

SPHEX paper
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POLAR OPPOSITES

Thank you for the opportunity to present my first SPHEX paper. I have certainly enjoyed all those that have gone before during my honeymoon period. I was given 2 pieces of advise early on. First, it is necessary to obscure the subject of your paper with a mysterious title. Second, it's nice to talk about something you knew nothing about before you began your investigation. I think that second was a ruse just to put me at the mercy of the audience. But I took the advice.

Slide: Tesla Motors logo

We all know the power and importance of branding. This is a car company it's been pretty successful with promoting it's brand. After just 15 years of existence it now has a market capitalization that rivals GM and Ford. Either the company or the CEO is constantly in news, without running one commercial, paying for one print ad or putting up one billboard.

Slide: Middle Age Nikola Tesla.

We are really interested in a different Tesla today. This one could've used much more effective branding. It was, perhaps, Nikola Tesla's tragic flaw from a legacy viewpoint. I would like to tell his story and in doing so talk also about an interesting episodes in science amid the great technological advances of the Gilded Age. This was the Battle of the Currents.

Slide: DC vs. AC

Slide: younger Tesla

The back-story is interesting. His family was ethnic Serbs, living in Croatia. He was born in 1856 in the town of Smiljan, ("Smeelan") the youngest of five children. His father was an Eastern Orthodox minister and as was the tradition of the time the youngest son was virtually designated to go to the priesthood. Young Nikola was an aesthetic boy bedeviled by vivid dreams and what he later referred to as visions. He learned to control these so they did not interfere with his daily life but clearly had intuition, imagination and spiritual quality. He was inspired by nature and fascinated by electricity, his first experiences being with the static electricity induced when he petted his cat.

His father finally relented on the requirement of going to the priesthood when Nikola was severely ill with cholera at 17, promising that if he survived he could then go to engineering school.

He entered engineering school at a polytechnical university in Graz, Austria, supported by two uncles. There were struggles, however. He was already obsessed with electricity and particularly the problem of alternating current. Edison and his company in the United States were already building electrical grids using direct current, but this problem of a workable motor for AC current remained. His obsession caused him to be distracted, depressed and he dropped out of school. Or, the less colorful explanation, depending on your source, was he just developed a bad gambling habit and was kicked out of school. But his father subsequently died, and Nikola rededicated himself, eliminating a number of bad habits, including the gambling.

He was able to move onto studies in Prague again with the support of his uncles and then briefly worked in Budapest at a telephone exchange. It was here that the critical inspiration occurred. In typical fashion, he describes the answer for the AC motor coming to him while walking in a park, reciting Goethe, with a friend. It is true he had this amazing ability to visualize theoretical structures and electrical systems in his imagination without preliminary drawings or sketches. This is what he said later of his ability:

Slide: Tesla on imagination

“When I get an idea I start at once building it up in my imagination. I change the constructions, make improvements and operate the device in my mind. It is absolutely immaterial to me whether I run my turbine in thought or test it in my shop. I even note if it is out of balance. There is no difference whatsoever, the results are the same. In this way I am able to rapidly develop and perfect a conception without touching anything.”

Now with an idea in mind and actually a prototype built, he was still unable to generate any enthusiasm for his ideas in the local scientific community for his “rotating electric field polyphase AC electric motor”. He was now working for Continental Edison, the Paris extension of Edison’s company. Investors in France and Germany turned him down. So he set his sights on the United States and ultimately arrived in 1884 reportedly with four cents in his pocket and an introduction letter to Edison from the director of the Paris office. He presented himself at the Edison Machine Works in the Lower East Side of Manhattan.

Slide: photo of Edison and Tesla in lab

Edison was already very well-known, the inventor of the incandescent light bulb and now well on his way to illuminating the well-to-do homes of New York, beginning with JP Morgan. Committed to DC current, he had relatively low voltage wires, usually carefully buried, but connected to dynamos serving very small grids of only up to a mile because of the difficulties in transmitting the DC current. The public streets of New York had already been illuminated in the 1870’s using arc lights on very high poles above the streets employing high-voltage, DC lines, creating the “Great White Way” of Broadway. These were bright and harsh, and with the high voltage suitable for outdoor lighting only. Edison was on a mission to electrify indoors the homes of Manhattan with low voltage DC power and incandescent bulbs.

