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I, Robot:
Nikola Tesla's Telautomaton

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in History

by
Kendall Milar Thompson

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ABSTRACT OF THE DISSERTATION

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Professor Matthew Norton Wise, Chair

In 1898 at the Electrical Exposition in Madison Square Gardens, Nikola Tesla presented his most recent invention, the telautomaton. The device, a radio remote controlled boat, was roughly three feet in length with blinking antennae and was propelled by a small motor and rudder. At the Exposition, Tesla directed audience members to ask the device mathematical questions, and it would respond by blinking the lights on its antennae an appropriate number of times. Tesla's display gave the illusion of an automaton; moving independently and mysteriously responding to mathematical questions with no apparent operator. Tesla and his telautomaton were at the intersection of major developments of nineteenth and early twentieth century physiology and physics. Thomas Henry Huxley, a physiologist, stimulated a debate among scientists about the extent human automatism. These debates centered on developments in physiology that suggested that there was no place for the soul in the brain; no energy was lost, and even with brain damage humans were able to function. The absence of energy loss created a

problem in conservation of energy in physics. Some physicists were involved in this debate, attempting to determine whether any energy was lost or added as a result of free will. Yet, all physicists were involved in a debate about the form of the ether, a medium that theoretically permeated everything. Electromagnetic waves, including the radio waves that controlled the movement of Tesla's telautomaton, were predicted to pass through the ether, a medium that permeated everything. The theories of some of these physicists attempted to combine ideas on the ether on communication between body and mind. Tesla attempted to synthesize several theories on the ether and eventually developed his own. His involvement with electrical healing experiments paralleled experiments in electrical mesmerism carried out by some British physicists that took an interest in psychical research. Tesla's telautomaton highlights the research in communication carried out at the turn of the century; communication between mind and body, through telegraphs and through spiritual mediums.

The dissertation of Kendall Milar Thompson is approved.

Anthony Friscia

Joan Waugh

Kevin Lambert

Theodore M. Porter

Matthew Norton Wise, Chair

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Vita

2008	BA, History and Physics, Mount Holyoke College
2008-2012	High School Physics Teacher, Spokane, WA
2010-2012	Teaching Assistant for Cluster Course “Evolution of Cosmos and Life”
2011	Summer Research Grant, History of Science, UCLA
2012	MA, History, UCLA
2013	Research Travel Stipend, UCLA
2013	Teaching Assistant for “History of China”, “Science and Technology from 1789-1989” and” History of Medicine
2014	Research Travel Stipend, UCLA
2014	Independent contractor for archive analysis, Indianapolis, Indiana

Publications and Presentations

Milar, K. (2014, November 7). The Machine as Body. Paper presented as part of the symposium “The Body as Machine” organized by Alexandra Bacopoulos-Viau at the annual meeting of the History of Science Society, Chicago.

Milar, K. (2014, April 5). Nikola Tesla, the Ether, and his Telautomaton. Presentation at the annual meeting of the American Physical Society, Savannah, GA.

Review of Tesla: Inventor of the Electrical Age, by Bernard Carlson, Perspectives in Physics (Volume 16, Issue 3, September 2014)

Introduction

Newspapers touted the annual Electrical Exhibition at Madison Square Gardens, New York in 1898 as one of the most impressive displays of electrical technology in the United States. *The New York Times* described the main floor of the Exhibition as a "scene of beauty" that featured a fountain illuminated by Thomas A. Edison, Jr. Several exhibits used the pool that surrounded the base of the fountain for their demonstrations. The Electrical Exhibition was not only a show for inventors and investors; but also for announcements boasting that the exhibition offered an educational opportunity for adults and children. The show opened with a telegraph message sent by President William McKinley and another by Vice President Garrett Hobart. Both lauded the work of American inventors and praised the opportunity that the electrical show offered. They referenced the long history of the study of electricity in the United States, with McKinley observing that Benjamin Franklin "even in the midst of patriotic duties and cares, gave [electrical science] his transcendent genius."[1] Although the telegraphed praise of President McKinley was certainly exciting, a much more elaborate opening to the Electrical Exhibition, as originally planned, would have included President McKinley remotely starting some of the machinery. Unfortunately, the supplies required for this activity were delayed because of "shipments of troops on the railroads."[2]

The Spanish American War did more than delay the shipment of some of the exhibition's machinery; it shaped the theme of the exhibits and the tone for the exhibition as a whole. The Spanish-American War resulted in part because of the United States' goal of eliminating European colonial power in the Western Hemisphere. Thus Cuba, Puerto Rico, Guam and the

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[1] "Electrical Show Opens: The Exhibition at the Garden Inaugurated by President McKinley from Washington," *New York Times*, 1898.

[2] "At the Electrical Exhibit: Chancey M. Depew Has His Picture Taken by Electric Light from Vacuum Tubes," *New York Times*, 1898.

Philippines, all colonies of Spain, were a source of tension in Spain's relationship with the United States. Tempers flared as Spain attempted to quash Cuban revolutionaries fighting for their independence, a revolution that disrupted United States trade interests. The revolution also drew the attention of the journalists Joseph Pulitzer and William Randolph Hearst, who sensationalized Spain's actions in suppressing the Cuban revolution. Pulitzer and Hearst's "yellow journalism" encouraged sympathy for the Cuban revolutionaries and vilified the Spanish, stirring public opinion. In February 1898, the *U.S.S. Maine* exploded and sank in Havana harbor with no clear cause and there was public outcry in the United States to respond. In April Congress passed a resolution, authorizing the use of military force, to assist Cuba in gaining independence from Spain.

The Electrical Exhibition featured impressive displays of new technology designed to either directly assist the war effort or aid in bolstering industrial support. For example, the demonstrations included dynamos for electrical railways, a new process for separating iron from ore and the new process of electrical welding. The war took place almost exclusively at sea so the most popular exhibits offered clear naval applications, including a new light signal method and code. One of these exhibits, according to the *New York Times*, promised to show "the manner in which harbors are protected and ships blown up by mines.[3]" Some saw the exhibition as an opportunity not merely to encourage American innovation but also to criticize the lack of Spanish progress. Dr. Chauncey M. Depew, a New York politician and later a United States senator, suggested that "if Spain, which had hardly emerged from the darkness of the Middle

[3] "The Electrical Show: President McKinley Will Formally Open the Madison Square Garden Exhibition Tomorrow Night," *New York Times*, 1898.

Ages, had made the progress in electrical knowledge and the sciences that this country had made there would be no war."[4]

The two most popular displays in the newspapers at the Electrical Exhibition were the demonstration of a vacuum tube lighting system and the system demonstrating the remote detonation of mines. Photographs of visitors, including Dr. Depew, were taken in the Moore Vacuum Tube Chapel "in a light nearly approaching daylight in intensity."[5] The light was achieved by sending current through a partially evacuated tube. The bulb produced by Dr. McFarlan Moore, the designer of the bulb, used gas discharge, similar to fluorescent lighting, instead of incandescent light. Moore required a higher voltage than that received from the Edison power mains and had to design his own transformer to increase voltage and decrease current. At the time of the Electrical Exhibition direct current, not its later alternative, alternating current, was dominant. The Edison Power mains, which transmitted direct current, required multiple power stations to be constructed within cities. Moore's display was remarkable because in comparison to the existing light bulbs, his evacuated tubes produced more light. This was in part because of the higher voltage and current.

