"Experiments with Alternate Currents of High Potential and High Frequency" (1892) by Nikola Tesla: A Canonical Book: A Canonical Book

Curated by Stephen A Batman
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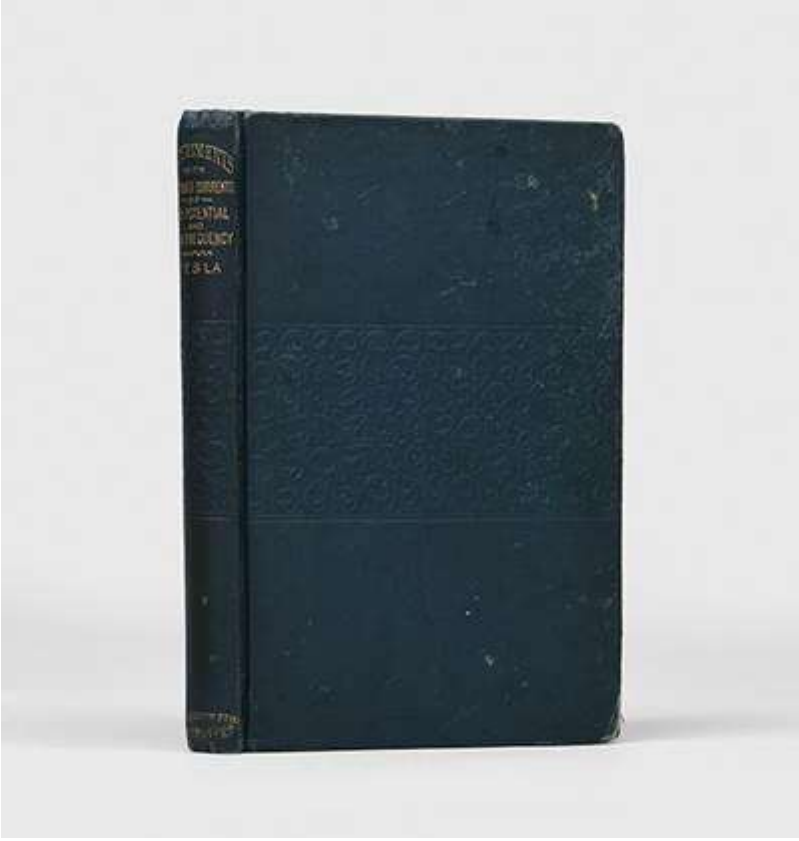
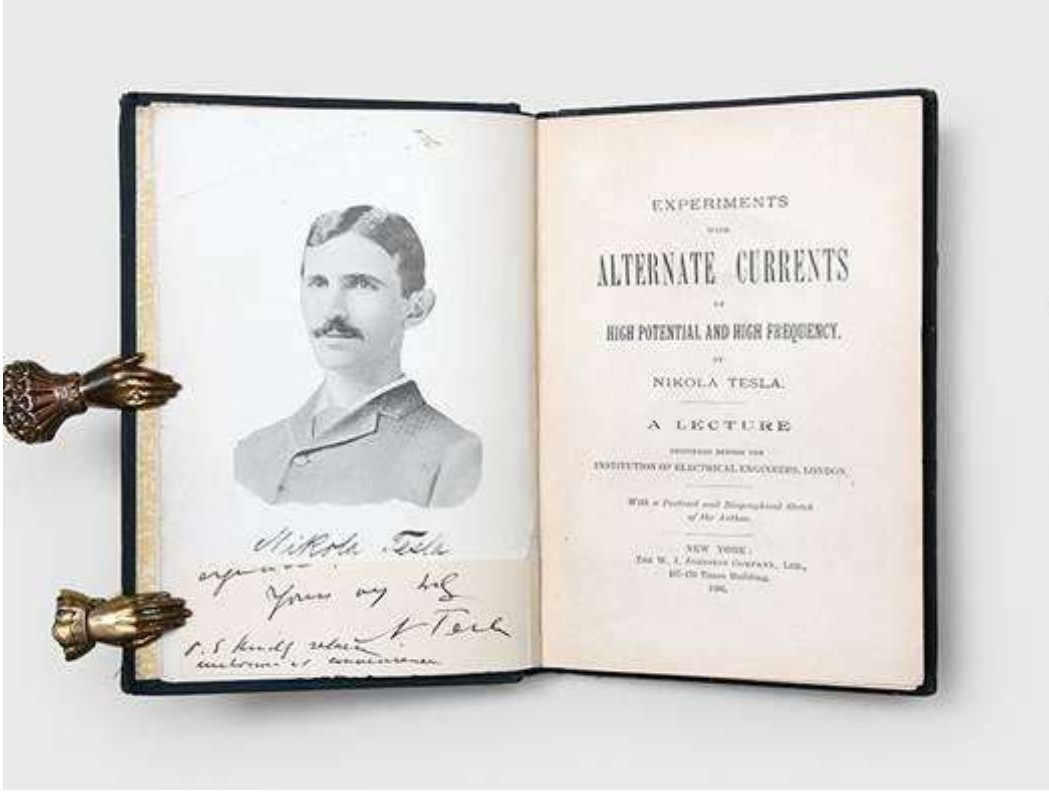
Summary of this Particular Rare First Edition

