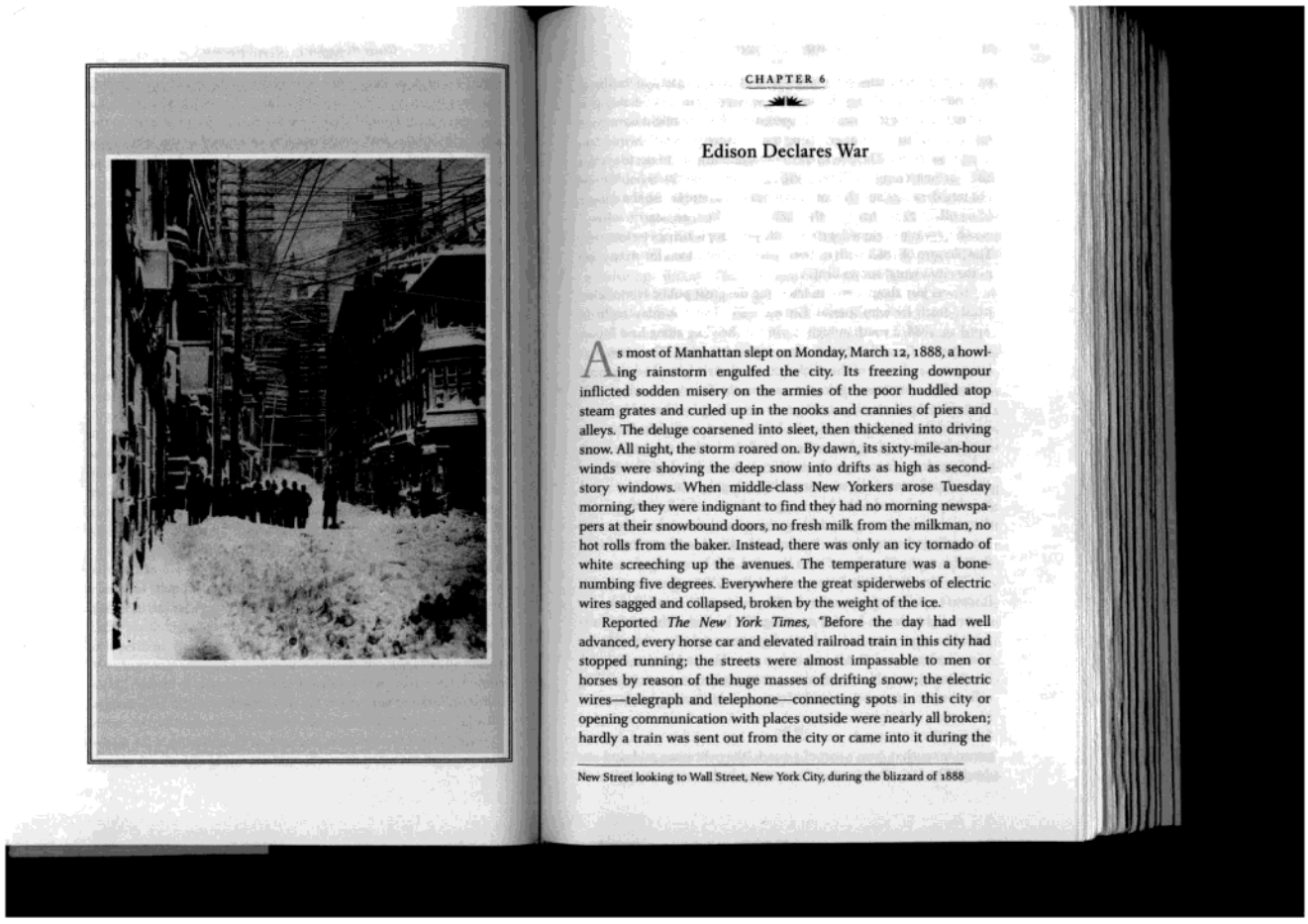
Day 7: Empires of Light

Saturday, September 26, 2020 2:50 PM



CHAPTER 6

Edison Declares War

As most of Manhattan slept on Monday, March 12, 1888, a howling rainstorm engulfed the city. Its freezing downpour inflicted sodden misery on the armies of the poor huddled atop steam grates and curled up in the nooks and crannies of piers and alleys. The deluge coarsened into sleet, then thickened into driving snow. All night, the storm roared on. By dawn, its sixty-mile-an-hour winds were shoving the deep snow into drifts as high as second-story windows. When middle-class New Yorkers arose Tuesday morning, they were indignant to find they had no morning newspapers at their snowbound doors, no fresh milk from the milkman, no hot rolls from the baker. Instead, there was only an icy tornado of white screeching up the avenues. The temperature was a bone-numbing five degrees. Everywhere the great spiderwebs of electric wires sagged and collapsed, broken by the weight of the ice.

Reported *The New York Times*, "Before the day had well advanced, every horse car and elevated railroad train in this city had stopped running; the streets were almost impassable to men or horses by reason of the huge masses of drifting snow; the electric wires—telegraph and telephone—connecting spots in this city or opening communication with places outside were nearly all broken; hardly a train was sent out from the city or came into it during the

New Street looking to Wall Street, New York City, during the blizzard of 1888

entire day; the mails were stopped, and every variety of business dependent on motion or locomotion was stopped. . . . Probably if it had not been for the blizzard the people of this city might have gone on for an indefinite time enduring the nuisance of electric wires dangling from poles." The newspaper once again urged the electric wires all be buried, citing the very specific hazards: "The city is liable to be put into darkness and the consequent perils. There is also the danger of conflagration through the failure of the fire alarm wires."[1] Nowhere was mentioned the possibility of people being electrocuted. The blizzard of 1888, with its twenty-two inches, stood for sixty years as the city's worst snowstorm.