Given the war, the public's interest was mostly focused on the demonstration of the detonation of mines. In the middle of the exhibition, near Edison's fountain, a large pool of water sat with a miniature version of the warship *Kalamazoo*. The demonstration took place every three hours. An observer described "a muffled, knocking report and the whole fabric of a ship leaped fifteen feet into the air in a column of spray and fell back in splinters on the surface of the water, while a hundred or more spectators nearest to the tank fairly fell over each other in

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[4] Ibid.

[5] "At the Electrical Exhibit: Chancey M. Depew Has His Picture Taken by Electric Light from Vacuum Tubes."

efforts to escape a wetting."[6] Originally designed by Guglielmo Marconi, the mines were modified by W.J. Clarke, the general manager of the United States Electrical Supply Company, and were spectacular because no wires connected the detonator to the mine. They were detonated by remote control from a balcony on the other side of the gallery. In one case, a forgotten mine was detonated in Thomas Edison Jr.'s desk, causing splinters to fly about Edison, "but he was uninjured except for the shock of the explosion," *The Chicago Daily Tribune* reported.[7] The spectacle of a wirelessly triggered mine fascinated the public and the press. Most of the newspapers focused on the novelty of the new mines and their potential application in the upcoming war. Clarke suggested that "it is as easy to send an impulse ten miles as twenty feet" and that by using his system an Admiral would be able to "discharge every gun on every ship at the same instant."[8]

One other device remotely controlled device had the potential to significantly affect naval strategy, Nikola Tesla's Telautomaton, yet received scant attention. The boat, seen in Figure 1, was approximately three feet long with three large antennae, two with blinking lights on the tips. The demonstration took place in the same central pool used for the mine detonations. The telautomaton was able to move about the pool independently, seemingly without any clear control mechanism that directed its actions. Tesla requested audience members to ask the device mathematical questions, and the lights on the antennae would blink in response:

> 'What is the cube root of 64?' The boat would answer, "4." Anything that I could answer the boat answered. My visitors were puzzled. I would open it [the boat]

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[6] "Detonated Mine Through Air: Exhibition of Use of Apparatus Which Apparently Sends Deadly Impulse Without Using Wires," *Chicago Daily Tribune*, 1898.

[7] "Accident in the Garden: Desk of Thomas A . Edison Jr, Partly Demolished," *New York Times*, 1898.

[8] "Detonated Mine Through Air: Exhibition of Use of Apparatus Which Apparently Sends Deadly Impulse Without Using Wires."“

and show that there was no one inside; it was just a little box filled with instruments.[9]

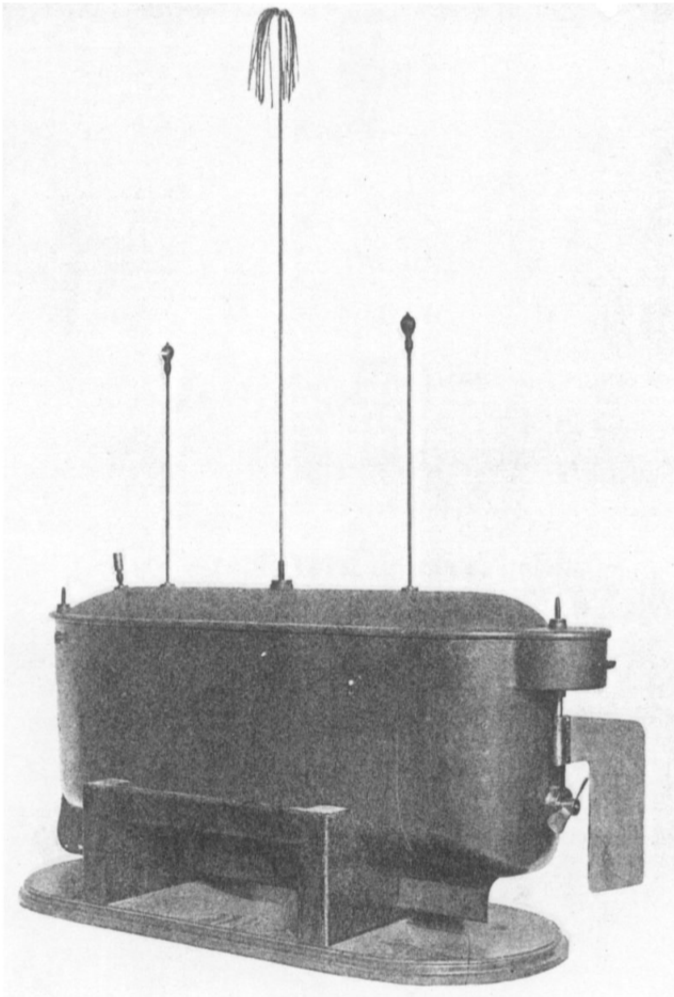

Figure 1 Nikola Tesla's Telautomaton from 1898 (See Image Note 1)

It was as though a small operator were within the unit controlling its actions and responding to the audience's questions. Although Tesla possessed a public reputation as an innovative and creative engineer, the device, far more complicated than remote mines, failed to receive any notice in the press. The telautomaton was not an automaton in the truest sense; it was governed by remote control, not automatic action. Although the telautomaton may have been one of Tesla's most impressive inventions the technology was only minimally implemented 20 years after its presentation in 1914.

Tesla's work as an inventor is well established by historians of technology. However, his contributions as a researcher and as an aspiring scientist were largely ignored by the 1890s press and have been largely neglected by scholars. Like many inventors, Tesla sought to transform the world with his inventions, but in contrast to many of his contemporaries he also sought to gain a deep scientific understanding of the principles used in his devices. This interest in

[9] Nikola Tesla and Leland I. Anderson, *Nikola Tesla on His Work with Alternating Currents and Their Application to Wireless Telegraphy, Telephony, and Transmission of Power* (Denver, Co: Sun Publishing, 1992), 158.

incorporating and applying the most recent scientific developments was, in itself, unique. This dissertation will examine those scientific understandings, asking how unique was his interest in incorporating and applying the most recent scientific developments? How, for instance, did he contrast Thomas Edison, who pursued his inventions with little regard to scientific principle? Edison is well remembered for his motto: "genius is ninety-nine percent perspiration and one percent inspiration" a claim that frustrated Tesla to no end.

This dissertation seeks to explore how did Tesla differed from his contemporaries. Particularly, how did some of his inventions attempt to demonstrate and contribute to active scientific debates? He thought highly of his telautomaton, and it in particular reflects developments in several major scientific fields in the late nineteenth century and early twentieth century. In an unpublished draft of an article he explained that

> A scientific man, in order to prove his theory, must be able to substantiate it in some or other way. He may bring forth logical arguments or show by calculations the truth of his contentions, but the best way to demonstrate it is by a practical working machine. If it be true, that we are automatic engines, why not, then, endeavor to construct such an engine?[10]

Was Tesla a scientific man? Why did an individual so entrenched and successful in the industrial world seek to achieve this type of scientific success? The telautomaton represents an abrupt departure from the direction of Tesla's previous work and allows us to explore his thinking. Although there is some overlap in his research on wireless and on alternating current, he seemed to consider his work on alternating current complete at the demonstration of successful alternating current generators at Niagara Falls in 1896. This speech marked a major turning point in Tesla's career, firmly dividing his work on alternating current from his work on wireless technology. At Niagara he announced his intention to pursue research on the ability to

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[10] Tesla, Nikola, Box 4, DOI 333-1, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

one day transmit the power generated at Niagara wirelessly to different locations around the world.