Nikola Tesla, Experiments with Alternate Currents of High Potential and High Frequency, 1892




EXPERIMENTS
WITH
ALTERNATE CURRENTS
OF
HIGH POTENTIAL AND HIGH FREQUENCY.
BY
NIKOLA TESLA.
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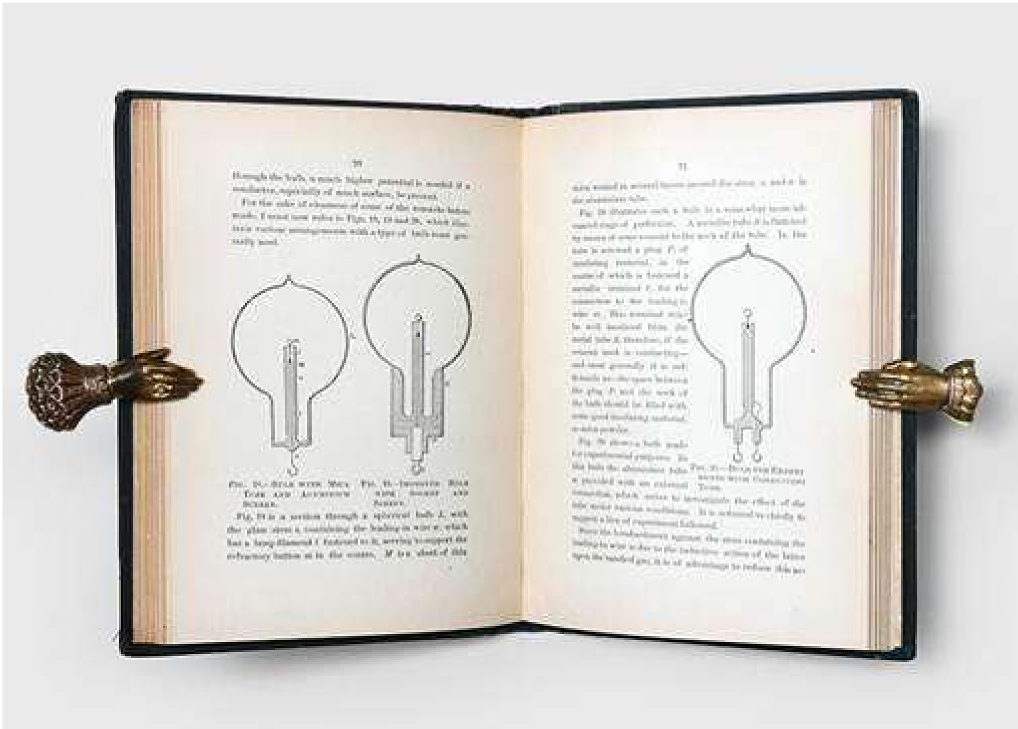
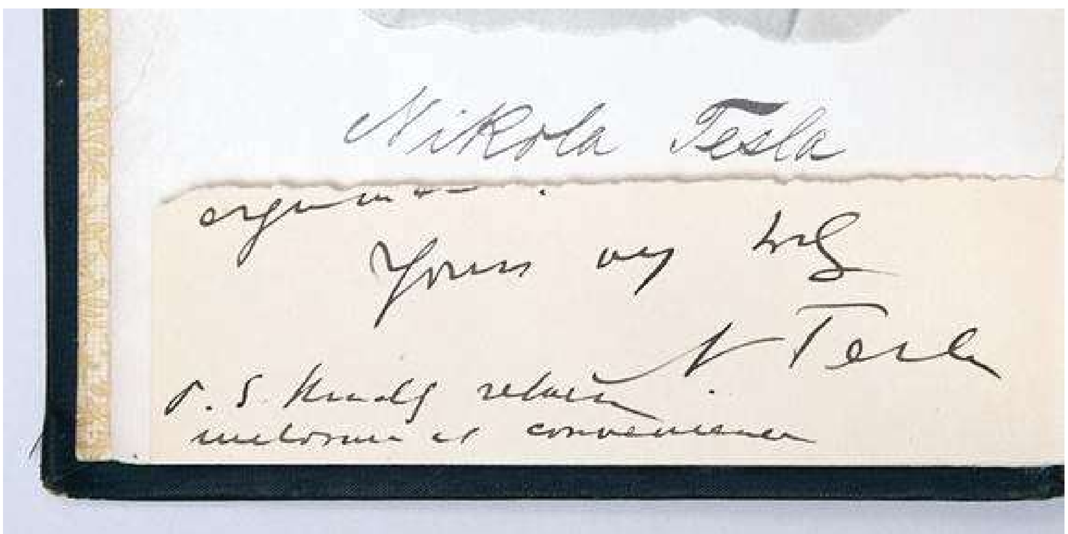
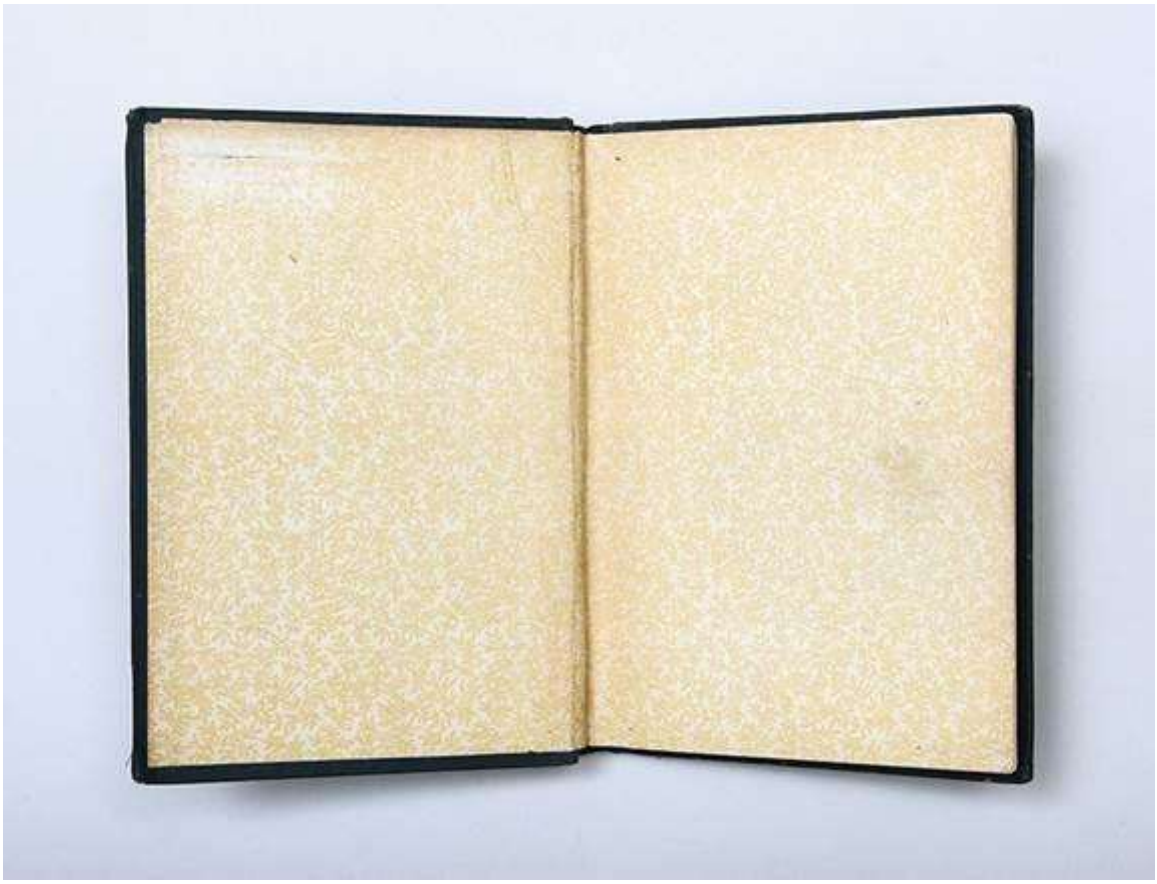
INSTITUTION OF ELECTRICAL ENGINEERS, LONDON.
NEW YORK:




Nikola Tesla



TESLA TRIUMPHS IN THE WAR OF THE CURRENTS

First edition in book form of the inventor's most celebrated lecture, with his signature tipped onto the portrait frontispiece, taken from a portion of an autograph letter signed "Yours very truly N. Tesla". Here Tesla promotes the benefits of high frequency alternating current, which became the world standard for most electrical devices. The biographical preface positions him as the creator of "this new branch of electricity" (p. ix).

The Serbian electrical engineer Nikola Tesla (1856-1943) worked for Thomas Edison in Paris and New York during the early 1880s before leaving to set up his own company, where he focussed on developing his competing arc lighting system and continued his research on high frequencies. "His major contribution to electrical technology was made in the period 1887-1891 when, drawing on mind experiments dating back to 1882, he applied for and received a series of patents based on the concept that two alternating current (AC) sources, out of phase, can create a rotating magnetic field, thus making possible an AC motor... His basic patents in this area, describing generators and transformers as well as motors, were purchased by George Westinghouse in 1888. They became the basis for the generating station at Niagara Falls in 1895, and for many other centralized stations, transmitting electricity over increasingly long distances in the years to come" (ANB).

Tesla's visionary annual predictions and numerous inventions in nascent fields soon established him as something of a cult figure in the field.

On 20 May 1891 Tesla delivered a landmark lecture on alternating currents of high frequency at Columbia College in New York; it and the accompanying demonstration were very favorably received. The contents were first published serially in journal form. He was subsequently invited to London in February 1892 to present on the same topic, this time at the Institute of Electrical Engineers. The immediate success and far-reaching impact of this lecture, which forms the contents of this book, prompted further invitations to speak at the Royal Institute and at similar establishments in Paris.

TESLA, Nikola. Experiments with Alternate Currents of High Potential and High Frequency. A lecture delivered before the Institution of Electrical Engineers, London. With a portrait and biographical sketch of the author. New York: The W. J. Johnston Company, Ltd, 1892

Small octavo. Original dark green cloth, spine lettered in gilt, spine and front cover decoratively blocked in blind, yellow floral patterned endpapers. Housed in a green cloth flat-back box by the Chelsea Bindery. Photographic portrait frontispiece, numerous diagrams and illustrations in text. 4 pp. publisher's advertisements at rear.

Late 20th-century ownership signature on frontispiece recto (one "William F. Northrop 1982 Los Angeles"), American Library Service label on rear free endpaper. Spine ends, joints, and inner hinges professionally restored, cloth a little marked and worn at corners but generally presenting nicely, evidence of label sometime removed from front pastedown, frontispiece a little brittle, with upper outer corner creased and 2 cm split where signature is tipped in, small hole (perhaps resulting from former adhesion) above the image, contents clean, with just a few ink spots in upper margins of pp. 61-4. A very good copy.

Introduction

In 1892, Nikola Tesla published "Experiments with Alternate Currents of High Potential and High Frequency," a work based on lectures he delivered before the Institution of Electrical Engineers in London in February of that year[1][7]. This seminal text emerged during a pivotal moment in electrical engineering history, often referred to as the "War of the Currents"[5]. Tesla's motivation for these lectures and subsequent publication was to demonstrate the superiority and practical applications of alternating current (AC) systems over the direct current (DC) systems championed by Thomas Edison. The book provides detailed descriptions of Tesla's groundbreaking experiments with high-frequency currents, which would lay the foundation for numerous future technological innovations.

The cultural and economic climate of the late 19th century was characterized by rapid industrialization and technological advancement. Electricity was transitioning from a scientific curiosity to an essential utility, with competing systems vying for market dominance. Edison's Edison Electric Light Company had established a significant foothold with its DC system, which was efficient for powering incandescent lighting but limited in transmission distance and efficiency[5].

Meanwhile, George Westinghouse's company had begun introducing an alternating current system in 1886 that could transmit power over longer distances from more efficient central generating stations[5]. Tesla, who had developed the AC induction motor and related polyphase AC patents (licensed by Westinghouse in 1888), became a key figure in this technological battle[3].

The political climate surrounding the publication was equally charged. Edison's company launched a campaign claiming that high-voltage AC systems were hazardous, attempting to influence public opinion and legislation against their adoption[5]. This included public demonstrations where animals were electrocuted with AC current to illustrate its supposed dangers, with technical assistance from Edison Electric[5].

Tesla's book and lectures came as a direct response to these challenges, systematically demonstrating not only the safety of properly designed AC systems but also their superior capabilities and potential applications beyond simple power transmission. In his own words, Tesla described the work as dealing with "alternating currents, and, to be more precise, with alternating currents of high potential and high frequency"[2], establishing the foundational principles that would eventually transform electrical engineering and power distribution worldwide.

The Author

Nikola Tesla (1856-1943) was born in Smiljan, in what was then the Austrian Empire (now Croatia), to a Serbian Orthodox family[3][12]. The son of an Orthodox priest, Milutin Tesla, and mother Georgina "Đuka" Tesla, Nikola showed early interest in engineering and physics, though he never completed a formal degree at the Graz University of Technology where he studied[3]. His

education continued at the University of Prague, and by 1880, he had completed his studies there[9].

Tesla's professional career began in Europe, working in telephony and electrical engineering. In 1881-1882, while working with the Central Telegraph Office in Budapest, he invented a device for telephone sound amplification[9]. It was during this period, in February 1882 in Budapest, that Tesla made his groundbreaking discovery of the rotating magnetic field and the multiphase currents that produce it[9].