It was just about a month later that the great public fear of electrical "death by wire" began. On the cold, clear Saturday night of April 15, 1888, a youth in high spirits was heading along East Broadway toward Catherine Street, skipping and leaping. The snow was long gone, and most of the thick webs of electric wires had not been buried but were once again restrung on the forests of cedar poles. That crisp April evening, carriages were rolling by, their shiny cabs and sleek horses gleaming in the bright street arc lights. Passersby noticed the bounding boy seize one of the broken telegraph wires dangling down from high above. Wire in hand, he playfully skipped around and around the towering telegraph pole, when amid a spurting shower of sparks, the boy staggered back and fell reeling on the dirty sidewalk. A crowd quickly gathered and the ambulance corps soon galloped up to take the boy, later identified as Moses (or Meyer) Streiffer, to the Chambers Street Hospital. But he was dead.

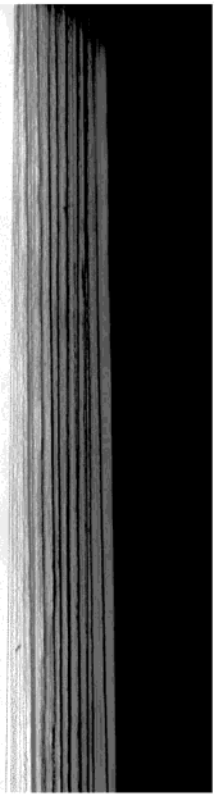
The *New-York Daily Tribune* editorialized, "It is almost a pity that it wasn't a millionaire or other leading citizen that was killed by the electric light wire on Sunday morning. If it had been, the community would have been startled, and its indignation might have brought the wires underground. But it was only a poor boy peddler—a little fellow fifteen years old, a Rumanian, a stranger in this great city, selling collar buttons and pocket combs from a modest tray to help support his mother and eight brothers and sisters. A wire had been swinging for months from a pole near where the boy took his stand, he happened to touch it, gave 'a sort of a quack,' the policeman said, and was

high-voltage wires strung along the avenues, was charged with neglect for allowing dangerous wires to dangle.[2]

In the spring of 1888, "death by wire" became, for the first time, a great preoccupation of the New York papers. "Overhead cables suddenly leaped into prominence not only as eyesores but as a public peril," notes Westinghouse biographer Francis Leupp. "Leading newspapers which till then had confined their discussion to the expediency of exchanging gas for electricity, began, with astonishing unanimity, to make a display of every happening that could be used to excite animosity in the popular mind toward the [high-voltage] alternating current."[3] The newspapers' rising indignation mirrored that of Thomas Edison, long a darling of the New York press. Suddenly alert to every casualty and fatality caused by high-voltage electrical wires, the press now gave full attention to the scandalous, tangled state of Manhattan's overhead electrical wires and the dangers posed by high-voltage arc light wires.

Less than a month after the peddler boy Streiffer died, there was another electrical victim. On Friday, May 11, a lovely spring day, a Brush Electric Company worker was up cutting away old wires on a second-story cornice at 616-18 Broadway, high above the thick port traffic below on West Houston. An employee inside one of the buildings "saw smoke curling in the window and heard a spluttering sound. He found Murray dead and one of the electric wires partly cut through and the insulating material burning at the point where it was cut."[4] The lineman for the arc light company had failed to wear his heavy gloves and was electrocuted. Rescuers trying to pull the body in through the window were promptly shocked. Finally they obtained some rubber sheets and, after wrapping the corpse in those, pulled the poor charred fellow off the cornice and took him over to the Tenth Precinct Station House. For six years, arc lights and their wires had been viewed as an eyesore and a nuisance in Manhattan. But now, the citizenry would begin to associate high-voltage electricity with danger and death, just as did Thomas Edison.

Ever since George Westinghouse had turned on the lights in the Buf-



been plagued by a steady stream of bad electrical news. In late 1886, Edison had jauntily written off his new rival, George Westinghouse, claiming, "None of his plans worries me in the least," albeit conceding that the "only thing that disturbs me is that Westinghouse is a great man for flooding the country with agents and travelers. He is ubiquitous and will form numerous companies before we know anything about it."[5] Indeed, with each passing month, Westinghouse was proving a more and more formidable threat to Edison dominance.

The hard-charging Westinghouse, after but one year in business, had constructed or had under contract 68 AC central stations. He had come from nowhere to loom as Edison's biggest competitor. Thomson-Houston, which had flourished primarily as an arc light company, had also taken up installing AC central stations just that spring, using Westinghouse transformers. *They* had already up or under contract 22 AC central stations. At the end of 1887, from the seat of his eight-year-old empire in Manhattan, Edison had built or had under contract 121 DC central stations in places as far-flung as Birmingham, Alabama, and Grand Rapids, Michigan. The Edison Electric Light Company's executives, in their 1887 annual report issued in late October, put a brave face on the AC situation, denouncing this electrical alternative as "from a commercial standpoint, having no merit in itself and, being of high pressure . . . notoriously destructive of both life and property."[6]

Edison was especially galled that Westinghouse had installed a big AC central station in New Orleans. Edison already had a plant in that steamy Louisiana port and viewed it as his exclusive incandescent turf. The 1887 Edison annual report chortled over the many Westinghouse woes there—constant breakdowns, transformers ruined by lightning, no AC motors for those who wanted to use their electricity for more than lighting. The report quoted W. T. Mottram, their Edison manager, as saying he was "thoroughly convinced that the Edison system is unassailable . . . they cannot compete with us or do us any permanent harm, and that a steady conservative policy will win the battle."[7] Brave words, these, and fine for the public, but meanwhile Edward Johnson was tartly rebuking Edison that without AC "we will do no small town business, or even much headway in cities

of minor size."[8] What were the Edison salesmen to say to city fathers who needed electricity for homes and factories more than half a mile away from the DC central station?