These questions are important because there is very little existing historical research on Tesla available, and all of the work is biographical. Two biographies of Tesla exist that were published by close friends or acquaintances, one that was published during his life. Thomas Commerford Martin's biography, *Inventions, Researches and Writings of Nikola Tesla*, was published in 1894, and although it provides valuable information about Tesla's early inventions, Tesla still was living and productive for an additional forty years.[11] Martin was a good friend of Tesla's at the time and the publisher of *Electrical World,* a publication Tesla's articles appeared in frequently. John O'Neill's biography, *Prodigal Genius,* is unsurprisingly positive of Tesla, and uncritical about the details of his life story.[12] Nevertheless, as a primary document, O'Neill provides detailed accounts of aspects of Tesla's life that are otherwise undocumented. Marc Seifer's biography, *Wizard,* published in 1996, was the next major biography of Tesla to appear.[13] Seifer made use of the extensive collection of Nikola Tesla's papers. These papers, located at the Nikola Tesla Museum in Belgrade, Serbia are immensely valuable to researchers. Despite the tremendous sources at his disposal, Seifer's biography lacks historical rigor and is populated with imagined conversations. Although his use of these sources contributes significantly to the available information about Tesla's personal life, the biography falls short. Bernard Carlson's biography of Tesla perhaps best utilized the available archival sources to bring significant depth to Tesla's life story. Carlson's *Tesla: Inventor of the Electrical Age*,

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[11] Thomas Commerford Martin, *The Inventions, Researches and Writings of Nikola Tesl* (New York: D. Van Nostrand Company, 1894).

[12] John J. O'Neill, *Prodigal Genius* (New York: David McKay Co., 1944).

[13] Marc J Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius* (New York: Kensington Publishing Corp., 1998).

focuses on writing the biography of an inventor.[14] He does this by devoting particular attention to a detailed discussion of the inventions and his work marketing these inventions.

In summary, all of the current historical works on Tesla are biographies. In addition, they do not examine Tesla's interactions with nineteenth-century science. Similarly, none of these biographies seeks to offer any contextualization for the scientific climate in which Tesla's inventions took place. Unlike Thomas Edison and Guglielmo Marconi, Tesla regularly corresponded with scientists and followed developments in the scientific community. His life and inventions have become a powerful symbol to the geek counterculture as the triumph of true genius over the oppressive grind of the *status quo*. He is seen as a young inventor who persisted in the pursuit of alternating current despite the direct opposition of established inventor and businessman, Edison, as well as others that were convinced that alternating current was inferior. Admirers and conspiracy point to several inventions as examples of his genius and his perseverance in the face of adversity. His contemporaries often overlooked Tesla's major achievements: Marconi received the Nobel Prize for the invention of radio despite what some perceive as Tesla's patent priority. Some fanatical admirers of Tesla claim he was decades or even a century ahead of his time. Instead, perhaps his radical inventions can be understood as reflections of the scientific theories and research from the late nineteenth and early twentieth centuries. Does his work represent a radically different approach to understanding nineteenth-century science? Instead of writing theoretical treatises like his scientific contemporaries, or ignoring science like his fellow inventors, he sought to use his inventions to demonstrate the major principles in physiology, physics and electrotherapy.

This dissertation examines Tesla's wireless system, particularly the telautomaton, to develop a synthetic portrait of nineteenth-century science. This is not a biography of Tesla,

[14] W. Bernard Carlson, *Tesla: Inventor of the Electrical Age* (Princeton: Princeton University Press, 2013).

intellectual or otherwise, but the intellectual biography of an invention.[15] What does the telautomaton reveal about nineteenth-century science? How can understanding that lead us to a deeper understanding of the connections between nineteenth-century disciplines? What applications and theories did Tesla seek to understand the telautomaton? How do these ideas shape Tesla's other wireless inventions? The telautomaton, the cornerstone of the wireless system, served several purposes for Tesla, all of which are useful for a historian. First, he used the device as a way to interact and understand a wide variety of scientific theories in the nineteenth century. In some cases, he sought explicitly to use the telautomaton, or other inventions to demonstrate the major principles of scientific study. Additionally, with this invention, Tesla, an inventor who was acutely conscious of his public image, attempted to develop a legacy as a scientist as well as an inventor. Although his work on alternating current firmly established his position as an inventor, Tesla presented much of his work before scientific societies and sought approval from his scientific friends he admired so greatly. The telautomaton strengthens connections between several divergent disciplines in the nineteenth century, but he also used it to demonstrate principles from these disciplines. In this way, the telautomaton provides a very different perspective on the theoretical discussions in the mid and late nineteenth century.

The first chapter explores the context the telautomaton and the wireless system within Tesla's lifetime. I approach this in two different ways: first to examine the telautomaton as a mechanical object within the industrial and inventive context of the nineteenth century and second, to understand the telautomaton within Tesla's personal story. Although there is significant biographical work on Tesla, most focuses on his alternating current system and fails

[15] Igor Kopytoff, "The Cultural Biography of Things: Commodization as Process," in *The Social Life of Things: Commodities in Cultural Perspective*, ed. Arjun Appadurai (Cambridge: Cambridge University Press, 1986), 66.

to treat seriously his wireless work. By reexamining his autobiography, the retelling of his early life provides valuable insight into his understanding of human automatism and the telautomaton. In an autobiography published in 1919, he devotes considerable attention to discussing his childhood and events that he considered crucial to his understanding of human automatism. Because his later life was well documented, he was unable to so dramatically retell those events. Tesla's telautomaton, although overlooked by his contemporaries, represents a major inventive project. The first major inventive project that Tesla attempted was his work in alternating current. With his alternating current work, instead of attempting to patent an individual invention, he sought to patent an entire system. By examining Tesla's development and promotion of the alternating current system, it is possible to tell what he anticipated might happen with his wireless work. The telautomaton fits within Tesla's larger body of wireless work and he sought to establish something similar to his alternating current system: several small inventions that worked together as a wireless system. Although Tesla is best recognized for his work in alternating current, his research on wireless power and transmission has proven difficult for historians to properly situate.[16] In part, this stems Tesla's own understanding of his wireless inventions, which is often regarded as peculiar and eccentric. Some call Tesla's work during the twentieth century "prophetic," and cherry pick some of Tesla's more radical predicted applications of his inventions. This chapter depends heavily on the existing biographies and other biographical sources. However, Tesla is an unreliable narrator and this account emphasizes corroborated information. The patents that Tesla filed, as well as the text from his presentations of these devices at scientific meetings also factor heavily into my attempts to outline his wireless system.

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[16] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*; Carlson, *Tesla: Inventor of the Electrical Age*. Both devote much more attention to understanding Tesla's alternating current work.