In 1884, Tesla immigrated to the United States, where he would spend the majority of his professional life and eventually become a naturalized citizen in 1891[3]. After briefly working at Edison Machine Works in New York City, Tesla ventured out on his own. With financial backing from partners, he established laboratories in New York to develop a range of electrical and mechanical devices[3].

Tesla's most significant contribution came through his work with alternating current. His AC induction motor and related polyphase AC patents, licensed by Westinghouse Electric in 1888, earned him considerable wealth and established the cornerstone of the polyphase system that Westinghouse would eventually market[3]. This system would prove instrumental in winning the "War of the Currents" against Edison's DC system.

Beyond his work with AC electricity, Tesla conducted extensive experiments with mechanical oscillators/generators, electrical discharge tubes, and early X-ray imaging. He also built and demonstrated one of the first wirelessly controlled boats[3]. His interests extended to wireless power transmission, radio technology, and numerous other fields where his visionary ideas often stretched beyond the technological capabilities of his time.

Tesla became well-known not only for his technical achievements but also for his showmanship, often demonstrating his inventions to celebrities and wealthy patrons at his laboratory[3]. His flair for the dramatic helped popularize his ideas, though his reluctance to focus on commercial applications would eventually contribute to financial difficulties later in life.

By the time "Experiments with Alternate Currents of High Potential and High Frequency" was published in 1892, Tesla was at the height of his scientific productivity and public recognition, positioned as one of the leading electrical engineers of his generation. However, his pioneering work on radio technology was yet to receive full recognition, and it wasn't until months after his death in 1943 that the U.S. Supreme Court upheld Tesla's radio patents over Marconi's, finally acknowledging his foundational contributions to this field.

Why this is a Canonical Book

"Experiments with Alternate Currents of High Potential and High Frequency" stands as a canonical text that profoundly influenced America's technological development and, by extension, its economic and cultural landscape. The book's significance lies in its comprehensive exposition of the principles and applications of alternating current at high frequencies, a field

that Tesla pioneered and that would form the basis for numerous technological innovations central to modern life.

First and foremost, this work played a crucial role in establishing alternating current as the dominant electrical system in the United States and globally. Tesla's detailed explanations and experimental demonstrations effectively countered Edison's claims about AC's dangers, helping to resolve the "War of the Currents" in favor of the more efficient and versatile AC system5. This outcome fundamentally shaped America's electrical infrastructure, enabling the widespread electrification that powered the nation's industrial and economic growth throughout the 20th century.

The book's detailed exploration of high-frequency phenomena laid the groundwork for wireless communication technology. Tesla's observations about how "alternate currents, especially of high frequencies, pass with astonishing freedom through even slightly rarefied gases" and how the "upper strata of the air are rarefied"10 hinted at the possibility of wireless transmission through the atmosphere. These principles would later contribute to the development of radio, television, and modern telecommunications-industries that have been central to American economic strength and cultural influence.

Furthermore, Tesla's descriptions of his experiments with wireless power transmission represented ideas that were well ahead of their time. His demonstrations of lighting bulbs wirelessly and his vision of a future with wireless energy transfer continue to inspire research in this field today. Tesla's experimental apparatus, including the Tesla coil described in this work, remains a standard tool in physics education and continues to be refined for modern applications.

The text also exemplifies the American ideal of innovation-driven progress. Tesla's experimental approach, combining theoretical insight with practical demonstration, embodies the spirit of American ingenuity that has driven technological advancement. His work represents the possibilities available to immigrants in America-Tesla himself having arrived as an immigrant and risen to prominence through his inventive genius.

Additionally, the book captures a pivotal moment in American industrial history when the nascent electrical industry was being formed. The systems and principles Tesla described would go on to power American manufacturing, transportation, communication, and domestic life. The standardization of electrical systems based on AC technology enabled the mass production and consumption patterns that came to characterize American economic life.

In summary, "Experiments with Alternate Currents of High Potential and High Frequency" must be included in the canon of books containing major ideas that reflect elements of America's economics and culture because it documents the technical foundations of electrical systems that transformed American society, economy, and daily life. It represents the triumph of a superior technology through scientific demonstration rather than marketing or political influence, reflecting American values of merit and progress through innovation.

Five Timeless Quotes

1. "Each day we go to our work in the hope of discovering,-in the hope that some one, no matter who, may find a solution of one of the pending great problems,-and each succeeding day we return to our task with renewed ardor; and even if we are unsuccessful, our work has not been in vain, for in these strivings, in these efforts, we have found hours of untold pleasure, and we have directed our energies to the benefit of mankind."[4]

This powerful quote encapsulates Tesla's philosophy toward scientific research and innovation. It remains profoundly relevant today as it speaks to the intrinsic value of scientific pursuit beyond mere practical outcomes. In our current era of goal-oriented research and pressure for immediate commercial applications, Tesla reminds us that the process of discovery itself holds value, both for the personal fulfillment it brings to researchers and for its potential to advance human knowledge and welfare. This perspective encourages persistence in tackling difficult scientific and technological challenges, such as renewable energy, climate change, and medical breakthroughs, even when solutions aren't immediately forthcoming.