Tesla did go to work in Edison's lab, but the relationship was doomed for failure. Edison, being highly committed to direct current had no interest and helping to develop AC generation as Tesla had hoped. Equally difficult was the distinct difference in their personalities with Edison being very methodical, practical, and working a lot by trial and error. He actually wasn't as well educated as Tesla. In addition, he paid ruthless attention to the bottom line and the commercial application of the research. Tesla, on the other hand was a contemplative and imaginative. He always wanted to understand the theory and the math. Reportedly, Edison promised him a bonus for helping to improve the DC systems they were producing, but claiming a misunderstanding, did not pay Tesla. The Serb left after approximately 6 months in Edison's lab, with some bitterness.

Slide: Tesla quote on Edison.

“If Edison had a needle to find in a 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 percent of his labor.”

For his part, Edison barely mentions Tesla in his autobiography.

Slide: schematic of AC generator

In order to understand what Tesla was about to do to the nascent industry of electrifying the world, we have to go back to the basic difference between alternating current and direct current, the generators that produce them and the motors that use them.

Faraday and Maxwell had already elucidated the relationship between magnetism and electricity. It was shown that an electric current would be produced when a magnet was moved within a conductor, commonly a coil of wire. The opposite was also true, that an electric current around a conductor would produce a magnetic field. An electromagnet.

This is a depiction of a circuit shows a rotating magnet within an electrical coil. So the rotation is provided by an external force of mechanical energy. Practically, it may be a hand crank, or a waterwheel in the river or a steam engine. The polarity of the magnetic field changes as it rotates, and the current produced also changes or “alternates”. So, in fact, the electrons do not flow all in one direction, but actually move back and forth through the wire. The “load” identified in the circuit is the light or the motor that uses the electrical energy.

Notice that there are no contact points in this generator or “alternator”. Therefore the simplest generation of electricity via induction is actually alternating current.

Slide: schematic of DC generator

To produce direct current we will still use the same properties of magnets and conductors, but now we have to interrupt the generation so only the current flowing in one direction

reaches the circuit. The coils are inside a fixed magnet and they are rotated by a source of mechanical energy within the magnetic field, but the circuit is interrupted, so that the current is produced only with one polarity.

Note the contact points required as they are weak point of the design.

Slide: Video of DC motor with rotating

For DC current, we can reverse the process in designing a motor. This will use electrical energy to perform work. Electricity is flowing from a battery and is transformed by the motor to mechanical energy.

Here you again see, in more detail, the coils of the electromagnet “core” as well as the contact points which are the “commutator”, including brushes. These would be required to get the rotational movement.

There was no comparable way to reverse the design for AC current to function as a motor.

Slide: Advantage DC

1. Effective generation and motors.
2. Low voltage transmission
3. No AC motors available
4. No AC metering available

So the advantages of direct current were readily evident. There were effective generators to create the current. The transmission, at least as Edison was doing it in the homes of Manhattan, was via a low voltage system, and there were motors, not just light bulbs that would run off DC. Conversely, there was no motor for AC current and, importantly no one had figured out how to meter alternating current yet. This was a distinct problem if you were selling electricity to public homes and businesses.

Slide: repeat of DC motor with detail

But there were weak points, notable the brushes and the commutator, which tended to spark dangerously and wear out. This was the first problem with the DC motor.

Slide: power formulas for current, voltage, watts, resistance

The second major weak point was transmission of the power over any distance. Edison’s systems required generators every few blocks with effective transmission at 120volts of less than a mile.

The problem is the resistance in the wire to current. We turn to the power formula to see how we can transmit potential energy. It turns out we can push power with either volts or current, that is, amps. If we add in Ohm’s law to see what resistance does to power loss, you see that the current (amps) is SQUARED.