Out in the far-flung marketplace of new central stations, the Edison camp was encountering continual and embittering setbacks. If a town bought a DC plant, it might well serve only half those who wanted electric lights. Those who lived more than half a mile away had to contemplate buying individual isolated plants or a whole other central station. In stark contrast, one AC station could serve the whole place and could be expanded as necessary to accommodate continued growth. So Thomas Edison's rancor toward Westinghouse continued to fester and grow with each passing month of 1887.

It was not that Edison did not have ready access to his own AC system. Even as Westinghouse was installing his first AC plant in late 1886, Edison's own people had been giving thorough consideration to buying a European-developed AC system that was causing a sensation on the Continent. Francis Jehl, a longtime Edison employee, had been in Europe on business in early 1885 when he was asked to travel to Budapest, with its famous castle and cafés, to look at the Ganz Company's new AC system. It was dubbed ZBD for its Hungarian inventors, Charles Zipernowsky, Otto Titus Blathy, and Max Deri. Jehl later recalled that in Budapest, "at the exhibition grounds I found 1,000 or more incandescent lights operating from an alternator running at a pressure of 1,300 volts. It was an 'eye opener,' for the pressure was reduced to that required by the lamps by means of poleless induction coils for which the Hungarian inventors called or coined the word transformers."[9] Jehl, who had once pumped the air out of the early incandescent bulbs at Menlo Park, described all the young European electricians as abuzz over AC.

The first ZBD customer had been none other than the Edison Company in Milan, run by John Lieb, former chief electrician of the Pearl Street Station. Lieb, who went down in history as the man who stood on his tiptoes to first pull the Pearl Street switch, had successfully launched the Milan branch. Wishing to light up a new customer, the Theater dal Verm, which was beyond the reach of the existing Edison DC mains, he had used the new ZBD system. So all through

1886 Lieb sang the wonders of AC, pleading with Edison to buy the ZBD patents. One of the ZBD inventors, Dr. Otto Titus Blathy of the Ganz Company, was equally anxious to hook up with Edison, for the Edison imprimatur would be the ultimate electrical accolade, a surefire guarantee of instant luminous glory and dominance. When Edison waffled and stalled, the good Hungarian doctor sailed to New York to personally lobby the great inventor, arriving in September of 1886. Edison still agreed to nothing, but he dispatched to Paris Francis Upton, who now ran the lamp company and had once supplied the math and physics back in the Menlo Park days. As Westinghouse had struggled to get its first AC system installed and functioning in the fancy Buffalo emporium, Upton had arrived in Paris, inspected the ZBD system, and strongly recommended the Edison Company buy an option on the American rights for $20,000.

When Edison had consulted Siemens and Halske of Berlin, *they* criticized the ZBD system as expensive, troublesome, and dangerous. They had, of course, given similar advice to Pantaleoni when he was considering the Gaulard and Gibbs apparatus for George Westinghouse. Pressed on all sides by his top men, Edison had reluctantly taken the option on the ZBD patent, well aware that Westinghouse was already launched. Yet he stubbornly and proudly refused even to consider using this AC system. Historians W. Bernard Carlson and A. J. Millard believe that Edison genuinely "feared that poorly designed and installed a.c. systems would impede the broad adoption of electric power."[10] One suspects a further cause—stubborn pride of authorship. Every aspect of the Edison DC system had been created from scratch by Edison or his colleagues. It is easy to imagine him obstinately balking at incorporating the inventions of others, especially if he could convince himself that their technology was dangerous.

The year 1887 was thoroughly trying to Edison. Not only was Westinghouse challenging Edison with his AC systems, the price of copper was also suddenly on the rise. This was worrisome for all electricians, for copper, with its peerless qualities of malleability and conductivity, was a major and critical component of their business. In December of 1887, the *Journal of Engineering and Mining* had

explained the sharp rise—from ten cents a pound to sixteen cents a pound—as the work of "a powerful combination in Europe who have managed the whole business in a very skillful manner."[11] And indeed, across the wintry Atlantic in the business precincts of Paris could be found the mastermind of the copper corner: a bald-headed little executive named Hyacinth Secretan, who had built up the Société des Metaux into Europe's largest manufacturer of gleaming brass and copper goods. Closely attuned at all times to the copper market, Secretan traced the metal's every flutter and dip. In late 1886, when one of his tremendous orders for copper ingots had briefly elevated prices, Monsieur Secretan concluded the moment was propitious to quietly corner copper, drawing on lessons learned during a previous failed attempt to manipulate tin.

So the foppish Secretan began contracting with the principal copper mines of the world for their whole production (subject, of course, to restrictions) at thirteen cents a pound, a very nice profit for them. He then offered this copper on the world market at steadily escalating prices, hitting sixteen or seventeen cents a pound by late 1887, a very nice profit for him. Monsieur Secretan had little trouble signing up a host of European financial luminaries for his copper syndicate, including the Rothschilds, Credit Lyonnaise, and the Comptoir d'Escompt, France's second-largest bank. Seeing swirling around them the proliferation of the copper-reliant electric light, trolley cars, and the telegraph, all these financiers expected to ride the copper corner to even greater fortunes. The world's appetite for this metal could only grow.

