



Sorcerer *of*

Lightning:

Nikola Tesla

He is a mysterious, almost forgotten, figure, but his inventions in the areas of electrical motors, electrical distribution, remote control, low and high frequency waves, radio, radar and even death rays continue to have a major impact on science and engineering today. He was years and even decades more advanced than his colleagues and many argue he took to his grave knowledge that we still struggle to discover today.

Part One
By Lee Krystek

Photo by Amos Struck



"Nikola Tesla and a Guest"
Illustration by Medellia Grey

the risk. Others had been warned: Outside the laboratory grounds were signs posted "KEEP OUT - GREAT DANGER" and over the door of the building was a quote from Dante's *Inferno*: "Abandon hope all ye who enter here."

When Tesla was ready, he shouted to his assistant, Czito, "Now! Close the switch!" Czito had been instructed to keep the machine running until

ing, "Why did you do that? I did not tell you to open the switch. Close it again quickly!"

His assistant shook his head. He hadn't turned off the current. The power company was no longer sending it.

A quick call to the power station revealed the trouble. In the one minute it had been operating, Tesla's machine had overloaded the powerhouse generator, setting it on fire. The town of Colorado Springs was in a blackout and Tesla himself would have to take a team of trained workmen to the station to fix the dynamo. Even so, Tesla knew his new invention, his "resonate transformer," really worked.

Early Life

Nikola Tesla was born in 1856 in a mountainous area of the Balkan Peninsula that was then part of the Austro-Hungarian Empire. His parents were Serbian. His father, an Orthodox priest, was a writer and poet. His mother had mechanical aptitude and invented many appliances to use around the household and farm, including an eggbeater.

Tesla was such a brilliant mathematician in school that he performed integral calculus in his head, a skill that left his teachers thinking he must be cheating. While still at

Tesla told him to turn it off. Inside the building the massive switch was thrown and outside fireworks started to take place.

A heavy current raced through the primary coil of the machine and lightning bolts started to explode from the mast. Tesla watched as giant electrical sparks 135-foot long jumped from the large copper ball. They generated a thunder that could be heard 15 miles away. Tesla was so enthralled with the display that he lost all track of time.

Suddenly the lightning stopped. Tesla snapped out of his trance and raced into the building yell-

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It was a summer night in 1899 when Nikola Tesla, perhaps the greatest electrical genius of his time, emerged from his Colorado Springs laboratory to observe the first major test of what he would later call "my greatest invention." From outside the square barn-like building he could see a wooden tower eighty feet in height from which a 142-foot metal mast emerged. At the very top of the mast was a three-foot copper ball.

An earlier test, lasting only one second, had confirmed that the equipment in the building, an enormous "tesla coil" and the tower seemed to work. Now would come the full test. Neither Tesla nor his assistant was exactly sure what would happen - giant sparks? fire? explosion? - but they were ready to take

school he decided he wanted to become an engineer. This was a career which conflicted with his father's desire for Tesla to follow him into the priesthood. In the end, Tesla won the battle and was enrolled in the Austrian Polytechnic School at Graz.

While studying electrical and mechanical engineering Tesla was shown the newly-invented Gramme dynamo that could be used both as an electrical motor and a generator. He studied it and observed to his teacher that there should be some way of doing away with the inefficient sparking connector on the device. His professor was skeptical, but Tesla was right. Over the next few years Tesla would come up with the idea of alternating the current flow (known as AC) to solve this problem. In the end, this idea

would underlie the design of every commercial electrical system throughout the world.

Tesla was hired by firms in Germany and France to improve their direct current (DC) generation facilities, but neither was interested in his radical AC designs. It became apparent to him that he would have to take his inspiration to someone who could really appreciate

it. To the greatest electrical engineer of the day, the renowned "Wizard of Menlo Park," Thomas Alva Edison.

After getting a letter of introduction from one of Edison's European business partners, Charles Batchelor, Tesla took a ship to New York City. At the age of 28 he was off to see the Wizard.