Therefore if you go back to the power equation, you see that you want to transmit with very high voltage, and as little current, or amps, as possible. That is why if you walk up to the base of the tower for a high power line it says, “Danger, HIGH VOLTAGE”, not “Danger, HIGH CURRENT” or “HIGH AMPS”.

But if you are transmitting at 1,000 volts, or 10,000 volts, you can't easily generate electricity at that voltage and you can't illuminate a light bulb or run a motor at that voltage. You have to be able to step it UP from the generator and step it DOWN at the user end.

Slide: transformer

What you need, is a transformer. This is a very simple problem to solve with AC current. You induce a magnetic field in a core with your current. It, in turn, induces another electric current in a nearby conductor or coil. The ratio of turns in the two coils determines how the voltage is stepped up or stepped down.

This CANNOT be done with DC current. AC current is easily transformable, DC current is not.

Slide: transmission system

So here is the everyday design of an AC system that we use today.

1. AC generation at lower voltage
2. Transformed up to high voltage for efficient transmission
3. Transformed down near the user for conversion to mechanical work or illumination or heat or whatever.

What's missing in 1886 is the AC motor.

Slide: advantage AC

1. Efficient high voltage transmission
2. More reliable generators without commutators or brushes
3. Cheaper (smaller wires and much less copper)

Slide: Irish manual laborers in NY

Tesla was naïve walking out of Edison's lab. He did not have immediate access to any funding for his ideas. He worked in manual labor spending about a year digging ditches in New York before his efforts to interest investors paid off. He had false starts. Still working on his ideas during this time, he developed some new improved designs for arc lighting, but was cheated out of those patents and paid nothing. That was a recurring theme. Tesla eventually found some funding from 2 new investors named Peck and Brown for the Tesla Electric Company and continued work on an Electro Magnetic Motor. Based on the design

he had imagined in the park in Budapest, he now created plans for the motor, transformers and generator and submitted the entire AC system for a patent in 1887. The patent office was immediately overwhelmed and asked him to break down all of his ideas and designs in to manageable chunks. So over the next two months he submitted designs that would lead to almost 40 patents, comprising his AC system.

Slide: Tesla AC motor patent diagrams

The breakthrough was creating a rotating magnetic field. These are diagrams from his original submission to the patent office. The core here is two electromagnets with separate circuits. So while one has strong polarity, the other is in transition. As the alternating current switches polarity the second magnet develops polarity and is pulled over while the first magnet's polarity wanes. This repeats as each magnet switches, creating rotational movement of the core.

This has been likened to standing next to a merry go round, and as each pole goes by, you grab it and pull, then release as it passes you.

Slide: photo of basic AC motor

This gives you an idea of what the earliest devices looked like. As you can see the actual design was somewhat more complicated in that multiple magnets were used. In fact, electric magnets were used both for the core magnet and the coil.

Slide: photo of George Westinghouse

Tesla was induced to give an academic lecture at Columbia University and the word started getting out in the scientific community of his newest designs for an AC motor.

George Westinghouse was interested. He was already competing with Edison installing arc lighting and some AC systems for illumination. He was not just an entrepreneur but also an engineer himself. He had the foresight to know an AC current motor was a game changer. He signed an agreement with Tesla, paying him a salary, \$25,000 in cash and \$50,000 in notes for the patents plus royalties of \$2.50 per horsepower of energy produced. This clause for the royalties per HP produced by their devices became crucially important. Tesla went to Pittsburgh as a consultant with Westinghouse where they began the production and promotion of the AC generators and transmission systems.

Ultimately, as Westinghouse's Company develop financial problems during the Panic of 1890 he became overextended and he said he could not pay the royalties. Tesla as an act of either gratitude or naïveté, abandoned the royalties to help ensure the company's survival. Primarily he felt Westinghouse had to survive in order for him to "give his AC system to the world". It proved to be a fateful decision as money problems proceeded to dog him and impair his research the rest of his career.