No one knew better than Thomas Edison the critical importance of copper's cost. Not long after his fateful visit to William Wallace's hissing arc lights aroused a great ambition to "get ahead of the other fellows" and light the world with incandescent light, Edison had seen what all others had been blind to. Drastically reducing copper use was *the* key to creating a practical incandescent lighting system, one that could compete financially with the coal-gas illuminating American cities. And Edison had, through his genius, lowered the amount of copper needed to a tiny fraction of original estimates. But in the winter of 1887, the copper problem returned to harry Edison with a

vengeance. As the *Electrical Engineer* noted by mid-February of 1888, "If the advance in the price of copper proves to be more than temporary in its effect, one of its incidental results will be to handicap seriously the low potential system of electrical distribution [Edison's DC], in their efforts to compete commercially with the high potential systems of more recent introduction [Westinghouse's AC]."[12]

By early March of 1888, a month later, the *Journal of Engineering and Mining* was reporting, "All the electrolitic copper in this country is now firmly in the grasp of the syndicate. There appears, in fact, nothing to prevent prices from being advanced to any figure the syndicate may wish."[13] This unfortunate and ominous turn of events was a real blow to the Edison Electric Light Company. For instance, in the spring of 1887, the company had been putting together a bid for a Minneapolis central station powering 21,700 lights. They estimated the feeders at 254,000 pounds of copper and the main at 51,680 pounds. At seventeen cents a pound, copper costs would total $51,965. Each one-cent rise in copper pushed costs up $3,056. A three-cent rise—for copper prices were escalating steadily—would add $9,000 to the almost $52,000 price tag for copper. In painful contrast, the new Westinghouse AC central plants required a third as much copper.

Just as he was being squeezed by Westinghouse on one side and the rising price of copper on the other, Edison was presented with an irresistible opportunity for wreaking some sub-rosa vengeance on his new enemy. In early November of 1887, Edison, America's most revered electrician, had received a beautifully penned letter from Dr. Alfred Southwick, a dour Buffalo dentist and one of three members of the New York State Death Commission. The commission's task was to find a civilized alternative to hanging for state prisoners condemned to execution. The committee chairman was the rich New York attorney and philanthropist Elbridge T. Gerry, best known for activism in the prevention of cruelty to animals. The third member was Matthew Hale, an Albany politician. After a series of repellently botched state hangings, New York governor David Hill had wondered if this "Dark Age" system might yield to something of a "less barbarous manner."[14] All the newspapers had described in revolting

detail the state hangman's scandalous and repeated incompetence, whereby benighted criminals dangled in agony on too loose ropes, gasping until slow-motion strangulation finally silenced their death rattle. Or there was the equally gruesome but opposite problem: a noose so overtaut that it bloodily severed head from body before horrified official witnesses. In his letter to Edison, Dr. Southwick sought the inventor's opinion on using electricity for electrocuting condemned criminals and also wondered if he could suggest "the necessary strength of current to produce death with certainty in all cases and under all circumstances."[15] Edison wrote back to Dr. Southwick declining to get involved, saying he opposed capital punishment. That was in November.

But Dr. Southwick was as hard pushing as his hometown of Buffalo. He was quite adamant that clean and modern electrocution should prevail (having once seen a man keel over neatly dead in an electrical accident), and he wrote the nation's foremost electrician again in early December. Appealing to Edison's sense of civic duty, he pleaded, "Science and civilization demand some more humane method than the rope. The rope is a relic of barbarism and should be relegated to the past." These three commissioners of death—Dr. Southwick, politician Hale, and philanthropist Gerry—had made a thorough study of the history of lethality, conducting a survey of the state's judges, sheriffs, prosecutors, and physicians on the issue, and Dr. Southwick was pleased to report that eighty-seven of the two hundred responding favored electrocution. What the Buffalo dentist needed now was Edison and his enormous prestige "as an electrician" to persuade the legislature.

Tellingly, on December 9, 1887, Thomas Edison changed his mind and wrote Dr. Southwick again. But this time, the world's most famous electrical wizard was full of very definite and very damaging opinions. The quickest, most painless death, he asserted, "can be accomplished by the use of electricity, and the most suitable apparatus for the purpose is that class of dynamo-electric machine which employs intermittent currents. The most effective of those are known as 'alternating machines,' manufactured principally in this country by Geo. Westinghouse. . . . The passage of the current from these

machines through the human body even by the slightest contacts, produces instantaneous death."[16] Was it the steadily rising price of copper? Had Westinghouse just won yet another central station contract from the Edison camp? Was it that the gas companies were proving harder to dislodge than anticipated, with their dropping prices and the much brighter gas mantle for their lights? We can only speculate. Whatever the reason for this hostile act, Edison's endorsement did the trick, and in mid-1888 the New York State Legislature would establish electrocution—much to the outrage of (the rest of) the electrical fraternity—as the new means of capital punishment starting January 1, 1889. Edison had just quietly (and secretly) planted something of a legislative land mine intended to damage his AC rivals.

By February of 1888, Thomas Edison was no longer content to vent his rancor with secret attacks. Using the vehicle of the Edison Electric Light Company, he lashed out publicly, issuing what surely stands as America's longest and most splenetic howl of corporate outrage. The eighty-four-page Edison diatribe, jacketed in angry scarlet and emblazoned with the title *WARNING!*, served as the official public salvo in one of the most unusual and caustic battles in American corporate history. Edison, with his DC system, was making his first open attack against Westinghouse and AC in the War of the Electric Currents. Thomas Edison, who had long (and reasonably) assumed that the electrical future was securely his—with all its glory and potential for riches—suddenly saw the famously tough, reckless, and industrially wealthy Westinghouse boldly swooping in from Pittsburgh to steal away his hard-earned prize. Edison would not sit back quietly and let what he saw as a dangerous system imperil not just his company, but the whole marvelous field of electricity.