The telautomaton as a demonstration of nineteenth-century theories on automatism is the focus of the second chapter. The development of Darwin's theory of evolution in combination with new theories in reflex action as well as greater knowledge of the brain led to tremendous uncertainty about the nature of free will and human automatism. Physiologists struggled to understand how free will could have developed and how it might act. The telautomaton was constructed, in part, as a way to determine if it was even possible to construct a device that might behave as a human. This is the clearest example of Tesla's pursuit of the demonstration of scientific principles using his inventions. Although he wrote about human automatism on several occasions, the telautomaton represents a concrete example of how he sought to participate in the scientific developments in the nineteenth century. Additionally, his writings reflect his familiarity with the wide range of writings on free will and human automatism. His familiarity and selective engagement with these theories provides a completely different perspective than previous historians have examined.[17] By treating the problem as concrete and capable of being solved simply through the construction of devices demonstrating these problems, he provides a completely different perspective of these debates. Although historians have examined the major contributors to these discussions, the perspective an outside observer attempting to construct a concrete device demonstrating these principles is entirely new. Frank Miller Turner's designation of the group of scientific naturalists in the nineteenth century is particularly useful as the work from this group of scientists seems to permeate Tesla's work. Kurt Danziger, Lorraine Datson, Ruth Barton and other historians help to connect the work of these scientific naturalists to the ideas of free will, scientific societies, automatism, and

[17] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*; Carlson, *Tesla: Inventor of the Electrical Age*; O'Neill, *Prodigal Genius*. Although all note Tesla's use of the phrase "meat machines" none of these historians develop these ideas parallel to those in nineteenth-century physiology.

nineteenth-century science.[18] With the telautomaton, I seek to provide a physical link between these ideas and perhaps integrate some small, previously unconnected ideas to the major ideas in physiological and psychology in the nineteenth century.

In Chapter 3, I seek to extend this use of the telautomaton, and the entire wireless system to understand the underlying scientific theories in physics. Most of the earliest writings of the telautomaton incorporated ideas on physiology and physics simultaneously. In part, this was facilitated by the ether, which was the defining problem in physics in the nineteenth century. The ether, a medium that was theorized to permeate all space, was required for the transmission of light. All waves must pass through a medium and the ether was proposed as the medium that allowed the transmission of light waves. By the time Tesla began his work on the wireless transmission of information, the work of James Clerk Maxwell on electromagnetic waves was established. He was careful to incorporate these and other physical theories into his work. But beyond that, he frequently considered himself qualified to engage and discuss new scientific developments. He promoted his own theory of the ether, and also publicly criticized work of Heinrich Hertz, whose work offered experimental evidence supporting Maxwell's theories. His ether theory drew on notable components from the most prominent existing ether theories. Because of his emphasis on the construction and demonstration of theories and how best to exploit these theories in his inventions, his ether theory offers a very different perspective than that offered by nineteenth-century scientists. The ether and nineteenth-century electromagnetic physics have been the subject of considerable study, most notably Bruce Hunt, Norton Wise and

[18] Kurt Danziger, "Mid-Ninteenth-Century British Psycho-Physiology: A Neglected Chapter in the History of Psychology," in *The Problematic Science: Psychology in Ninteenth-Century Thought*, ed. Mitchell G. Ash and William R. Woodward (New York, New York: Praeger Scientific, 1982); Lorraine J. Daston, "British Responses to Psycho-Physiology, 1860-1900," *Isis* 69, no. 2 (1978): 192–208; Ruth Barton, "'An Influential Set of Chaps': The X-Club and Royal Society Politics 1864–85," *The British Journal for the History of Science* 23, no. 1 (1990): 53.

Crosbie Smith.[19] These histories are essential in establishing the scientific context that Tesla worked in, but it is his attempt to use an invention to further this understanding that differs significantly. Most notable is how Tesla's work reflects how the ether provided a medium for scientists seeking to connect physical theories with ideas on God and spiritualism.

The connections between ideas on God and spiritualism are explored further in Chapter 4. An undercurrent of Tesla's interest in the ether, physiology and free will was the study of psychical research that permeated much of nineteenth-century science, particularly study in those fields. Mesmerism and Odylism were two disciplines that arose out of an interest in exploring the potential effects of electricity and magnetism on the human body. These disciplines emphasized the idea that the human body could be manipulated magnetically and electrically to improve the passage of a new fluid called animal magnetism. Alongside these attempts, which largely took place outside of conventional scientific research, there was also an increased interest in using electrical currents for the treatment of nervous disorders in the nineteenth century. Medical personnel primarily carried out this research, but many of Tesla's devices were developed or modified to fit these applications. Yet alongside this careful medical research, Tesla sometimes discussed the possibilities of research on the psychical. This reflected the interest of many scientists that were convinced that the ether could offer a possible physical explanation of the metaphysical. In particular, a group of British physicists that Tesla admired formed the Society for Psychical Research that pursued scientific research of psychical phenomena. The Society for Psychical Research and the rise of spiritualism and Mesmerism in

[19] M. Norton Wise, "The Maxwell Literature and British Dynamical Theory," *Historical Studies in the Physical Sciences* 13, no. 1 (1982): 175–205; Crosbie Smith and M. Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge: Cambridge University Press, 1989); Bruce J. Hunt, *The Maxwellians* (Ithaca: Cornell University Press, 1991); Bruce J. Hunt, "Experimenting on the Ether : Oliver J . Lodge and the Great Whirling Machine," *Historical Studies in the Physical and Biological Sciences* 16, no. 1 (2013): 111–134; Bruce J. Hunt, "Lines of Force, Swirls of Ether," in *From Energy to Information: Representation in Science and Technology, Art, and Literature*, 2002.

the late nineteenth century is well studied historically.[20] This same tendency, the attempt to explain the psychical with physical language, appears in Tesla's work. Although, he does not participate in psychical research directly, much of his research and writings run parallel to these ideas. This is particularly evident when he presented and wrote about his telautomaton. For him, the wonders of mind reading, telepathy and other psychical phenomena were simply a matter of inadequate technology or scientific understanding of the material available.

The final chapter develops much of what Tesla sought to accomplish with the worldwide implementation of his wireless system. Here, the telautomaton reaches a completely new stage in its development. Instead of being used to understand the science that surrounds it, the device is used to forge a new image for the future. Beginning in 1898 with the demonstration of the Telautomaton, Tesla began to envision a potential future in which he could implement all of the inventions in his wireless system on the scale that he believed was necessary to transform human society. Unlike his alternating current system, he was not successful in selling the system to potential investors and could not find the guidance and support he sought. In 1900, while researching the practicality of the transmission of wireless electrical power he believed he detected a transmission from Mars. Interest in Mars was increased at the time due to the observations of astronomers of straight formations on the surface of the planet. They concluded that these must represent canals on the surface, indicating that intelligent life must exist on the planet. When Tesla detected an apparently deliberate wireless transmission while Mars was visible, he concluded that the transmission must represent our first communication received from another planet. With his failure to successfully market his wireless system, he believed that

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[20] Allison Winter, *Mesmerized: Powers of the Mind in Victorian Britain* (Chicago: University of Chicago Press, 1998); Janet Oppenheim, *The Other World: Spiritualism and Psychical Research in England, 1850-1914* (Cambridge: Cambridge University Press, 1985); Courtenay Grean Raia, "The Substance of Things Hoped for : Faith , Science and Psychical Research in the Victorian Fin de Siecle," 2005.