Slide: photo of Edison

There was now competition between the AC and DC systems as the urban areas all embraced electrification. Tension mounted between the two camps as each side made claims, mostly about the potential dangers of the other current. The marketplace was gradually consolidating into the three major players. Edison Electric selling direct current systems while Westinghouse and Thomson-Houston sold alternating current generation and distribution. It was a time rife with patent infringements, under the table deals and lawsuits flying back and forth. In fact, missing blueprints of Tesla's AC system turned up in an Edison facility in Lynn, Massachusetts.

Slide: photo of NY street scene with wires

The dangers of the transmission wires and current were becoming better known with deaths to line workers having occurred in New York during the proliferation of electrical installations and repairs throughout the city in 1886 through 1888. Now generators and transmission systems were being sold to cities all across the United States. Each company would string their own system, resulting in a morass of wires above the streets.

This particular blizzard in 1888 engendered a number of deaths as the wires came down in the snow.

Edison opened a new front in what came to be known as the "War of Currents" with a published pamphlet entitled "A Warning from the Edison Electric Company" extolling the dangers of AC current. Westinghouse had to defend himself with a back and forth in the newspapers. Edison attacked with multiple lawsuits as well.

The issue of capital punishment came up next. Some botched hangings in New York State had left the government looking for alternatives for executions. A commission was established and reached out to various people and organizations for comment. Edison, when contacted, made it clear he was against the death penalty and wanted nothing to do with the discussion of using electricity. With encouragement though he saw an opening. His next response to the state commission in 1887 predictably recommended alternating current "principally manufactured by the Westinghouse Corporation" as the best means to an end.

There entered on the scene a self-educated electrical engineer named Harold P. Brown who became an anti-AC crusader of sorts, independent from Edison initially. He proceeded with a series of gruesome demonstrations electrocuting dogs and other animals to prove that AC was lethal. There arose intense opposition to Mr. Brown's demonstrations, but growing concern about the dangers of AC as well. Edison chose to put Mr. Brown on the payroll.

Slide: engraving of horse to be electrocuted

At the Edison's West Orange laboratories and in front of the New York Medico-Legal Society, the state commission, Thomas Edison and the press, he proceeded to electrocute a

series of animals working up to what was referred to as a “lame horse”. 750 volts later he had made his point and the recommendation was made by the commission that capital punishment should be carried out with 1000 to 1500 volts, of alternating current, carefully noting that was less than the current being carried on Mr. Westinghouse’s lines in the city.

The argument probably reached its peak when Harold Brown challenged Westinghouse to a bizarre electric duel. Each was to subject themselves to gradually increasing currents of AC and DC respectively until one of the participants quit. Westinghouse did not take up the challenge.

William Kemmler was a convicted of murdering his girlfriend with a hatchet. He, unfortunately, was the first to be dispatched with the new electric chair in 1890. The event did not go off well, with two shocks of increasing voltage required. He did not die expeditiously. Westinghouse’s comment was, “They would have done better using an axe.” Edison, for his part, took to referring to electrocution as “getting Westinghoused”. This did nothing for the reputation of electricity and AC current in particular. At this point, only 8% of homes had electricity and it remained a deeply mysterious and powerful force.

Slide: photo of Chicago fair

Westinghouse may have lost that public relations battle, but AC was gaining ground. The next opportunity arose with the worlds fair in Chicago in 1893. This was the Columbian Exposition and an enormous display of technology and lighting was planned. Over the years Edison had aggressively defended his patents around the incandescent light bulb. These had mostly been successful and Edison Electric was convinced they were the only ones who could provide the lighting for this extravagant event. The bid came in so high that the reaction from Chicago was “outrage”. Westinghouse had an opportunity as they had developed a slightly different kind of bulb that avoided the patent and the AC system was inherently less expensive than direct current. They could use much smaller caliber wire and therefore much less copper was required. The contract was secured and the fair opened to incredible fanfare and awe at the technological advances demonstrated. 160,000 light bulbs illuminated the buildings and fair grounds. The fair drew three times as much current as the entire city of Chicago.