What had triggered this furious verbal assault from the Wizard of Menlo Park? Why did he launch the War of the Electric Currents then? Edison, not the introspective sort, never did say. But we know that until 1885 Thomas Edison had been too busy (and fully confident of market dominance) to even bother suing the many lesser companies infringing on his 1879 light bulb patent. He had dismissed and largely ignored his competitors as shameless imitators, "patent pirates" who stole his ideas and inventions but who posed little genuine threat. But by 1885, as other companies began hurting his business, Edison had finally unmuzzled his top-dollar lawyers. Certainly part of his rising bitterness toward the Pittsburgh magnate was fueled by his anger at all infringers, for Westinghouse *was* among those making free use of an Edison-style bulb. Yet historian Harold Passer explains that Edison competitors "seriously questioned the validity of the Edison lamp patents. The United States company [controlled by Westinghouse], for example, considered its patent position much stronger than Edison's because it owned the incandescent-lamp patents of Farmer, Maxim, and Weston. Both Farmer and Maxim had worked in the incandescent lighting long before Edison."[17] Westinghouse, ever a fighter, had further goaded Edison by filing a counter light bulb patent suit. Thus, however much the Edison attorneys might huff and puff in the courts, there was still at this point, says Passer, "reasonable doubt that the basic Edison [light bulb] patent would be sustained. It is probable that few manufacturers and users of incandescent lamps considered it a serious business risk to make and use these lamps without permission from the Edison company."[18]

But angry as Edison was about light bulb infringers, George Westinghouse's biggest fault was daring to trespass at all on Edison's electrical terrain. When Thomas Edison first heard that the Pittsburgh industrialist was eyeing electricity, he famously snapped, "Tell him to stick to air brakes."[19] Not only had Westinghouse defied Edison, he was selling something original, a power system that was new, not just a second-rate copy of the Edison system. While the first half of *WARNING!* was dedicated to excoriating the light bulb infringers, much of the second half assailed Westinghouse. The whole AC system was "the most uneconomical yet offered to the public," insisted the Edison people, once you factored in the greater efficiency of DC generators, the reliable track record of the more tested DC systems, the lack of a meter to measure AC use, and the absence of any AC motor.[20] The DC motor remained Edison's great trump card. Those who preferred AC were dismissed as "Cheap Johns" and "the Apostles of Parsimony," shysters foisting inferior equipment on the unsuspecting.[21] Edison had no interest in acknowledging the great strength

of the AC system—its ability to serve large areas and expand as needed.

But Edison reserved his greatest fury for AC's sheer dangers. Decreed the *WARNING!* booklet, "It is a matter of fact that any system employing high pressure, i.e. 500 to 2,000 units [volts], jeopardizes life."[22] The Edison people warned that if a transformer failed to step down the current, the whole building served would be a possible death chamber reverberating with high-voltage electricity. Thomas Edison had always prided himself on his system's safety: "There is no danger to life, health, or person, in the current generated by any of the Edison dynamos" and "the wires at any part of the system, and even the poles of the generator itself, may be grasped by the naked hand without the slightest effect."[23] No other electrical company had invested such time and energy in devising safe insulation for its wires and careful placement in the ground far away from the public as had Edison. In contrast, Edison detailed in his *WARNING!* pamphlet the gruesome deaths by high-voltage AC of numerous AC workers. DC was a gentle, friendly current. AC was a stone killer. Edison suggested the AC people were criminally indifferent to safety just to save a buck and get ahead.

Edison's rancorous corporate diatribe culminated by rallying the electrical troops to rise up against the infidels of AC: "All electricians who believe in the future of electricity ought to unite in a war of extermination against cheapness in applied electricity, wherever they see that it involves inefficiency and danger." Edison humbly volunteered to serve as the moral compass in this holy war. Those, like George Westinghouse, who dared to forge ahead on an alternate and alternating path, however shimmering and promising, were now the official enemy, the besmirchers of the sacred ways. George Westinghouse is, they sneered, "the inventor of the vaunted system of distribution which is to-day recognized by every thoroughly-read electrician as only an *ignis fatuus*, in following which the Pittsburg company have at every step sunk deeper in the quagmire of disappointment."[24] The first open, public shots had now been fired toward Pittsburgh in the War of the Electric Currents.

In the spring of 1888, even as the papers began to track every instance of "electrocution by wire" and the Edison Electric Light Company had made known its ire with AC, the small world of New York electricians began to buzz with rumors about the former Edison man Nikola Tesla. He was said to have reappeared and to be up to something big down on Liberty Street, filing a steady stream of patents related to an AC system. And indeed Nikola Tesla *had* been wonderfully productive, churning out one new AC machine after another. To handle all the work, he had summoned from Europe his old school chum and fellow engineer Anthony Szigety, who had sailed into the choppy waters of New York Harbor on May 10, 1887, to the rousing sight of Auguste Bartholdi's long-aborning Statue of Liberty. For six months now, the monumental goddess had been gleaming forth through each gray dawn, her torch of enlightenment radiantly lit from within by electricity and her bronze robes and grave face aglow from the thousands of candlepower at her feet. This luminous figure of welcome had been dedicated the previous winter with festive fanfare, after working-class readers of the *New York World* had sent in their pennies and dimes, showing the nation that ordinary people—not millionaires—would be the ones to finally erect the majestic sculpture on her Bedloe's Island pedestal. And so, emerging from Castle Garden to see the greensward of Battery Park, crisscrossed by shaded gravel paths and so wonderfully cooled by the harbor breezes, Szigety was reunited with his old friend Tesla. The two were soon putting in intense all-night hours constructing numerous variants on the AC induction motor Tesla had drawn for him in the sands of the Budapest park.

Years later, Tesla's first biographer, science writer John O'Neill, would recall how proud Tesla had been about the integrity of his vision. "When the machines were physically constructed not one of them failed to operate as he had anticipated. . . . Years had elapsed since he evolved the designs. In the meantime he had not committed a line to paper—yet he had remembered perfectly every last detail."[25] The rest of 1887 was a frenzy of creativity and secret construction as Tesla and his helpers turned out all the necessary components for three complete AC systems—single-phase alternating current, two-

phase, and three-phase. He designed and built copper and iron models for each system—a dynamo (without the commutator!) that generated the electric current, an induction motor with its rotating magnetic core (again no commutators) to produce power, and then transformers to step up and step down that power. At the end of a whirlwind six months, Tesla had in his laboratory a whole system based on polyphase AC. On October 12, 1887, Tesla submitted an omnibus patent application, but the patent office requested it be broken down further. In November and December, Tesla filed for the first of what would eventually be forty patents covering the whole range of his AC system with its revolutionary induction motor. He was perfecting his AC system even as his old boss was denouncing AC to the world.

