible by offering every country an "invisible Chinese wall."

The idea generated considerable interest and controversy. Tesla went immediately to J. P. Morgan, Jr. in

search of financing to build a prototype of his invention. Morgan was unconvinced. Tesla also attempted to deal directly with Prime Minister Neville Chamberlain of Great Britain. But when Chamberlain resigned upon discovering that he had been out-maneuvered by Hitler at Munich, interest in Tesla's anti-war weapon eventually collapsed.

By 1937 it was clear that war would soon break out in Europe. Frustrated in his attempts to generate interest and financing for his "peace beam," he sent an elaborate technical paper, including diagrams, to a number of Allied nations including the United States, Canada, England, France, the Soviet Union, and Yugoslavia. Titled "New Art of Projecting Concentrated Non-Dispersive Energy Through Natural Media," the paper provided the first technical description of what is today called a charged particle beam weapon.

What set Tesla's proposal apart from the usual run of fantasy "death rays" was a unique vacuum chamber with one end open to the atmosphere. Tesla devised a unique vacuum seal by directing a high-velocity air stream at the tip of his gun to maintain "high vacua." The necessary pumping action would be accomplished with a large Tesla turbine.

Of all the countries to receive Tesla's proposal, the greatest interest came from the Soviet Union. In 1937 Tesla presented a plan to the Amtorg Trading Corporation, an alleged Soviet arms front in New York City. Two years later, in 1939, one stage of the plan was tested in the USSR and Tesla received a check for $25,000.

Tesla hoped that his invention would be used for purely defensive purposes, and thus would become an anti-war machine. His system required a series of power plants located along a country's coast that would scan the skies in search of enemy aircraft. Since the beam was projected in a straight line, it was only effective for about 200 miles — the distance of the curvature of the earth.

Tesla also contemplated peacetime applications for his particle beam, one being to transmit power without wires over long distances. Another radical notion he proposed was to heat up portions of the upper atmosphere to light the sky at night — a man-made aurora borealis.

Whether Tesla's idea was ever taken seriously is still a mater of conjecture. Most experts today consider his idea infeasible. Though, his death beam bears an uncanny resemblance to the charged-particle beam weapon developed by both the United States and the Soviet Union during the cold war.

Nonetheless, Tesla's dream for a technological means to end war seems as impossible now as it did when he proposed the idea in the 1930s.

One of the more controversial topics involving Nikola Tesla is what became of many of his technical and scientific papers after he died in 1943. Just before his death at the height of World War II, he claimed that he had perfected his so-called "death beam." So it was natural that the FBI and other U.S. Government agencies would be interested in any scientific ideas involving weaponry. Some were concerned that Tesla's papers might fall into the hands of the Axis powers or the Soviets.

The morning after the inventor's death, his nephew Sava Kosanovic´ hurried to his uncle's room at the Hotel New Yorker. He was an up-and-coming Yugoslav official with suspected connections to the communist party in his country. By the time he arrived, Tesla's body had already been removed, and Kosanovic´ suspected that someone had already gone through his uncle's effects. Technical papers were missing as well as a black notebook he knew Tesla kept—a notebook with several hundred pages, some of which were marked "Government."

P. E. Foxworth, assistant director of the New York FBI office, was called in to investigate. According to Foxworth, the government was "vitally interested" in preserving Tesla's papers. Two days after Tesla's death, representatives of the Office of Alien Property went to his room at the New Yorker Hotel and seized all his possessions.

Dr. John G. Trump, an electrical engineer with the National Defense Research Committee of the Office of Scientific Research and Development, was called in to analyze the Tesla papers in OAP custody. Following a three-day investigation, Dr. Trump concluded:

His [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.

Just after World War II, there was a renewed interest in beam weapons. Copies of Tesla's papers on particle beam weaponry were sent to Patterson Air Force Base in Dayton, Ohio. An operation code-named "Project Nick" was heavily funded and placed under the command of Brigadier General L. C. Craigie to test the feasibility of Tesla's concept. Details of the experiments were never published, and the project was apparently discontinued. But something peculiar happened. The copies of Tesla's papers disappeared and nobody knows what happened to them.

In 1952, Tesla's remaining papers and possessions were released to Sava Kosanovic´ and returned to Belgrade, Yugoslavia where a museum was created in the inventor's honor. For many years, under Tito's communist regime, it was extremely difficult for Western journalists and scholars to gain access to the Tesla archive in Yugoslavia; even then they were allowed to see only selected papers. This was not the case for Soviet scientists who came in delegations during the 1950s. Concerns increased in 1960 when Soviet Premier Khrushchev announced to the Supreme Soviet that "a new and fantastic weapon was in the hatching stage."

Work on beam weapons also continued in the United States. In 1958 the Defense Advanced Research Projects Agency (DARPA) initiated a top-secret project code-named "Seesaw" at Lawrence Livermore Laboratory to develop a charged-particle beam weapon. More than ten years and twenty-seven million dollars later, the project was abandoned "because of the projected high costs associated with implementation as well as the formidable technical problems associated with propagating a beam through very long ranges in the atmosphere." Scientists associated with the project had no knowledge of Tesla's papers.

In the late 1970s, there was fear that the Soviets may have achieved a technological breakthrough. Some U.S. defense analysts concluded that a large beam weapon facility was under construction near the Sino-Soviet border in Southern Russia.

The American response to this "technological surprise" was the Strategic Defense Initiative announced by President Ronald Reagan in 1983. Teams of government scientists were urged to "turn their great talents now to the cause of mankind and world peace, to give us the means of rendering these nuclear weapons impotent and obsolete."

Today, after a half-century of research and billions of dollars of investment, the SDI program is generally considered a failure, and there is still no realistic means of defense against a nuclear missile attack.

For many years scientists and researchers have sought for Tesla's missing papers with no apparent success. It is conceivable that if Nikola Tesla knew a means for accurately projecting lethal beams of energy through the atmosphere, he may have taken it to the grave with him.