Tesla and Edison

Arriving at Edison's office Tesla presented him with the letter of introduction from Batchelor. In part it read:

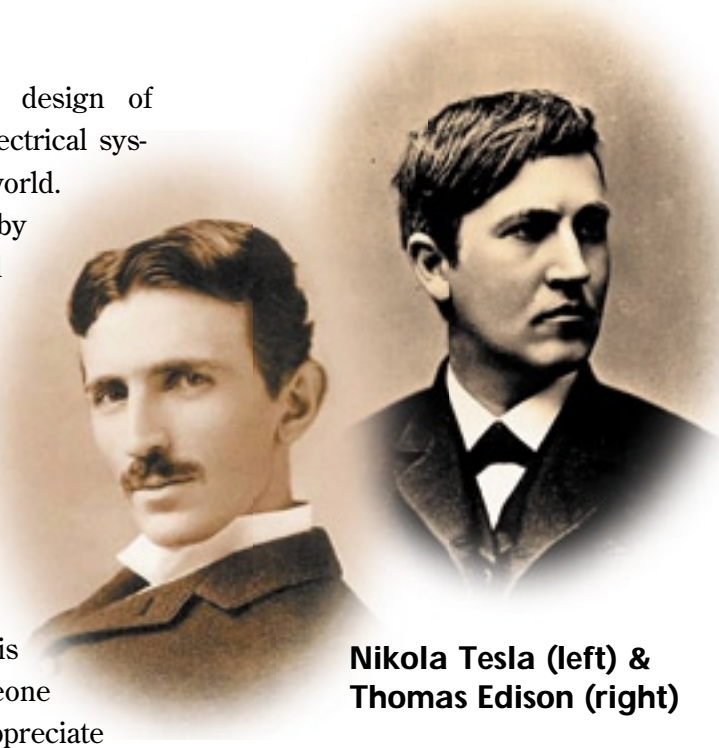
My Dear Edison, I know two great men and you are one of them. The other is this young man!

Tesla proceeded to explain his work and his idea for alternating current. Edison

wasn't interested. Edison already had an enormous amount of money invested in his own DC system and didn't want to change. He did recognize that this young man from Europe was very talented and offered to hire him, promising him \$50,000 if he could make certain improvements in his DC generation plants.

Despite both being genius inventors, Tesla and Edison had very different styles. Edison was largely self-taught, while Tesla had a formal European education. Edison discovered by trial and error, a method he expressed best in his famous saying, "Invention is five percent inspiration and 95 percent perspiration." Tesla preferred to think about an invention and would only build the actual model when he had it all worked out in his mind. Tesla's thinking was so precise that the first model would almost always work the way he expected with no alterations.

Tesla once said of Edison: *If Edison had a needle to find in a*



Nikola Tesla (left) & Thomas Edison (right)

Lightning from a 2-story tall Tesla coil



haystack, he would proceed at once with the diligence of the bee to examine straw after straw until he found the object of his search.. I was a sorry witness of such doings, knowing that a little theory and calculation would have saved him ninety per cent of his labor.

It wouldn't be long before the men would clash. Just a few months after starting, Tesla finished his improvements and went to Edison to get his \$50,000. Edison, who probably thought that what he had sent Tesla to do an impossible job, refused to pay, saying that the offer had not been meant to have been taken seriously. "When you become a full-fledged American, you will appreciate an American joke," Edison quipped.

Disgusted, Tesla resigned and soon got involved with investors who wished to build an improved arc lamp. They founded the *Tesla Electric Light Company*. His design was a success, but all the money went to the investors. Tesla was soon looking for another opportunity.

It came in the form of A.K. Brown of the Western Union Company. Brown agreed to invest in Tesla's idea for an AC motor. In a small laboratory not far from Edison's office, Tesla developed all the components necessary for an AC generation and distribution system along with his AC motor. Late in 1887 Tesla filed for seven U.S. patents on his AC systems. The inventions were so unique

1892 Chicago World's Fair featuring Tesla's AC generators



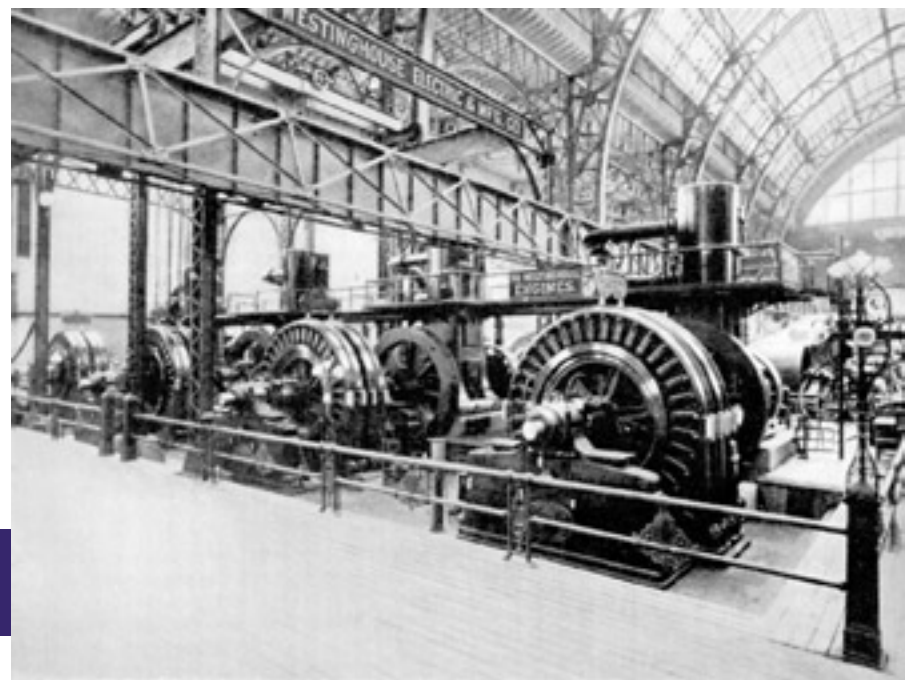
Letterhead design for the Nikola Tesla Company