The ambitious young editor of *Electrical World*, Thomas Commerford Martin, a personable and ambitious bald English immigrant who sported a giant mustachio, stopped by Tesla's lab. He quickly grasped that this little-known but highly charming Serb was going to be the next electrical titan, a visionary whose radiant dreams rivaled Edison's. As a journalist, Martin savored the further drama that the unknown Tesla's electrical dreams clashed with those of the world-famous Edison—AC versus DC. Tesla, just thirty-one, was as much a true humanist as ever, seeking to ease the hard labor of the whole world with his spectacular induction motor and alternating current system. What AC had lacked up until now was a workable motor that it could power (although many a well-placed inventor was struggling to solve that puzzle and cover himself in glory). Now here was Nikola Tesla, a little-known electrician of minor accomplishment, seizing that prize.

Thomas Commerford Martin appreciated immediately the epochal nature of Tesla's AC motor and polyphase system and began considering how best he could shepherd this new genius to certain fame and millions of dollars. Martin was, fortunately, in a uniquely influential position. Not only was he the editor of the electrical field's top American journal, he was also the current president of the prestigious American Institute of Electrical Engineers (an organization all of four years old). He was therefore well versed in the feuds and cut-

throat rivalries of the electrical universe and knew how best to introduce such a large and brilliant star into its heavens at such a delicate and stormy moment. Martin departed Tesla's Liberty Street lab in a great thrill of excitement, planning his campaign to launch Nikola Tesla. The English editor's first task was to get others equally enthralled with Tesla's system.

First, the AC polyphase machines needed to be tested and their revolutionary nature acknowledged by an outside expert of high standing. Martin arranged for Professor William Anthony, an eminent academic of electrical engineering at Cornell University, to come to Liberty Street and meet Tesla and his machines. Then machines were sent to him and several others for further testing. In March of 1888, Professor Anthony excitedly wrote a friend that he "was shown the machines under pledge of secrecy as applications were still in the Patent Office. . . . I have seen an armature weighing 12 pounds running at 3,000, when *one* of the (ac) circuits was suddenly reversed, reverse its rotation so suddenly I could hardly see what did it. In all this you understand there is *no* commutator. The armatures have no connection with anything outside. . . . It was a wonderful result to me . . . in the form of motor I first described, there is absolutely nothing like a commutator, the two (ac) chasing each other round the field do it all. There is nothing to wear except the two bearings."[26] So, just as Martin hoped, Tesla's name and riveting invention were filtering out among the people who mattered. Professor Anthony, a completely disinterested party, had judged Tesla's motors the equal in efficiency of existing direct current models.

Now Martin recommended to Tesla that he prepare a lecture to establish himself before the electrical world. Tesla demurred. When the first seven of Tesla's fourteen foundation patents were granted May 1, 1888, Martin again urged the Serbian inventor to make formally known to his electrical peers his magnificent breakthrough. Again Tesla excused himself politely, pleading exhaustion from the tremendous exertion of designing and constructing his whole complex system so swiftly. Professor Anthony then joined T. C. Martin in pressing Tesla to speak as soon as possible. Franklin Pope, editor of

the *Electrical Engineer* and a Westinghouse engineer and patent attorney, had also been invited to Liberty Street, and he added his voice. Some years later, Martin would write that he "had great difficulty in inducing Mr. Tesla to give the Institute any paper at all. Mr. Tesla was overworked and ill, and manifested the greatest reluctance to an exhibition of his motors, but his objections were at last overcome. The paper was written the night previous to the meeting, in pencil, very hastily, and under the pressure just mentioned."[27] Martin brushed aside Tesla's worries about discussing aspects of his system for which he had not yet even filed patents. Nikola Tesla needed to establish his preeminence in this field. So on the cool Tuesday evening of May 15, Tesla traveled up to Columbia College on Madison and 47th Street, where the American Institute of Electrical Engineers was convening.

The meeting that evening commenced with various laudatory remarks celebrating Martin's energetic term as president. Then Nikola Tesla, tall, slender, his hair parted in the middle above a wide forehead, stood before the assembled electricians, a sea of men attired in high hats and dark frock coats, the crowd interspersed with the occasional interested lady. Tesla, with his high cheekbones, looked like a foreign, somewhat eccentric aristocrat in his preferred swallowtail coat. Speaking in his excellent but accented English, he first thanked his benefactors, Professor Anthony and Mr. Martin and Mr. Pope, men any ambitious electrician would wish as patrons. Then he excused his wan and weary appearance and the inadequacy of his presentation. "The notice," he said in his high voice, "was rather short, and I have not been able to treat the subject so extensively as I could have desired, my health not being in the best condition at present. I ask your kind indulgence, and I shall be very much gratified if the little I have done meets your approval."

Standing behind his shiny AC induction motors, Tesla began his talk, making his point by starting and stopping the machines and showing through drawings and diagrams also how they worked. "The subject which I have the pleasure of bringing to your notice is a novel system of electrical distribution and transmission of power by means of alternate currents, affording peculiar advantages, particularly in

the way of motors, which I am confident will at once establish the superior adaptability of these currents to the transmission of power and will show that many results heretofore unattainable can be reached by their use; results which are very much desired in the practical operation of such systems, and which cannot be accomplished by means of continuous currents."[28] Tesla went on to tell all present that what they took quite for granted—the presence of commutators and brushes on existing motors to redirect the naturally produced alternating current into direct current when it entered the machine—would from here on in be unnecessary. He had invented a motor that was like no other, one that operated in a system expressly designed for it by him. Consequently, from this time forward, "alternate currents would commend themselves as a more direct application of electrical energy."[29]