2. "We wind a simple ring of iron with coils; we establish the connections to the generator, and with wonder and delight we note the effects of strange forces which we bring into play, which allow us to transform, to transmit and direct energy at will."[4]

Tesla's expression of wonder at the manipulation of electromagnetic forces highlights the marvel of turning abstract scientific principles into practical technologies. This sentiment remains relevant in our digital age, where we often take for granted the extraordinary physics behind everyday devices. The quote serves as a reminder of how transformative the ability to control electricity has been for humanity, enabling countless technologies we now consider essential. It also inspires continued amazement at human ingenuity and the ongoing development of new methods to harness natural forces for practical purposes, from quantum computing to fusion energy.

3. "All these observations fascinate us, and fill us with an intense desire to know more about the nature of these phenomena."[4]

This quote captures the essence of scientific curiosity that drives progress. Tesla articulates how observation leads to questioning, which in turn fuels further investigation-a cycle that remains at the heart of scientific advancement. In today's information-saturated world, cultivating this sense of genuine curiosity and methodical investigation is perhaps more important than ever. The quote reminds us that technological progress isn't merely about application but is rooted in a fundamental desire to understand the natural world, a principle that continues to motivate scientific research across disciplines.

4. "Alternate currents, especially of high frequencies, pass with astonishing freedom through even slightly rarefied gases. The upper strata of the air are rarefied. To reach a number of miles out into space requires the overcoming of difficulties of a merely mechanical nature."[10]

This remarkably prescient quote demonstrates Tesla's early understanding of principles that would later become crucial to radio transmission and wireless communication. His insight about the conductive properties of rarefied gases and the atmosphere anticipated developments in telecommunications that would transform the 20th century. Today, as we develop increasingly sophisticated wireless technologies and explore space communications, Tesla's fundamental observation remains relevant. His characterization of the remaining challenges as "merely mechanical" reflects his visionary confidence in human ingenuity to overcome practical obstacles once the scientific principles are understood.

5. "This investigation, then, it goes without saying, deals with alternating currents, and, to be more precise, with alternating currents of high potential and high frequency. Just in how much a very high frequency is essential for the production of the results presented is a question which, even with my present experience, would embarrass me to answer."2

This quote reveals Tesla's intellectual honesty and the exploratory nature of his work. Even as he pioneered high-frequency currents, he acknowledged the limits of his understanding regarding which aspects were truly essential for the observed effects. This scientific humility remains a valuable model for researchers today, reminding us that breakthrough innovations often occur at the frontiers of knowledge where certainty is limited. The quote also highlights how empirical observation sometimes precedes complete theoretical understanding, a pattern that continues in emerging fields like artificial intelligence, where practical applications sometimes advance ahead of comprehensive explanations.

Five Major Ideas

1. **The Superiority of Alternating Current Systems**

One of the central ideas presented in "Experiments with Alternate Currents of High Potential and High Frequency" is the fundamental advantage of alternating current (AC) over direct current (DC) for electrical power systems. Tesla methodically demonstrates how AC systems, particularly those operating at high frequencies, offer significant benefits for power transmission, efficiency, and versatility. He explains that "of the various branches of electrical investigation, perhaps the most interesting and immediately the most promising is that dealing with alternating currents"2.

The book presents extensive experimental evidence showing how alternating currents, especially at high potentials (voltages), can be transmitted over longer distances with less loss than DC systems. This was revolutionary at the time, as it directly challenged Edison's established DC power infrastructure. Tesla's work provided both theoretical explanations and practical demonstrations of how transformers could be used to step voltage up for efficient transmission and down for safe use-a fundamental capability that DC systems lacked. This insight ultimately shaped the entire global electrical infrastructure, establishing AC as the standard for power generation and transmission that continues to this day.

2. High-Frequency Phenomena and Their Unique Properties

A second major idea explored in depth throughout the book is the unique behavior of electrical currents at high frequencies. Tesla discovered and documented how "in augmenting the potential and frequency we rapidly intensify the streams"2, revealing properties that differ significantly from those of low-frequency currents. He details how high-frequency currents tend to flow along the surface of conductors (the skin effect), pass through insulating materials that would block lower frequencies, and create distinctive luminous effects when interacting with rarefied gases.

Tesla's experiments with what we now call the "Tesla coil" demonstrated these principles, showing how properly designed circuits could generate extremely high-frequency oscillations with remarkable properties. He observed that these high-frequency currents could pass through the human body without the harmful effects associated with lower frequencies, leading him to speculate about potential medical applications. His detailed documentation of these phenomena laid the groundwork for numerous future technologies, from radio transmission to electrotherapy devices, and helped establish the field of high-frequency electronics.