Mars represented the possibility of a place where his wireless system was completely implemented. Although some historians suggest that writings on Mars and the future utopia represent a clear deterioration in Tesla's work and mind, I argue that they simply represent a change in his approach. Tesla's vision for a future or Martian utopia in which his inventions were successfully used was his way of moving forward with his inventions without investor backing. Although this chapter does draw from existing discussions of interest in Mars and the development of the extraterrestrial life debate, it primarily draws from archival sources and articles written by Tesla.

The telautomaton offers a practical and concrete connection to explore the key ideas in nineteenth-century science. In comparison to his contemporaries, Tesla's intense interest in scientific study and research was unusual. The incorporation of these ideas into, what Tesla labeled, his greatest invention indicates how central these theories were to his research. The telautomaton is a demonstration of fields that previously were linked only with theories. However, this connection changes significantly at the end of Tesla and the telautomaton's life. Moreover, the wireless system and all of Tesla's later inventions that historians struggle to understand, are part of a far more ambitious goal than his alternating current system. This system represented, to Tesla, the ultimate triumph of science. His inventions, highly dependent on scientific theory, were the foundation representing the potential that science offered to mankind.

Chapter 1
Tesla's Telautomaton

"'Twill be a sight to see—and more. It will be a liberal education in electricity […] Words won't do—you'll need to come and see."

New York Times

Nikola Tesla, despite his role as the primary inventive and motivational genius behind alternating current, remains a shadowy figure. He was more active in scientific societies and corresponded more regularly with scientists than his contemporaries, such as inventors Thomas Edison and Guglielmo Marconi, and he was a far more prolific writer, but is less well known. Yet, his writings and inventions provide insight into debates in physics, physiology and psychical research in the nineteenth and twentieth century (explored in Chapters 2, 3, 4 and 5 of this dissertation). Because Marconi and Edison shied away from participation in the scientific community, Tesla's work provides a very different perspective on nineteenth-century science and invention. Frequently, historians consider him within the industrial and inventive context of the late nineteenth century, and although that is explored here, this chapter seeks to explore in more detail his later research on wireless technology.[1] This is done particularly with consideration of the telautomaton, a device that Tesla believed would "mechanically represent" him.[2] How can the telautomaton be understood as an object within the nineteenth-century industrial and inventive context? In what ways was the telautomaton valuable in that context?

[1] Carlson, *Tesla: Inventor of the Electrical Age*; Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*.

[2] Tesla, "The Problem of Increasing Human Energy."

How did the telautomaton shape Tesla's life story and in turn how did Tesla's life story shape the telautomaton? I suggest that the inventions from his later life were part of a new wireless system, a system to which he was so devoted that he rewrote his own childhood in an attempt to emphasize its importance. His philosophical writings and inventions also take an important role in the retelling of his life. By first contextualizing these writings biographically Tesla's later work and inventions can be better understood.

Tesla reimagined his early life and this imagined childhood helps to develop an understanding of Tesla's wireless system and his relationship to other inventors. Particularly important is his retelling of several specific events from his childhood. These stories reveal many of the attributes that he viewed as essential to his inventions and his inventive process. Why did Tesla emphasize these qualities? How did he think this retelling of his childhood would change the perception of his inventions? This retelling becomes relevant in the development of the telautomaton. Not only did he claim to understand his own automatism as early as twelve years old, but also he claimed that this began his interest in pursuing the construction of a device like the telautomaton.[3] His claims about the generation of abilities that aid in his inventive process promoted the public image that he wished to encouraged. This image became clearer in his later life, as he published in magazines and newspapers on a variety of subjects that he considered well within his expertise.

Inventors are motivated by problems they encounter regularly, and Tesla's childhood and background offer an important context to his later work. His key inventions can be divided into two main systems: his alternating current system and his wireless system. Other historians have examined the wireless system as a series of individual inventions, but I argue that he considered all of these as part of the same system, much like his alternating current work. Although some of

[3] Nikola Tesla, "My Inventions," in *The Nikola Tesla Treasury* (Radford, VA: Wilder Publications, 2007), 623.

these inventions predate his departure from alternating current research, once his alternating current system was successful, he pursued this wireless system almost exclusively. Because he was able to successfully oversee the implementation of his alternating current system, it serves as a strong example of how he would later seek to view his wireless inventions as part of a whole. The alternating current system also succeeded whereas the wireless system failed. George Westinghouse, a powerful investor, purchased and employed these alternating current patents. Yet, investors largely ignored the patents associated with the wireless system. Tesla initially sought to fund and promote his wireless system in much the same way as his alternating current work. He seemed uncertain about precisely what applications he sought for the telautomaton and without experienced backers he was largely unsuccessful in his efforts to secure financing.

Tesla as an Automaton

Tesla's telautomaton is of great importance in his later career, and aspects of his interest in automatism appear frequently in his own telling of his life story. The primary source for biographical information about his early childhood is his autobiography. Tesla first published the autobiography in 1919, at age 63 as a six-part series in *Electrical Experimenter* magazine. It is frequently difficult to believe some of Tesla's accounts of his youth; for example, he claims that his early observations of water turbines immediately made him think of Niagara Falls and that he "pictured in [his] imagination a big wheel run by the falls."[4] He would later install the first water turbines at Niagara Falls, but his claim of inventing a device and thinking of its potential application thirty years earlier is scarcely credible. Although John O'Neill, Tesla's friend and earliest biographer, provides some additional information, his work is based on his personal relationship with Tesla and presents many of the same difficulties as the autobiography.

[4] Ibid., 633.

Some of the philosophical themes, like automatism, that did not emerge until Tesla's writings after 1898, appear in the early childhood stories included in his autobiography, adding to the skepticism of an already incredulous reader.

One of the more noticeable themes is Tesla's understanding and interpretation of human automatism. Concerns about how automatic human actions arose in the nineteenth century as scientists gained a deeper understanding of the brain.[5] John Tyndall, Thomas Henry Huxley and others were convinced that humans were automata, that human actions were completely automatic and solely in response to external stimuli.[6] Because of the connection to his later research, his childhood stories emphasize the particular aspects of automatism that were later important to him. This focus particularly includes his claimed ability to trace emotional influences to purely external causes. In writing his own history, he sought to convince the readers of his commitment to the concept of automatism. Although claims of an early understanding of his own automatism may be a deliberate exaggeration, it serves to highlight what he considered most essential to human automatism. The telautomaton, the cornerstone of the wireless system, was fundamentally a demonstration attempting to construct as human of as automaton as possible, but with his wireless system, Tesla sought to do much more.

Nikola Tesla was born in 1856 in present day Croatia. His parents named him after his grandfather, a military man who had served in Napoleon's Illyrian army. Tesla wrote that his mother, Djuka, descended from a "line of inventors" and that she "invented and constructed all kinds of tools and devices," but these were mostly for the completion of household tasks, and he

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[5] Danziger, "Mid-Ninteenth-Century British Psycho-Physiology: A Neglected Chapter in the History of Psychology," 124.