that they were issued without a successful challenge.

The War of the Currents

George Westinghouse, inventor of railroad air brakes, heard about Tesla's system and visited him at his laboratory. After viewing the inventions, Westinghouse paid \$60,000 for the patents, which included \$5,000 in cash and 150 shares of stock in the Westinghouse Corporation. Westinghouse then used Tesla's AC system to challenge Edison's DC system for the future of electrical distribution within the United States.

The AC system was clearly superior. In order to send electricity any distance, it must be at very high voltages. The voltage in an AC system could be stepped up or down to different voltages very easily with a



device called a transformer. Transformers were not available for DC at that time, which meant that DC power couldn't be sent more than a few blocks because lower voltages needed to be used in homes. A DC system like Edison's might require a power plant within a few blocks of every house, instead of a single power plant for the whole city.

Edison, ignoring this, started a full scale propaganda campaign against Westinghouse, Tesla and AC current. He hired a man by the name of Harold Brown to go around the country and demonstrate how AC was more dangerous than DC (something that wasn't necessarily true) by staging shows where he electrocuted dogs and old horses. Brown referred to this process as being "Westinghoused." Brown even managed to buy a used Westinghouse generator and get it hooked up to the world's first electric chair at

He discovered that he could make a lamp light with no wires attached to it at all just by using high frequency electricity that would pass through air.

New York's Auburn State Prison so that AC would be associated with electrical executions.

Despite the smear tactics employed by Edison, it became clear that the AC system had many advantages. In 1892 the Chicago World's Fair was lit entirely with AC power coming from twelve thousand-horsepower AC generation units located in the fair's Hall of Machinery. Competitors had bid a DC system for the fair, but lost the job because the huge amount of copper needed for such a DC system (because of its low efficiency) was too high.

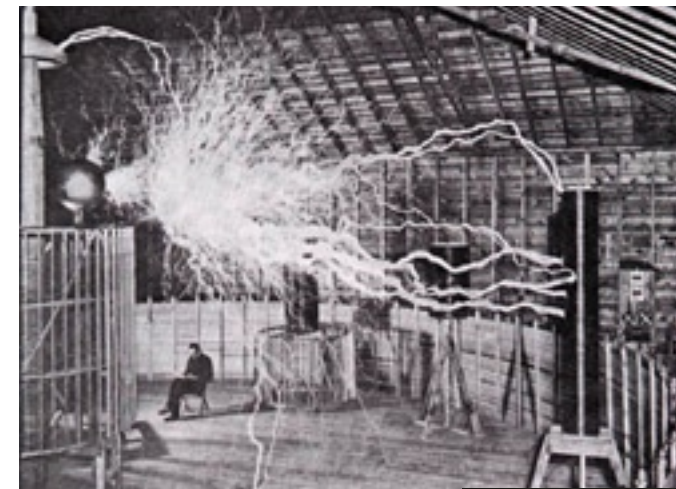
As Westinghouse started winning the war, Edison was forced to merge his company with the newly formed General Electric Corporation. General Electric would have taken control of Westinghouse too if it hadn't been for the generosity of Tesla. Tesla gave up control of AC patents worth millions of dollars because he believed that an independent Westinghouse Company was the only way his AC system would be widely adopted.

This move by Tesla ensured the future of AC, but left him short

of cash to pursue his research in the future.

Taming Niagara Falls

As a boy Tesla had seen an engraving of the great falls of the Niagara river and dreamed of harnessing their power. In 1893 he actually got his chance. Lord Kelvin, the head of the commission in charge of a project to tap power from the falls,



Tesla sits in his laboratory while his lightning strikes around him in this trick photograph by Carl Willis and Marc Seifer

originally had argued against Tesla's AC system, but changed his mind after visiting the Chicago World's Fair. Impressed, Kelvin supported AC for the project and Westinghouse won a contract to build a powerhouse at

the falls.