3. Wireless Transmission of Energy

Perhaps the most visionary idea presented in the book is the possibility of wireless energy transmission. Tesla describes experiments where he illuminated gas-filled tubes without wires, using resonant circuits to transfer energy through space: "I have glued two very thin wires w w, so as to form a name. The wires may be bare or covered with the best insulation-it is immaterial for the success of the experiment...when the light in the room is turned off the name formed by them appears in brilliant letters"2. This demonstration of wireless lighting was revolutionary for its time.

Tesla envisioned a future where energy could be transmitted wirelessly over great distances, potentially even globally, eliminating the need for complex transmission infrastructure. While this ambitious vision has not been fully realized in the way Tesla imagined, his fundamental insights about electromagnetic wave propagation and resonant coupling have informed modern wireless technologies, from radio and television broadcasting to Wi-Fi, Bluetooth, and wireless charging systems for consumer electronics. The principles of resonant inductive coupling that Tesla pioneered are now being applied in short-range wireless power transfer systems, demonstrating the enduring relevance of his ideas.

4. The Importance of Resonance in Electrical Systems

A fourth major idea elaborated in the text is the critical role of resonance in electrical systems, particularly for high-frequency applications. Tesla explains how properly tuned circuits, where inductive and capacitive elements are balanced, can produce dramatically amplified effects with minimal input energy. He describes how "adjusting the discharge circuit so that there are no oscillations set up in it"2 allows for precise control of electrical phenomena.

Tesla's insights about resonant circuits revolutionized electrical engineering, providing methods to generate high voltages and frequencies with relatively simple equipment. His detailed

explanations of how to design resonant transformers (Tesla coils) established principles that remain fundamental to radio frequency engineering. The concept of electrical resonance that Tesla developed continues to be essential in numerous technologies, from radio tuning circuits to medical imaging devices and particle accelerators. His demonstration that resonant systems could achieve effects impossible in non-resonant circuits opened new possibilities in electrical engineering that continue to be explored today.

5. Novel Illumination Technologies

The fifth major idea presented in the book concerns novel methods of electrical illumination. Tesla demonstrated various ways that high-frequency currents could produce light more efficiently than conventional incandescent bulbs: "in augmenting the potential and frequency we rapidly intensify the streams; and, though it may be very sanguine, it is surely not altogether hopeless to expect that we may succeed in producing a practical illuminant on these lines. We would then be simply using burners or flames, in which there would be no chemical process, no consumption of material, but merely a transfer of energy, and which would, in all probability emit more light and less heat than ordinary flames"2.

Tesla experimented with phosphorescent materials, rarefied gases, and various electrode configurations to produce light without the inefficient heating of solid filaments. His observations about how electrical discharges could excite gases to produce light anticipated the development of fluorescent, neon, and other gas-discharge lighting technologies that would later become ubiquitous. Tesla's vision of more efficient lighting that converted electricity directly to light rather than heat represented a conceptual breakthrough that guided subsequent research and development in illumination technology, ultimately contributing to more energy-efficient lighting systems that reduce electricity consumption worldwide.

Three Major Controversies

1. The War of the Currents: Safety and Efficiency Debates

The most significant controversy surrounding Tesla's work with high-potential alternating currents was the infamous "War of the Currents" that pitted his AC system, backed by Westinghouse, against Edison's established DC system. Edison and his associates mounted a vigorous campaign claiming that high-voltage AC systems posed unacceptable safety risks. According to search result5, "In the spring of 1888, a media furor arose over electrical fatalities caused by pole-mounted high-voltage AC lines, attributed to the greed and callousness of the arc lighting companies that operated them." Edison's camp went so far as to stage public electrocutions of animals using AC current to demonstrate its alleged dangers.

Tesla's book directly addressed these safety concerns, explaining how properly designed AC systems could be both safe and far more efficient than DC alternatives. He detailed how insulation, grounding, and transformer-based voltage conversion could mitigate risks while enabling the superior transmission capabilities of AC. The controversy was intensified by significant financial interests on both sides, with Edison having invested heavily in DC infrastructure and Westinghouse committing to Tesla's AC patents.

The political dimensions of this controversy included attempts to legislate against high-voltage AC systems. Search result5 notes that "Both [Edison and engineer Harold P. Brown] also colluded with Westinghouse's chief AC rival, the Thomson-Houston Electric Company, to make sure the first electric chair was powered by a Westinghouse AC generator, effectively associating Westinghouse's electricity with death." These political maneuvers represented an early example of corporate interests attempting to shape technology policy through manipulation of public opinion and regulatory processes.