Slide: Chicago Fair pavilion.

The brilliance of Edison was on display in the pavilion, but Tesla and Westinghouse dominated the landscape with extravagant displays and Tesla himself was on stage with arcing high voltage currents and tubes of illuminated phosphorescent gasses held aloft.

By now Edison’s company had merged with Thomson Houston to become General Electric. They can be seen in the picture wedged between two large Westinghouse displays.

Slide: Tesla turbines at Columbian Exposition

It was made clear that the Tesla generators made it all happen. The Tesla name was clearly marked on the AC motors as well. The practicality and success of AC current were on full display.

NIAGARA

Slide: Old Niagara, NY

The Falls at Niagara had long been used to turn waterwheels for milling and basic machine work.

Slide: Niagara Falls

Niagara Falls presented an irresistible opportunity to those who wanted to showcase the generation of electrical power. The challenge was not only the generation, but the transmission of power to Buffalo, 11 miles away. Multiple proposals were made in the past, but finally, the bid of Westinghouse was accepted by a group of 103 New York financiers called the Cataract Construction Company. Westinghouse won this enormous project with the designs of the Tesla turbines and AC current. Edison's company, now GE, competed, but they were awarded only some peripheral contracts to the project.

Slide: turbines at Niagara

The engineering was daunting as it involved the construction of enormous underground conduits where the water was diverted, falling 190 feet to the turbines below. The plant required 20 generators and ultimately produced 100,000hp of electricity, opening the circuits to an ALCOA smelter in Niagara in 1895 and later transmitted to the city of Buffalo in 1896. This demonstration of large-scale generation and especially transmission over distance was the final triumph over DC current. The merger of Edison Electric with Thomson Houston to form GE had given them access to some AC patents. General Electric along with Westinghouse would go on to be the two companies to electrify cities across the country in the ensuing years.

Edison, on the other hand, gradually lost control of his stake in the company as these mergers occurred and turned his attention away from illumination to other pursuits.

RECOGNITION AND IDIOSYNCRASIES

Slide: Tesla with bulb

Tesla had reached a significant level of recognition, however. He was now independent of Westinghouse and living back in NY. He was a darling in high society. He was this rather striking, impeccably dressed, lean gentleman at least 6' 2" tall. He had an interesting accent and blue eyes. He spoke 8 languages. Tesla was a wonderful, interesting conversationalist, fond of poetry and literature. Tesla would dine regularly at Delmonico's. He was a

vegetarian and an ardent antivivisectionist and environmentalist. He knew Sarah Bernardt and John Muir. Mark Twain repeatedly visited his laboratory.

Slide: photo of Twain with Tesla in lab

This is Samuel Clemens in the lab with Tesla in the background. This is thought to be the first photograph ever taken with incandescent light.

Tesla never married or had any known romantic relationships; single, he moved into the Waldorf Astoria Hotel where he lived for 20 years. He noted that marriage was probably good for the poet or the musician, but was decidedly a hindrance for the committed inventor.

He was clearly obsessive compulsive, having always had a germ phobia. Tesla did not shake hands. He insisted on 12 napkins with dinner and he would clean all his silverware at the table. He had counting compulsions as well. He counted his steps. He always stayed in hotel rooms whose number was divisible by three. In going places he would circle the block 3 times before arriving. For some unknown reason he had an aversion to pearls, peaches and earrings.

He coped, however, and was able to continue working, establishing a laboratory in lower Manhattan. He was even able to recover with additional financing when the laboratory burned in 1888 and he had to rebuild.

Slide: Tesla on stage

He continued to give dramatic lectures to professional and lay audiences that would go on for hours. He was an amazing showman. These would include Tesla Coils on stage that would generate very high voltage and arcing currents across the stage. He would run current through his body to light up bulbs held in his hand and shoot sparks from his fingertips. He would wave phosphorescent tubes illuminated wirelessly by the high voltage fields created by the Tesla Coils. Here's how Tesla later described it:

Slide: Tesla's description of show

“...a sight marvelous and unforgettable. One sees the experimenter standing on a big sheet of fierce, blinding flame, his whole body enveloped in a mass of phosphorescent wriggling streamers like the tentacles of an octopus. Bundles of light stick out from his spine. As he stretches out the arms, thus forcing the electric fluid outwardly, roaring tongues of fire leap from his fingertips. Objects in his vicinity bristle with rays, emit musical notes, glow, grow hot.”