[6] Lorraine J. Daston, "The Theory of Will versus the Science of Mind," in *The Problematic Science: Psychology in Nineteenth-Century Thought*, ed. Mitchell G. Ash and William R. Woodward (New York: Praeger Scientific, 1982), 101.

believed much of her ingenuity was wasted.[7] His father, Milutin, was a clergyman in the Eastern Orthodox Church and came from a largely military family. He had a library in which young Nikola read widely. Although he describes his father as strict, hiding candles so he would not read books from the library at night, it is clear that Milutin encouraged his children's education. He instructed them in mental exercises that focused on memory and problem solving. Tesla grew up with several sisters and an older brother, Dane (sometimes called Daniel), who died in an accident when Nikola was seven years old. There are few accounts of the accident outside of Tesla's own, and the circumstances of his death change in each of Tesla's retellings. Sometimes Tesla suggested that he was responsible for the accident, at other times he claimed it was an accident with his favorite horse. It is clear that he ascribes a great deal of importance, and possibly guilt, to this event. In an unpublished article, he remembered the event:

> The old fashioned clock indicated midnight when my mother stepped in the room took me in her arms and whispered almost inaudibly: "Come and kiss Daniel." My only brother, a youth of eighteen and an intellectual giant, had died. I pressed my mouth against his ice cold lips knowing that the worst had come to pass. My mother put me again to bed, tucked me in and lingering a little said with tears streaming: "God gave me one at midnight and at midnight He took away the other."[8]

He described Dane as extraordinarily talented and as a child he felt that "the recollection of his [Dane's] attainments made every effort of mine seem dull in comparison."[9]

Tesla's descriptions of his close connection with Dane represent the earliest appearance of his later interest in automatism. According to his autobiography, they both experienced visions that frequently appeared in their line of sight, obstructing their view of real objects. He

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[7] Tesla, "My Inventions," 621.

[8] Tesla, Nikola, "A Strange Experience" Box 18, DOI 433-1, Activity - Articles – Physical Phenomena, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[9] Tesla, "My Inventions," 621.

continued to experience similar visions throughout his life. In his autobiography he described them as the result of a reflex action from the brain that acted on the retina. This theory, that thoughts and emotions could be understood as reflex actions within the brain, were commonplace in nineteenth-century physiology and evoked significant debate. Tesla's writings intersected directly with these debates; he later wrote that humans were automata "entirely under the control of external influences."[10] This basic idea that he fully articulated only in 1915, appeared already in his autobiography and are described as part of his childhood visions. He wrote that the visions became increasingly automatic and that eventually he became aware that every thought stemmed from an external stimulus. This argument reflected, in part, the opinion of the physiologist and popular lecturer Thomas Henry Huxley. He suggested that humans were automata and that their actions could be explained as a series of reflex actions. William Carpenter, a prominent physiologist in the nineteenth century, believed in voluntary actions and searched for physiological evidence that might support the existence of free will. Tesla's understanding and participation in the discussion of these ideas on human automatism and free will is explored further in Chapter 2.

Tesla soon discovered that these visions were subject to his will, and he could control the direction his visions took and was able to recall vividly people and places that he had already visited. He claimed in his 1919 autobiography that as he began to invent he used this ability to aid in the invention process, which he described as taking place entirely in his mind so that by the time he actually built one of his inventions, the product was nearly perfected:

> When I get an idea, I start at once building it up in my imagination. I change the construction, 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 whatever; the

[10] Nikola Tesla, "Did the War Cause the Italian Earthquake?," *New York American*, February 7, 1915.

> results are the same. In this way I am able to rapidly develop and perfect a conception without touching anything. When I have gone so far as to embody in the invention every possible improvement I can think of and see no fault anywhere, I put into concrete form this final product of my brain. Invariably my device works as I conceived that it should, and the experiment comes out exactly as I planned it. In twenty years there has not been a single exception.[11]

Tesla suggested something incredible: that he was able to complete his inventions in his mind without ever testing an individual component. He later traced these visions to purely external influences, external influences that he was convinced dictated all of human action. His adaptation of these visions into a method for constructing his inventions provided background for his later emphasis on the eye as the most important sense organ.

After the death of his brother, he faced significant parental pressure to join the clergy like his father. He completed his initial studies at the local Gymnasium in Gospic, his hometown, and then traveled to study at the Real Gymnasium, in Karlovac. At the Real Gymnasium, Tesla excelled in mathematics and became "intensely interested in electricity," but his parents refused to consider his dream of becoming an engineer. He resigned himself to a career in the clergy, even though he claimed that the thought of it filled him with dread. After completing his studies at Karlovac he returned home, against his father's appeals, in the midst of a cholera epidemic. Tesla became seriously ill and for a time it appeared that he might die:

> In one of the sinking spells which was thought to be the last, my father rushed into the room. I still see his pallid face as he tried to cheer me in tones belying his assurance. "Perhaps," I said, "I may get well if you will let me study engineering." "You will go to the best technical institution in the world," he solemnly replied.[12]

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[11] Tesla, "My Inventions," 621.

[12] Ibid., 636.

Tesla's father held true to his promise and after his full recovery, Tesla traveled to Gratz, Austria to study at the Polytechnic Institute.

In his autobiography, Tesla explained that his father, Milutin Tesla, selected the Polytechnic Institute because it was one of the "oldest and best reputed institutions" and he eagerly undertook his studies. He sought to prove to his parents that he was making the most of his education. Unfortunately, he was so devoted that one of his teachers wrote his father suggesting that Tesla's single-mindedness was putting his health in peril. At the end of his second year, however, he underwent a dramatic change. He started gambling, stopped attending lectures, and lost his scholarship. During this time, Tesla's father died. His gambling continued until his mother confronted him. She suggested that he should lose all they owned, only then would he be able to overcome his addiction. He recalled that she told him to ""Go and enjoy yourself. The sooner you lose all we possess the better it will be. I know that you will get over it."[13] He wrote that in this moment he was able to conquer his addiction and set aside any wishes to gamble ever again. That exertion of will conflicted with Tesla's conviction that humans are automata. If his actions stemmed from outside stimuli, how could an exertion of will occur? He suggested that it was in reading *Abafi,* a Serbian translation of a Hungarian novel, that he was able to awaken the "dormant powers of will" and begin to practice "self-control."[14] He described *Abafi* as a book teaching lessons much like those of *Ben Hur*. It is unclear what lessons he referred to, but later philosophical writings and some of the automata theories in the nineteenth century provide some insight. These suggested that although most human actions were automatic, it was possible for free will to be exerted. But there is no evidence that these ideas

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[13] Ibid.

[14] Nikola Tesla, "Some Personal Recollections," *Scientific American*, June 1915.

factored into his thinking until the twentieth century, though the depth of his philosophical interpretation of his own childhood emphasized the importance of these ideas.