Scientist and Tesla biographer Robert Lomas notes that others who came before Tesla found that the magnetic fields produced by alternating current entered motors and "just churned about, not turning the motor. What Tesla did, was to use two alternating currents that were out of step with each other [polyphase]. Like the propelling waves of legs that move a millipede forward, the magnetic fields worked together to push the rotating shaft of the motor around. By using more than one set of currents, he could ensure that there was always a strong current available to power the motor. As one of the currents died away, the other would continue to move the motor round. The magnetic field rotated and carried the motor round with it, and it did so without using any electrical connections to the rotating shaft."[30]

After Tesla delivered his lecture, Martin stepped forward to propose that the distinguished Professor William Anthony say a few words. The professor, in turn, bestowed his prestigious blessing on this brilliant Serb's astonishing new motor: "I confess that on first seeing the motors the action seemed to me an exceedingly remarkable one." He briefly discussed the technical advantages—few wearing parts—and the motor's efficiency. Then the well-known electrical inventor Elihu Thomson, whose fast-growing firm Thomson-Houston had also entered the AC central station business six months

earlier in the fall of 1887, stood up. Thomson, a tall man with deep-set eyes and a thick brush mustache, was not—like Edison, Westinghouse, or Tesla—an inventor who had created original and pathbreaking technologies. But he was immensely skillful at improving and making commercially viable the work of the field's pioneers. Thomson-Houston, seeing the demand for Westinghouse AC systems, had begun offering their own line of central stations, prompting an outraged George Westinghouse to swiftly sue them for infringing on his Gaulard-Gibbs patents. Within a couple of months, the two companies reached terms, with Thomson-Houston agreeing to pay a $2-per-horsepower royalty on each transformer it produced. (About the same time, Hiram Maxim's old firm, United States Electric, also began selling AC central systems. The Westinghouse response to this infringement was so bellicose, U.S. Electric opted instead to let itself be bought by the flourishing Westinghouse electrical empire.)

When Professor Thomson stood up after the Columbia College AC talk, he complimented Mr. Tesla on "his new and admirable little motor." But what Thomson really wished to establish was that he, too, had been working on an AC motor. "I have, as probably you may be aware, worked in somewhat similar directions and towards the attainment of similar ends. The trials which I have made have been by the use of a single alternating current circuit—not a double alternating current—a single current supplying a motor constructed to utilize the alternation and produce rotation."[31] However, Thomson's AC motor depended—as had all others attempted up to this time—upon that troublesome object the commutator. Tesla understood exactly what Thomson was trying to do—establish precedence. He gracefully parried the challenge, declaring himself flattered to be noticed by someone as eminent as Professor Thomson, "being foremost in his profession." Tesla was highly deferential, acknowledging, "I had a motor identically the same as that of Professor Thomson, but I was anticipated by him."

But he also honestly suggested that Thomson would be hard put to claim any kind of equality or anticipation here. Tesla pointed out that Thomson's "peculiar form of motor represents the disadvantage

that a pair of brushes must be employed to short circuit the armature coil."[32] Tesla had thought briefly along Thomson's lines but had soared forward, eliminating the commutators with his completely original solution—magnetic fields continuously pushing round the motor's core. Martin deftly cut off discussion while Tesla held the advantage. But this bristly public exchange marked the start of a lifelong antipathy. As Nikola Tesla returned to his seat, the assembled electricians comprehended uneasily and somewhat resentfully that a new titan had risen unbidden among them, eclipsing much of what they had done, making irrelevant many of their dearest labors. His name was Nikola Tesla, and the ambitious and influential Thomas Commerford Martin was his prophet.

Tesla's first lecture, "A New System of Alternate Current Motors and Transformers," was all Martin could have hoped, catapulting Tesla to instant fame in the engineering world. This paper, printed in all the foremost engineering journals, quickly became a landmark for its lucid description of an entirely new kind of very simple "induction" motor. Engineers and the press were astonished at the originality, simplicity, and promise of his AC design. Edison viewed it as but a variant on a technology that was unsafe and unfit for use in human habitations.

It is likely that George Westinghouse had learned about Tesla's revolutionary rotating motors and AC system before the Serb inventor made his dazzling public debut in mid-May before the engineers. After all, Franklin Pope, editor of the *Electrical Engineer* and a Westinghouse employee, had visited the Liberty Street lab at Martin's behest. But it was not until Westinghouse read Tesla's landmark lecture that he took action. He quickly dispatched H. M. Byllesby, a one-time Edison engineer lured away to become a Westinghouse vice president, to visit Nikola Tesla in Manhattan and see if the now famous motors merited such huzzahs. On May 21, 1888, Byllesby wrote his boss that he had met up with Tesla's backers, engineer Alfred S. Brown and lawyer Charles Peck, and then proceeded to the Liberty Street lab with them. There he had met Tesla and witnessed several demonstrations, all of which, he admitted, were somewhat over his head. "His [Tesla's] description was not of a nature which I

was enabled, entirely, to comprehend. However, I saw several points which I think are of interest. In the first place, as near as I can get it, the underlying principle of this motor is the principle which Mr. Shallenberger is at work at this present moment. The motors, as far as I can judge from the examination which I was enabled to make, are a success. They start from rest and the reversion of the direction of rotation can be suddenly accomplished without any short-circuiting."[33]

After the demonstration, Byllesby and his escorts returned to Alfred Brown's office to talk business. The Westinghouse executive inquired about the possibility of purchasing the patents. He learned they were held by the Tesla Electric Company and that already Peck and Brown had an offer from a San Francisco capitalist of $200,000 plus $2.50 per horsepower on all apparatus. Reportedly, Cornell professor William Anthony was joining this syndicate. If Westinghouse intended to match or better this offer, they needed to know by Friday at the latest. Byllesby was aghast. He wrote the home office, "The terms, of course, are monstrous; and I so told them. . . . I told them there was no possibility of our considering the matter seriously but that I would let them know before Friday. . . . In order to avoid giving the impression that the matter was one which excited my curiosity I made my visit short."[34]