He had a traveling show that wowed scientific and lay audiences here as well as in Paris and London. Scalpers would sell tickets outside his public performances.

He continued to generate patents in the field of motors and electricity, but his imagination ran much wider. He designed a type of airplane, more akin to a helicopter with tiltable blades.

He designed and built a remote controlled boat, using early radio communication. He predicted robotics and saw that solar power (what he termed “radiant energy”) would be a ubiquitous source of energy for all people. He envisioned wind power electrical generation and had designed a system for geothermal energy. Interestingly, he didn’t think much about the prospects for nuclear power. Tesla said there was “Not enough energy from the process of disintegration”. He had a successful bladeless turbine and produced and sold an “air friction” speedometer.

Slide: Colorado lab

He moved in 1899 to the area of Colorado Springs and built a lab there with some funding from John Jacob Astor and a deal where he could get free power from the city. This is a picture of that workshop with the typical Tesla flair for the dramatic with arcing electricity from a Tesla coil. He worked with extremely high voltage devices using these Tesla coils which could now generate up to 4 million volts. In fact he blew out all the power in Colorado Springs on one occasion.

He was particularly interested in wireless transmission of voice and potentially images. Tesla did extensive work, and became a leading voice, in the field of wireless communication. Significantly, he had multiple patents in the technology leading to radio. In his usual visionary way he predicted communication devices that would reach the entire globe.

Slide: Tesla quote re communication.

“We shall be able to communicate with one another instantly irrespective of distance. Not only this, but through television and telephony we shall see and hear one another as perfectly as though we were face to face, despite intervening distances of thousands of miles; and the instruments through which we shall be able to do this will [fit in] a vest pocket” N.T. 1926

This was something the investors could sink their teeth into, and he was successful in getting funding for this kind of research.

In reality, he was doing more and more work on the idea of wireless transmission of power. In fact, there was a theme of universal availability of power to all people to improve their lives that ran through out his work. He saw harnessing power as the way to lighten the burden of labor for all mankind. He became convinced that there could be the transmission of energy through the air over long distances. Free energy available to everyone on the planet is not what investors had in mind, however. He found it increasingly hard to get funded.

Slide: Wardenlyffe

JP Morgan was anxious to have a stake in wireless communication. He and James Warden funded Tesla for 51% of the company and Nikola began building a tower for transatlantic

transmission. He chose this site on Long Island, called it Wardenclyffe and constructed a 187ft tower that included a 57 ton sphere at the top and a grounding shaft that went 120 ft into the ground.

Tesla purportedly continued to pursue wireless communications. Tesla's real interest, however was still the transmission of power and the idea of free electricity throughout the world. He claimed he would run the trolleys in Dublin with power from Long Island.

Slide: photo of Marconi

Meanwhile the Italian inventor, Marconi, was being funded by Edison and Carnegie. He was pursuing the goal of radio transmission, with some success over short distances. He admitted he was using Tesla coils in his devices.

Slide: Tesla comment on Marconi

Tesla responds in his usual haughty, dismissive way.

“Marconi is a good fellow. Let him continue. He is using 17 of my patents. Money does not represent such a value as men have placed upon it. All my money has been invested into experiments with which I have made new discoveries enabling mankind to have a little easier life.”

Marconi succeeds in sending the first transatlantic message in Morse code in 1901 and once again Tesla allows someone else to reap the rewards of his work. Morgan now cuts off his funding. The tower at Wardenclyffe becomes operational, but by then the creditors are coming after him and the equipment has to be sold. He now tries to pursue his claims against Marconi for his previous patents in radio, but this will not be settled until well after his death, as it worked its way through the courts. It provides him with no additional revenue. In 1943, six months after his death, the Supreme Court declares that the radio patents truly belong to Tesla.