Tesla as Electrical Engineer

The conclusion of Tesla's education and his emergence into the electrical world have little basis in the automatism and philosophy in his autobiographical interpretation of his early childhood. Instead, he emphasized his success as an electrical engineer and inventor. He built on this success in his later career to promote some of his ideas, like automatism, that technically fell outside of his area of expertise. The perspective in his autobiography shifted to the world surrounding him and his role in it, instead of focusing on his internal convictions as in his childhood. His first major inventive work, a successful system for transmitting alternating current, instilled confidence in him that he carried into his later work, especially on wireless technologies. He attempted to model his later inventions on the success of the alternating current system. This effort is clearest in his treatment of his wireless inventions as a system, but he also modeled his pursuit of financial backing on the successful financial backing of the alternating current system. In some cases, particularly his work on wireless power transmission, terms become confused, because his primary goal did not become the principal use. For example, his invention for transmitting wireless power was most successful as a method for wireless communication. Tesla also learned that by presenting his inventions dramatically he could draw more attention from the media and potential investors. He was conscious of his public image and encouraged the public perception of his genius by writing and offering comment on a wide variety of subjects. These comments often appeared in newspapers, but he was careful to maintain a presence in professional and scientific journals.

As his father had hoped, Tesla continued his studies in engineering at the Karl-Ferdinand University in Prague once his gambling addiction was behind him. Despite support from an uncle and aunt living in Prague, he was only able to afford one year. In 1881, after running out of funding for tuition, he started work at the Hungarian Central Telegraph Office. His work there quickly attracted the admiration of his superiors, because he was efficient and inventive. During his time there Tesla met Anthony Szigetti, another inventor, who worked with him periodically throughout his career. Within a few months, the American telephone exchange opened in Budapest and he and Szigetti were able to find employment there. Both continued to excel in their work and accepted positions at an Edison Lighting Company in Paris. The Paris Company formed after a successful presentation of American inventor, Thomas Edison's electrical system at the Paris Exposition.[15] The exposition served as Edison's first major demonstration of his system and the first opportunity for it to be demonstrated alongside his competitors. He formed several companies, including Edison Lighting Company in Paris, to establish the infrastructure required for his lighting system in continental Europe.

The Edison Company grew quickly and again Tesla distinguished himself as an engineer. After some time, he oversaw the installation of an incandescent lighting system at a new railroad station in Strasbourg. Since the work was likely to take several months, he hoped during his time there that he might be able to continue work on an early attempt at designing an alternating current motor. During his schooling at the Polytechnic Institute, Tesla had imagined the possibility of such a motor. Alternating current was not only easier to produce than direct current but it offered distinct advantages, because it could be transmitted easily at high voltages

15 Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1985), 67.

over larger distances.[16] He began by designing the alternating current electric motor within his own mind and claimed that it was during one of his walks with Szigetti in Budapest that he drew "with a stick on the sand the diagrams shown six years later in [his] address before the American Institute of Electrical Engineers."[17] Whether or not this *eureka* moment occurred, by the time Tesla went to Strasbourg he had already begun constructing a rudimentary alternating current motor.[18] He was able to complete construction of a working model in Strasbourg, but was unable to find further funding for the project. He returned to Paris upon the completion of the lighting project and continued unsuccessfully to seek investors there while working for the Edison Company. In 1884, Charles Batchelor, Tesla's supervisor, transferred to the Edison Machine Works in New York and requested that Tesla join him.

Tesla arrived in New York City on June 6, 1884 to join Batchelor at Edison Machine Works. It is unclear precisely when he began working for Thomas Edison because there are significant variations between sources. What is evident is that Tesla apparently repaired the dynamos (the electrical generators that produced direct current) on the *Oregon*, one of the first ocean liners with electric lighting, and it was his work on the *Oregon* that impressed Edison. The *Oregon* set sail on June 7. By the time Tesla began work for Edison, the direct current system was entrenched in the company and he realized there would be little support for his ideas in alternating current. Edison was convinced that alternating current was more dangerous and historians suggest that pride in his own system made him reluctant to realize that the dangers of

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[16] Jill Jonnes, *Empires of Light* (New York: Random House, 2003), 136.

[17] Tesla, "My Inventions," 640.

[18] A discussion of the possible impediments that might make such a "eureka" moment unlikely are discussed in W. Bernard Carlson, *Tesla: Inventor of the Electrical Age* (Princeton: Princeton University Press, 2013), 50.

alternating current were overstated and admit the drawbacks of direct current.[19] Edison had opened his first electric illuminating station in 1882 on Pearl Street in Manhattan, New York. The station provided direct current power to 472 customers by October 1883.[20] Several other stations opened by 1884 when Tesla joined the company. Instead of pursuing alternating current, he focused specifically on the development of a system to support an arc light patent of Edison's. He completed it with little supervision, but Edison decided to shelve the project. Tesla was frustrated by Edison's decision and after six months with the company, he quit. Some accounts suggest he had been promised a bonus upon completion of the project, that Edison promised there would be "fifty thousand dollars in it for you."[21] When he went to Edison for his payment, he was told: "you don't understand our American humor."[22]

Tesla's work with arc lighting at Edison's company attracted the attention of a pair of investors. He redesigned his work and was able to patent an entire arc lighting system. Unfortunately, Edison shelved the arc lighting system because it was neither popular nor profitable. The development of more powerful incandescent lights quickly made arc lights obsolete. The speculators soon abandoned Tesla because the investment was a failure. Unable to find any other employment, he spent a period doing manual labor to make ends meet. During this time, his patent on a thermomagnetic motor sparked the interest of a new pair of investors,

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[19] Jonnes, *Empires of Light*, 146.

[20] Consolidated Edison, "Con Edison: Pearl Street," accessed December 28, 2013, http://www.coned.com/pearlstreet125.

[21] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*, 39; Margaret Cheney, *Tesla: Man Out of Time* (New York: Touchstone, 1981), 57; O'Neill, *Prodigal Genius*, 74.

[22] Cheney, *Tesla: Man Out of Time*, 57.

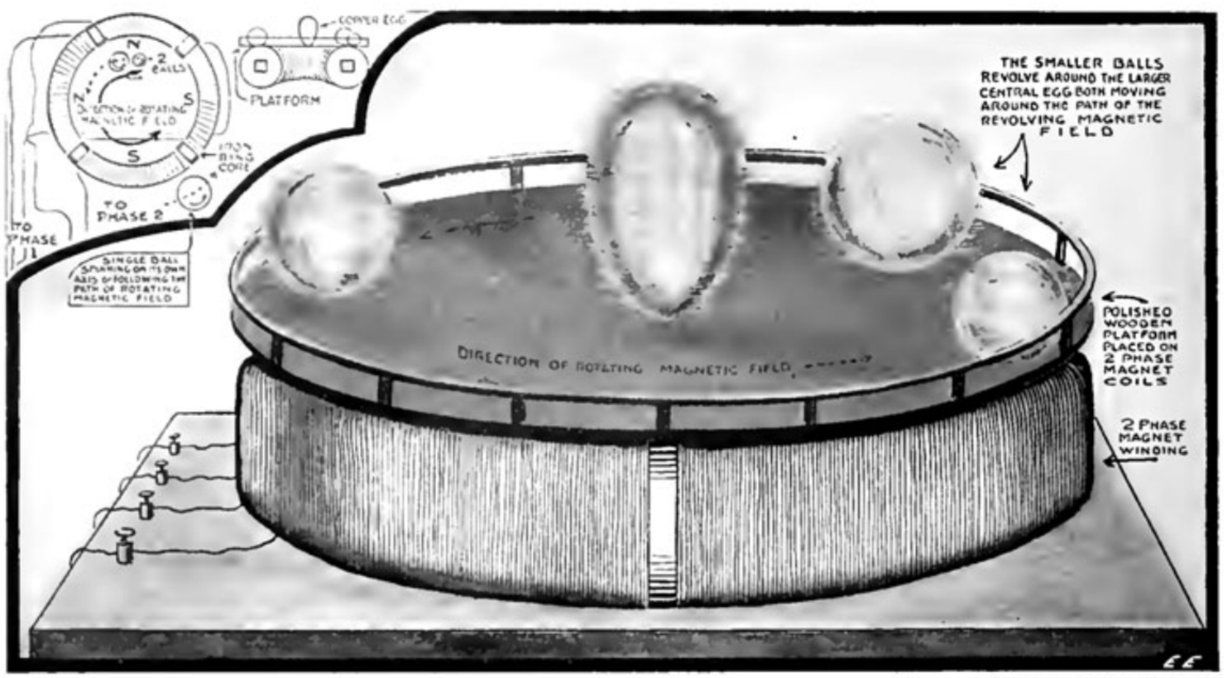
Charles Peck and Alfred Brown, whose help enabled him to establish his own workshop.[23] Although he was interested in pursuing this research, Tesla saw a far greater opportunity in convincing his investors of the practicality of alternating current. He began developing a practical way of creating and transmitting alternating current.