Tesla designed the systems and was confident they would work, though a project

of this magnitude had never before been done. Investors, including J.P Morgan, were nervous about the success of the venture. The project was difficult, expensive and took five years to complete. On November 16, 1896, when the switch was thrown, Tesla's systems worked perfectly. One by one each of the ten planned generators came online over a few months. The Niagara power station generated some 15,000 horsepower of electricity, a phenomenal amount for the time.

Newspaper and engineering journals agreed that, as the New York Times put it, Tesla deserved the "undisputed honor" of making the project possible. Lord Kelvin said Tesla had "contributed more to electrical science than any man up to his time."



Tesla holding a wireless fluorescent bulb

Experimenting with High Frequency

Back at his laboratory in New York City, Tesla started to look into what happened with electricity when you alternated it at extremely high frequencies. At first he tried altering one of his AC generators to do this, but the machine flew apart when it reached twenty thousand cycles (alterations) per second. To go

further he had to invent a new device. Dubbed the "Tesla coil," it could take normal household current (60 cycles a second) and step it up to thousands of cycles per second. The coil could also generate extremely high voltages.

Testla thought that high frequency electricity would have many advantages: Lamps would give out more light, electricity would travel more efficiently through wires, and systems would be safer because high frequency electricity passed across the surface of a person's body rather than through it.

Using this technology, Tesla tried to make better and brighter lamps

than the incandescent bulbs Edison had marketed so successfully. In incandescent lamps, only about 10 percent of the energy it uses comes out as light. Tesla hoped he could find a better solution. His work resulted in the first neon and fluorescent lights ever made. It was during this phase of his experimentation that he discovered that he could make a lamp light with no wires attached to it at all just by using high frequency electricity that would pass through air. The effect would eventually be known as radio transmission.

By using a Tesla coil tuned to the same frequency as another Tesla coil sending energy, Tesla realized that

he could send signal through thin air. He was about to demonstrate this in 1895 by sending a signal 50 miles to West Point, New York, when his lab caught fire and burned down. For this reason he didn't get to file a patent on the system until 1897. Unfortunately, an Italian inventor, Guglielmo Marconi, had filed a patent in England in 1896 for a less capable system. As Marconi worked, at first Tesla was unconcerned about his progress saying, "Marconi is a good fellow. Let him continue. He is using seventeen of my patents", but later a fight broke out between the inventors over who had first invented radio. The fight would become

particularly bitter when Marconi won the Nobel prize for the invention in 1911. Marconi's first American patent application, made in 1900, was denied because of Tesla's earlier patent, but later the U.S. patent office reversed its decision, giving a patent to Marconi. It wasn't until 1945, two years after Tesla's death, that American courts upheld Tesla's patent and his claim to the invention of radio.

Robotic Boat

From radio signals it was only a short hop in Tesla's agile mind to radio remote controls. In 1898 at an electrical exhibition in Madison Square Garden, Tesla had a small indoor pond built and into this pond he placed a strange iron-hulled boat that looked like a small bathtub with a lid. By using radio signals, Tesla was able to control the boat's motor, sending it zipping around the pond seemingly under its own control. He even installed lights on it he could blink at a distance from his control box. Many observers, unfamiliar with radio waves, thought that the device must have a brain of its own or that somehow Tesla was controlling it with his mind. When it was first shown "it created a sensation such as no other invention of mine has ever produced," Tesla would later write.

Tesla called the object a "teleautomaton" and thought of it as the first of many robotic inventions that would serve mankind. When a reporter suggested that such a boat might be made to carry an explosive charge and used as a weapon of war, Tesla grew angry. "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."

Wireless Power

Tesla's experiments with radio convinced him it was possible to send not only electrical signals through the air, but power. Conditions for this would be best at high altitudes where the air was thin. Knowing this, Tesla's patent lawyer and friend Leonard E. Curtis, suggested that Tesla might set up a new laboratory near mile-high Colorado Springs, Colorado. Curtis owned

part of the El Paso Power Company located there and could get him free electricity for his experiments.

Tesla spent a year at the site in Colorado testing and experimenting with his "resonate transformer." The results convinced him it was possible to send power through the air. In the spring of 1900 he packed up his Colorado laboratory and returned to the East coast, determined to bring the world a new way to get electrical power. Ω

To be continued next month in Part Two: Power Through the Air.

The plasma lamp, another one of Tesla's many inventions

Photo by George Georgiades

Portrait by Künstler Prudikoff