PROFILE

Nikola Tesla: Electrical savant

By Marc J. Seifer, PhD

On July 10, 2006, the scientific community will celebrate Nikola Tesla's 150th birthday. As part of this celebration, PEO has declared 2006 the "Year of Nikola Tesla." A prolific inventor, Tesla laid the groundwork for many technologies that contribute to our standard of living today, including his discovery of the rotating magnetic field that enabled alternating currents to be harnessed efficiently for electrical power distribution.

Nikola Tesla was born in the small hamlet of Smiljan, Croatia, in 1856 during a lightning storm. He attended the University of Graz in Austria and Charles University in Prague before taking a job in Budapest with the Pukas brothers, who were associates of Tom Edison. It was at this time, in 1882, that Tesla discovered his first major invention, the rotating magnetic field. Shortly after, Tesla moved to New York City to apprentice with Edison, but he would last only a year, forming a partnership with George Westinghouse a short time later.

AC polyphase born

Electrical lighting for factories and homes was in its infancy in the late 1880s, but the direct current power distribution system that had been in use for about 20 years was inefficient. The problem had to do with the mystery of electricity, which, by its nature, was alternating. That is, it changed its direction of flow many times each second. William Sturgeon first discovered the trick for making electricity go in a single direction in 1832 with his invention of the commutator, a series of wire brushes with a small gap in the middle. When the electricity flowed downstream from the generator, it had the impetus to jump the gap to the motor or light bulb on the other side. When it reversed its direction, nothing happened. In this way, the commutator captured a unidirectional flow, but was highly inefficient.

Tom Edison and his competitors were dotting the landscape with coal-operated electrical power stations at every mile across cities and towns, because that was as far as electricity could travel at that time. DC generators and competing AC generators, which also used commutators, could be used only for lighting homes, not for running electrical equipment, unless the generators were placed inside or right next to a factory.

Before Tesla's invention of the rotating magnetic field (Figure 1), all factories were situated along rivers. After George Westinghouse purchased Tesla's patents in 1889, factories could soon be located anywhere. By setting up two or more electrical currents out of phase with each other, Tesla made the commutator obsolete and eliminated the need for thousands of polluting coal-operated power stations. Tesla's renewable, clean energy invention, which comprised 40 patents, is fundamentally unchanged today, over 100 years later.

The Chicago World's Fair of 1893 became the first metropolis to be lit by the Tesla-Westinghouse AC Polyphase System. Just four years later, a set of Tesla turbines placed at Niagara Falls could distribute electrical power for hundreds of miles to run factories and distribute light and power to hundreds of thousands of private dwellings. Never one to rest on his laurels, it was during Tesla's speech at the Niagara Falls installation ceremony that he discussed his next invention: the transmission of electrical power without wires.

"The day when we shall know exactly what 'electricity' is will chronicle an event probably greater, more important, than any other recorded in the history of the human race."

Nikola Tesla, 1893

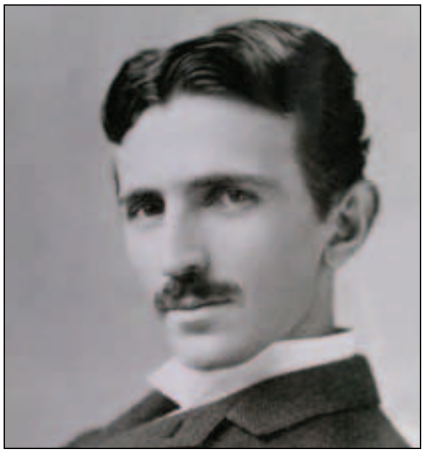

Photo: MetaScience Foundation

Tesla in 1895

Photo: MetaScience Foundation

The AC electrical power system at Niagara Falls

Sea of electricity

Earlier, in 1891, speaking at Columbia University before such peers as Elihu Thomson, later head of General Electric, Nobel Prize winner Robert Millikan, and gyroscope inventor Elmer Sperry, Tesla related his work in high-frequency phenomena. He began his talk somewhat nervously, but gained momentum as it progressed: "Of all the forms of nature's immeasurable, all-pervading energy…electricity and magnetism are perhaps the most fascinating… We know," Tesla continued, "that [electricity] acts like an incompressible fluid; that there must be a constant quantity of it in nature; that it can neither be produced nor destroyed… and that electric and ether phenomena are identical." Having established the premise that our world is immersed in a great sea of electricity, Tesla proceeded to astound the audience with his myriad experiments. He displayed his Tesla coil, which stepped up frequencies to very high voltages, precursors to both radio and television tubes, a button lamp that could disintegrate matter, and fluorescent and neon lights that illuminated when the proper resonant frequency was generated.