Westinghouse Electric goes into receivership with the banking crisis of 1907 and Westinghouse dies in 1914. Astor had drown on the Titanic in 1912 and JP Morgan dies in 1913. Then with the advent of WWI Tesla no longer receives any royalties from European patents that he held.

He still has some irons in the fire with his bladeless turbine, ideas for radar and other inventions, but he always seems to sabotage the deals either with lack of business acumen or not being able to work interpersonally with engineers and investors.

Slide: Tesla quote on stolen ideas

“I don't care that they stole my ideas.... I care that they don't have any of their own.”

He wasn't without his pride, however. He was eminently quotable and the newspapers loved his public pronouncements.

With the passing of time Tesla's public announcements are more about eccentricity than electricity. He proposes being able to photograph thoughts. He describes sending communication beams via the "Teslascope" to other planets and stars, sure to contact other beings, and resulting in a "universal brotherhood".

Slide: death beam newspaper article

In the years leading to WWII he describes a "death beam" capable of dropping 10,000 airplanes out of the sky from 200 miles away and destroying an army.

Slide: death beam prototype

The altruistic, humanitarian theme persists in his vision, however. He sees his weapon as the ultimate defensive deterrent, so that no nation would be able to wage war any longer. There are plans and a prototype, but it must not be much as no one in the US is interested and the British government turns it down as well. He finally does offer it to the Russians who do some testing and pay him \$25,000, but the weapon never appears. The idea of particle beams, however, persists.

Tesla retreats to New York City and now has to move to successively less elegant hotels as his debts mount. For many years he had a fixation with pigeons, feeding them in the parks or at his window sill. He writes of very intense grief when his favorite dies.

Yet he was not totally isolated or forgotten. He had an annual birthday party at the hotel where he would regale the press with his visions for the future. On his 80th, he was feted in Belgrade and Yugoslavia awarded him its highest medal.

Slide: Tesla death announcement

Finally in 1942, at age 85, he dies alone in the Hotel New Yorker, found by the maid. The Yugoslav government lays out a state funeral for him at St. John the Divine attended by 2000 people and condolences come in from Eleanor Roosevelt and all the scientific luminaries of the time.

Slide: plaque at Hotel New Yorker

This is a marker at the Hotel New Yorker. He remains much more of a rock star in Serbia with the Tesla Museum located in Belgrade where his ashes eventually reside.

Slide: light bulb

Yet in the United States his legacy fades rather quickly. While Edison had certainly won enduring fame and admiration with tangible inventions that changed everyday life: the light

bulb, the phonograph, the movie camera. The Edison light bulb itself has become synonymous with creativity, ideas and the inventor. Tesla, on the other hand, had made enormous theoretical contributions, and built the infrastructure, but his devices were not in the hands of every day people. Knowledge of his significance simply faded over time.

Slide: Tesla quote about future

“Let the future tell the truth, and evaluate each one according to his work and accomplishments. The present is theirs; the future for which I have really worked, is mine.” N.T.

Tesla wouldn't have been very surprised by that, however. He never doubted the significance of his own contributions and their impact on our lives.

Slide: photo Tesla statue in Palo Alto

I like this depiction of Tesla. It is in a park in Palo Alto. Fittingly, it is also a hotspot with a wireless internet connection.

Slide: Tesla portrait

Reflecting on this story of Tesla and the currents, I had two take away thoughts. First, it's interesting to see how different technologies battle it out for pre-eminence. I think in the long run, you can be pretty sure that the best technology will eventually win, but it is not a given, and there is no doubt that it can be derailed by political subterfuge, marketplace maneuvers, and individual interests.

Second, I am not surprised that Tesla is now starting to capture our imagination as he really is the story of a tragic hero. Supremely gifted, rising to great heights, and then succumbing to his tragic flaws. He is a compelling figure.

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