2. **Wireless Power Transmission: Visionary Breakthrough or Impractical Dream?**

A second major controversy surrounded Tesla's ambitious claims about wireless power transmission. While his demonstrations of lighting bulbs wirelessly at short distances were verifiable, his grander vision of global wireless power transmission met with considerable skepticism from the scientific establishment and potential investors.

Tesla's book describes experiments showing how "high frequency currents pass with astonishing freedom through even slightly rarefied gases" and how "the upper strata of the air are rarefied"10, suggesting the potential for long-distance wireless transmission. These ideas later evolved into Tesla's more elaborate Wardenclyffe Tower project, which aimed to demonstrate transcontinental wireless power transmission but was never completed due to funding challenges.

Critics argued that the inverse square law governing electromagnetic radiation would make long-distance power transmission impractically inefficient. The controversy centered on whether Tesla had truly discovered some novel resonant phenomenon that could circumvent these physical limitations or whether he had overextended valid short-range observations into an impossible global vision.

The mainstream scientific community's skepticism toward Tesla's more ambitious wireless power claims contributed to his difficulty securing continued funding for these projects and to his gradual marginalization within the scientific establishment. This controversy reflected broader tensions between visionary thinking and practical engineering constraints, as well as the challenges of evaluating claims that push beyond the boundaries of established scientific understanding.

3. **Intellectual Property and Recognition Disputes**

A third controversy involved Tesla's intellectual property rights and proper recognition for his contributions to electrical engineering and radio technology. While not explicitly discussed in "Experiments with Alternate Currents," the book documented many of Tesla's innovations that would later become subjects of patent disputes and attribution controversies.

Tesla's relationship with Westinghouse involved complex patent licensing arrangements that, while initially lucrative, eventually saw Tesla relinquishing potential royalties to help the company survive financial difficulties. His innovations described in the book, particularly those related to resonant circuits and high-frequency phenomena, later became central to radio technology development.

Although Tesla demonstrated wireless transmission of signals years before Marconi's famous demonstrations, Marconi initially received credit for inventing radio. It wasn't until 1943, months after Tesla's death, that the U.S. Supreme Court upheld Tesla's radio patents over Marconi's. This belated recognition exemplified how Tesla's work, though extensively documented in publications like "Experiments with Alternate Currents," often failed to receive timely acknowledgment.

These intellectual property controversies reflected broader issues in America's patent system and scientific community regarding how credit and commercial rights are allocated for fundamental discoveries versus their specific applications. Tesla's case illustrated how publication alone, without aggressive patent enforcement or commercial development, could result in others receiving credit and profit from building upon one's foundational work.

In Closing

Civic-minded Americans should read "Experiments with Alternate Currents of High Potential and High Frequency" for several compelling reasons that transcend its technical subject matter. First, this book offers unique insight into a pivotal moment in American technological history when crucial decisions about electrical infrastructure were being made. Understanding how the AC system championed by Tesla prevailed over Edison's DC system through scientific merit rather than marketing or political influence provides an important model for how technical debates can and should be resolved in a democratic society.

Second, Tesla's work exemplifies the American tradition of innovation-driven progress and the contributions of immigrants to the nation's technological leadership. As a Serbian-American who arrived with little more than his ideas and ambition, Tesla's rise to prominence through intellectual achievement represents the meritocratic ideal that continues to attract talented individuals to the United States. His story, as documented in this book, serves as a reminder of how America's openness to foreign talent has consistently enriched the nation.

Third, at a time when technological literacy is increasingly essential for informed citizenship, Tesla's clear explanations of complex electrical phenomena provide an accessible entry point to understanding the fundamental principles that underlie our modern technological society. His ability to communicate technical concepts through vivid demonstrations and analogies offers a model for how specialized knowledge can be made accessible to broader audiences, an essential skill in democratic discourse about technology policy.

Fourth, the book illustrates both the power and limitations of visionary thinking. Tesla's accurate predictions about wireless communication and efficient lighting stand alongside his as-yet-unrealized dreams of global wireless power transmission. This tension between realized and unrealized visions offers valuable perspective for evaluating contemporary technological promises and claims, from artificial intelligence to renewable energy systems.

Finally, Tesla's emphasis on how technological development should serve humanity's broader interests rather than merely generate profit speaks to ongoing questions about the proper relationship between technology, commerce, and public welfare. His statement that "we have

directed our energies to the benefit of mankind"4 articulates an ethical framework for innovation that remains relevant as we navigate the impacts of emerging technologies on society and the environment.

In an era when technology increasingly shapes every aspect of American life and governance, engaging with foundational texts like Tesla's "Experiments with Alternate Currents of High Potential and High Frequency" provides historical perspective and conceptual tools for more informed participation in technological citizenship. The book not only illuminates how we arrived at our current electrical infrastructure but also offers enduring insights about innovation, scientific communication, and the social purpose of technological development that can guide our collective decisions about future technologies.

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