Before this moment, the world was caught up in Heinreich Hertz' wireless spark-gap device. The Hertzian apparatus was later advanced by Guglielmo Marconi to transmit Morse code over long distances. But the problem with this device was twofold: 1. It was next to impossible to establish separate channels, and 2. Complex forms of information could not be transmitted.

On the other hand, Tesla's invention of wireless communication, in combination with high-frequency phenomena tuned circuits and a ground connection, laid the foundation for radio and TV transmissions. His vacuum tube was constructed on principles he learned from studying the human eye, as both the eye and radio tube respond to signals sent from afar.

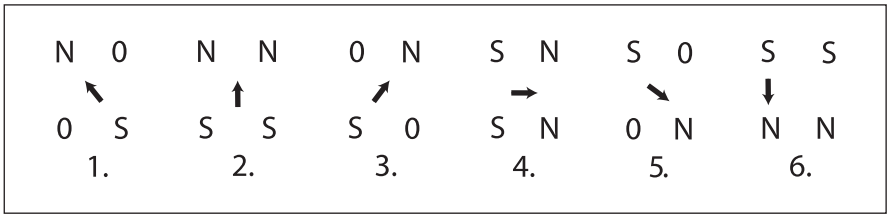

Figure 1. Tesla's rotating magnetic field. Follow the north poles. Each quadrant represents two circuits kitty-corner to each other. The north-south pole in circuit 1 (top left corner to bottom right corner) starts to reverse itself by appearing in 2 still as N/S, in 3 as 0/0 (because it is reversing), and then S/N in 4, 5 and 6. The other circuit is out of phase so that an armature attracted to the north pole will spin, thus the rotating magnetic field.

As a finale to his lecture, and as a way to tell the world that alternating currents were perfectly safe if used correctly, Tesla sent hundreds of thousands of volts through his body to issue forth sparks from his fingertips and illuminate wireless cold lamps. He explained that, unlike the Edison light bulb that loses 90 per cent of its energy to heat, Tesla's fluorescent bulbs had no filament, were cool to the touch, and had no wires attached to them!

Thinking machine

In 1898, Tesla displayed his remote-controlled robotic boat, which he called the "telautomaton" at Madison Square Garden.

Tesla realized that if, for instance, a remote-controlled torpedo were launched, it would be a simple matter for a target ship to send out its own signal to cause the weapon to turn around and attack the hand that sent it. Having studied Spencer's work on nerve conduction, Tesla got the idea of combining frequencies to send complex information along separate secure channels. This invention, which he patented in 1901, became the basis for radio guidance systems developed by his protégé, John Hays Hammond Jr., who called the invention Tesla's "prophetic genius patent." By combining frequencies, Tesla had set the stage for the age of cell phones, whereby a virtually unlimited number of individual wireless phone numbers could be set up.

But the telautomaton was much more than this. From Tesla's point of view, he had created the first prototype of a *thinking* machine, the first of a new species on the planet. Within the construction of Tesla's telautomaton are such devices as the garage door opener, the cell phone, the TV remote, wireless communication, radar, artificial intelligence and robotics.

Wireless transmission

Having astonished the world in four separate areas–electrical power transmission, fluorescent lighting, wireless communi-

cation and robotics–Tesla set out in 1899 to Colorado Springs to experiment with the transmission of electrical power to distant points without the use of wires. His idea was simple: use the resonant frequency of the Earth itself as a carrier wave to distribute electrical power. Having calculated the length of his electrical frequencies and the location of the nodal points around the globe, he hoped eventually to erect receiving towers. In that way, if, for instance, a major wireless transmitter were put in at Niagara Falls, electrical power could be transported through the Earth and air to distant places.

Tesla erected a 200-foot-tall transmission tower in Colorado and, from this experimental station, created 60-foot-long lightning bolts and measured the resonant frequency of the Earth. Tesla also claimed that he circumscribed the Earth with his electrical waves, setting up a nodal point at the antipode, which he calculated was in Australia. After tracking thunderstorms at distances of 600 miles, Tesla announced to the world in the *Colliers* article, "Talking With The Planets," that he had received pulsed frequencies from outer space. These, he speculated, came from intelligent beings from some neighbouring planet like Venus or Mars.

A year later, Tesla returned to New York City and his home at the Waldorf Astoria. At this time, he formed a partnership with J. Pierpont Morgan, the most powerful financier of the day. His goal: to erect a wireless transmitter to send signals across the Atlantic.