It's not clear if Peck and Brown really did have such a lucrative offer, for a week later, they were willing to grant Byllesby a $5,000 option for six weeks. George Westinghouse began seriously consulting with his in-house engineers and patent experts. What Tesla and his partners did not know was that a Westinghouse representative—the peripatetic Guido Pantaleoni—was once again in Europe on an AC mission, this time seeking to buy an AC motor patent from his Italian engineering professor, Galileo Ferraris. A month before Tesla's talk before the American Institute of Electrical Engineers, even as Tesla's patents were being considered at the U.S. Patent Office, Professor Ferraris of Turin had given a lecture laying out his own version of an alternating current motor. There was, however, a monumental difference between Tesla and Ferraris, and that was that the Italian electrician viewed his effort purely as a tantalizing and amusing toy,

while Tesla had designed a machine and system intended for heavy-duty commercial work. Martin had been properly impatient that Tesla declare his great discovery in a high-profile way, for others were indeed working away on the dilemma. With AC systems spreading across Europe and America, the pressing need for a working motor had become more than well-known. Among engineers, AC motors were in the air. Mere weeks before Tesla's talk, Westinghouse engineer Oliver Shallenberger had solved one of the outstanding gaps in the company's AC lighting system, the lack of a meter to measure electrical use. That meter was also based on the rotating effects of out-of-phase currents, and Shallenberger had begun to experiment with a possible motor. While Westinghouse continued to survey the general status of AC motors, he instructed Pantaleoni to buy the Ferraris patent for the small sum of $1,000.

The wiry William Stanley would complain later in life (when George Westinghouse was dead and gone) that Westinghouse never really appreciated the possibilities of alternating current in the pioneering days and never compensated him fairly. Now, in the wake of Tesla's triumph, Stanley claimed to his boss that he, Stanley, had already invented an AC motor. "I have built an AC system on basically the same principle," he said. However, like Elihu Thomson, Stanley was overlooking the inconvenient fact that his AC motor was still using commutators and brushes. Only Nikola Tesla had designed an AC induction motor free of those troublesome, sparking objects. On July 5, 1888, Westinghouse, his option running out, wrote to one of his lawyers and partners, "I have been thinking over this motor question very considerably, and am of the opinion that if Tesla has a number of applications pending in the patent office, he will be able to cover broadly the apparatus that Shallenberger was experimenting with and that Stanley thought he had invented. It is more than likely that he will be able to carry his date of invention back sufficient time to seriously interfere with Ferraris and that our investment there will probably prove a bad one.

"If the Tesla patents are broad enough to control the alternating motor business, then the Westinghouse Electric Company cannot afford to have others own the patents."[35] Early hopes of using the Fer-

raris patents as leverage now evaporated, and the Westinghouse people simply had to go along with what Brown and Peck were asking, which was, in fact, far less than the original $200,000. They sought and received $20,000 in cash and $50,000 in notes (payable in three installments), plus the $2.50 royalty per horsepower on every AC Tesla motor, with $5,000 minimum paid in royalties the first year, $10,000 the second, and $15,000 the third. Westinghouse was his usual phlegmatic and pragmatic self: "With reference to the Tesla motor patents, the price to be paid seems rather high when coupled with all of the other terms and conditions, but if it is the only practicable method for operating a motor by the alternating current, and if it is applicable to street car work, we can unquestionably easily get from the users of the apparatus whatever tax is put upon it by the inventors."[36]

Even if the California offer was real, the Tesla Electric Company partners may have preferred to sell to George Westinghouse. In an era of robber barons, Westinghouse had developed a reputation as a fair but indomitable, no-nonsense businessman who defended his patents ferociously. He had already sued Thomson-Houston over his transformer and forced them to make a royalty deal. And he had simply bought up United States Electric when they dared to trespass. In the sharklike atmosphere of Gilded Age capitalism, Nikola Tesla and his partners well knew that they needed such a fearless fighter if they were ever to see more than three years of royalties. Tesla very much admired Westinghouse's qualities as a businessman. He said once, "No fiercer adversary than Westinghouse could have been found when he was aroused. An athlete in ordinary life, he was transformed into a giant when confronted with difficulties which seemed insurmountable. When others would give up in despair he triumphed. Had he been transferred to another planet with everything against him he would have worked out his salvation."[37]

Nor could Tesla and his investors overlook, as they considered their options, the overt hostility of Thomas Edison toward AC. The War of the Electric Currents was only likely to escalate as the stakes rose, and Tesla's much needed AC motor put him squarely in the enemy camp. That being so, Tesla would later say that George Westinghouse was "in my opinion, the only man on this globe who could take my alternating system under the circumstances then existing and win the battle against prejudice and money power. He was a pioneer of imposing stature, one of the world's noblemen."[38] Tesla, who had little trouble envisioning that the whole world would soon be operating on millions of AC-generated horsepower, viewed the deal for his patents as quite fair, even if he had to give five-ninths to his partners. Like Edison, Tesla wanted great wealth not for itself, but so he would be completely free to think, invent, and develop his ideas. The ardent idealist, he saw himself as finally bestowing his great gift on the world. Years earlier, when he had first conceived of the whirling magnetic field, he declared to the doubting Szigety, "No more will men be slaves to hard tasks. My motor will set them free, it will do the work of the world."

Thus, in late July 1888, Nikola Tesla quit the heat of Manhattan, ferried across the breezy Hudson, and boarded the comfortable cars of the Pennsylvania Railroad for the ten-hour journey to Pittsburgh, where he had agreed to serve as a Westinghouse consultant. By bestowing his new all-important AC induction motor upon George Westinghouse's rapidly expanding electrical empire, Tesla was eliminating the one great remaining advantage of Edison's DC system. The War of the Electric Currents was about to be joined in earnest.