Morgan had given the inventor $150,000 to complete a 90-foot tower and laboratory. But just as Morgan sailed for Europe for his yearly extended stay, Tesla learned that Marconi was pirating his apparatus. Unbeknownst to his benefactor, Tesla then decided to double the size of the tower. He thought that by doubling the size, not only would he be able to send messages to Europe, but he would also be able to reach the whole world. Thus, instead of the revenues being doubled, because the costs had doubled, they would increase in exponential proportions as everybody on the planet would be tuned into his system.

However, a stock market crash and an argument with Morgan destroyed any chance for the tower to be completed. It was eventually torn down in 1917 and the salvage used as partial payment to the Waldorf Astoria for back rent owed.

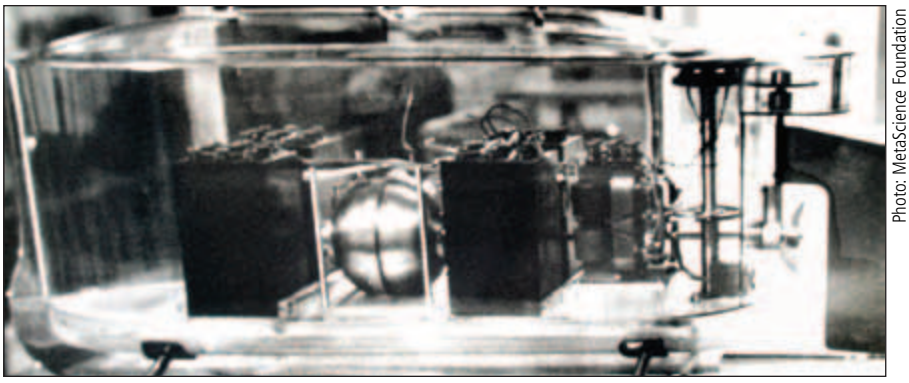

Photo: MetaScience Foundation

Tesla's telautomaton

Flying machines and death rays

In 1910, Tesla began work on bladeless steam turbines, which he hoped would replace the gasoline engine in Henry Ford's cars. This plan, too, fell through. Tesla then began work on a variety of flying machines, including a hovercraft and a reactive jet dirigible, which was an early prototype that led to such airplanes as the vectored thrust Harrier jet and the flying wing. Tesla also patented a tilt-rotor aircraft, which he called the flivver plane. This machine, which took off like a helicopter and then, after rotating the propeller, flew like an airplane, evolved a half-century later into the V-22 Osprey aircraft, a $40-million airplane that the military still uses today.

Tesla's last great accomplishment, which he designed as far back as 1915, is often called the death ray. It was actually a particle-beam weapon based on princi-ples found in the pop gun he had used to shoot crows as a child. The idea was simple. Tesla generated a belt of highly charged ions that circulated around the base of the machine. At the site of the barrel, the inventor found a way to chip off small pieces of tungsten that carried the same charge as the electronic belt, causing individual pellets to be repelled from the barrel at enormous velocities. As the Second World War was brewing, Tesla planned to provide these Star Wars-type weapons to every major nation, so their borders would become impregnable, with the result, in Tesla's mind, that there would never be war again.

Bestowing honours

In 1917, Tesla was awarded the Edison Gold Medal. With honorary doctorates from Columbia University, and universities in Zagreb, Vienna, Bucharest, Prague and Paris, the inventor was nominated for a Nobel Prize in 1937.

On Tesla's 100th birthday, the Serbian inventor was posthumously awarded his finest honour when the Institute Electrotechnical Committee designated the "tesla" as the measure of magnetic flux density. From then on, Tesla could stand beside such other scientific giants as Ampere, Angstrom, Curie, Fermi, Hertz, Volta and Watt. In 1999, *Life* magazine listed Nikola Tesla as one of the 100 most important people of the last 1000 years.

MARC J. SEIFER, PHD, IS THE AUTHOR OF ***WIZARD: THE LIFE & TIMES OF NIKOLA TESLA*** (WWW.MARCSEIFER.COM), CITADEL PRESS, A BOOK "HIGHLY RECOMMENDED" BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. HE HAS LECTURED ON TESLA AT WEST POINT MILITARY ACADEMY; COLORADO SPRINGS; ZAGREB, CROATIA; LUCASFILMS INDUSTRIAL LIGHT & MAGIC; AND THE UNITED NATIONS. HE TEACHES PSYCHOLOGY AT ROGER WILLIAMS UNIVERSITY.
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