Although Tesla had repeatedly suggested the use of alternating current while working for the Edison Company in Paris, his suggestions fell on deaf ears. Yet he remained firmly convinced that alternating current provided a much more practical method for transmitting power than direct current. In 1887, with the assistance of the recently arrived Szigetti and the funding of investors Peck and Brown, Tesla was finally able to produce a rotating magnetic field using alternating current. The AC motor depended on two major components, a stator and a rotor. The stator consisted of a series of paired coils positioned opposite each other. The coils were wound in such a way that each pair produced a north and a south pole when a current flowed through them. This magnetic arrangement would remain if the motor was only supplied with direct current, but because alternating current powered the motor, the poles would rapidly switch back and forth. The rotor consisted of another pair of coils that also created a magnetic field. The magnetic field in the stator combined with the magnetic field in the rotor would result in a rapid rotation of the rotor. Establishing a rotating magnetic field was crucial in creating a motor that would allow alternating current to be transformed into mechanical energy. With a rotating magnetic field any metal device could be spun, transforming alternating current into rotation. This was the first practical alternating current motor. One of Tesla's most notable demonstrations showcased the effectiveness of the alternating current motor. Using an egg, made entirely of metal, placed on a platform resting above an alternating current motor, he was

[23] The thermomagnetic motor exploited that the magnetic properties of an iron magnet weakened when it was heated.

able to demonstrate that the alternating current motor below would produce a rotating magnetic field. The egg would lay stationary on its side, but when the motor turned on it would begin to rotate at greater and greater speed until finally it would flip onto the small end and continue a steady rotation in the center.

Tesla's investors, Peck and Brown, realized the potential after the demonstration of the egg and sought to present the alternating current to the American industrialist George Westinghouse. Westinghouse had made much his fortune from early inventions and investments in the railroad industry.[24] But in 1885 Westinghouse decided to enter into the electrical industry. He realized the potential advantages that alternating current offered, particularly in the



Copyright, 1919, by E. P. Co.

Fig. 2. Illustrating the Polyphase Coil and Rotating Megnetic Field Which Caused Copper Eggs to Spin.
Fig. 3. Insert: Detail of Coil Apparatus Showing Coil Connections to Different Phases.

Figure 2 Tesla's alternating current motor demonstration using the egg of Columbus. (See image Note 2)

[24] Jonnes, *Empires of Light*, 118.

United States market.[25] Westinghouse acquired the rights to several European patents and began establishing his own electrical network in the United States. In 1888, Westinghouse purchased many of Tesla's patents involved in the transmission and creation of alternating current and promised him a royalty on its implementation. He could not risk any of his competitors gaining access to the patents. Westinghouse purchased the patents at significant cost: "$25,000 in cash, $50,000 in notes, and a royalty of $2.50 per horsepower for each motor."[26]

In February 1888, Edison launched the first attack in "The War of the Currents." He published a booklet titled "A Warning from the Electric Light Company." The booklet attacked alternating current as dangerous and "uneconomical." At that time, he still had a distinct advantage, the DC motor, but with Westinghouse's acquisition of Tesla's patents that problem disappeared. Tesla focused his attention on improving and establishing alternating current. Although the system he sold to Westinghouse was complete in principle, Tesla's patents required modifications to be compatible with Westinghouse's existing infrastructure. Tesla's motors used a polyphase system with four wires while Westinghouse sought a single phase system with two wires.[27] Although some of Westinghouse's engineers were resistant, the necessary modifications worked. Edison was heavily invested in direct current technology and would lose significantly if Westinghouse was successful. The Westinghouse system was quickly gaining dominance, and the research of Harold Brown, the inventor of the electric chair, began to shift the publicity battle in Edison's favor.[28] Brown studied the effects of electrical current on animals, particularly several stray dogs. In a public demonstration at Columbia College, Brown and his assistant

[25] Hughes, *Networks of Power: Electrification in Western Society, 1880-1930*, 104.

[26] Carlson, *Tesla: Inventor of the Electrical Age*, 113.

[27] Ibid., 114.

[28] Hughes, *Networks of Power: Electrification in Western Society, 1880-1930*, 108.

subjected dogs to various jolts of direct and alternating current. The demonstration showed that after administering several direct current shocks of various voltages, a lower voltage shock of alternating current resulted in the death of the dog. The experimenters planned to perform further demonstrations but these plans were stopped by a member of the American Society for the Prevention of Cruelty to Animals. Because of Brown's research, alternating current became the primary method for the execution of criminals sentenced to death. The first execution, however, required two separate jolts of electricity and the corpse caught fire, resulting in a tremendous amount of negative publicity directed at Westinghouse and alternating current.[29] The legal and publicity battle drained Westinghouse's finances and, in a gesture that showed Tesla's dedication to the successful implementation of alternating current, he released Westinghouse from the royalty contract in 1897.

Perhaps the most important step in the development of alternating current was the implementation of Tesla's water turbines at Niagara Falls. In 1886, industrialists formed a plan to build around the protected land surrounding Niagara Falls.[30] They sought to exploit the potential power from the falls. A series of canals and tunnels would carry water from the top of the falls, outside the nature preserve, and then return it to the lower portion of the river. The Cataract Construction Company, newly financed and formed, oversaw the project. Instead of only providing power to local companies, the company sought a wider-scale use of the power and sought bids to build generators for the falls to transmit power to Buffalo. Westinghouse was able to secure a contract to build the first two generators. They would produce alternating current and would be enti rely of Tesla's design.

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[29] Mark Essig, *Edison and the Electric Chair: A Story of Life and Death* (New York: Walker and Co., 2003), 256.

[30] Robert Belfield, "The Niagara System: The Evolution of an Electric Power Complex at Niagara Falls, 1883-1896," *Proceedings of the Institute of Electric and Electronic Engineers* 64, no. 9 (n.d.): 1345.

The successful power station at Niagara Falls concluded Tesla's focus on alternating current and signaled the beginning of his work on wireless power and communication. He considered the successful installation and construction of the generators to be the conclusion of his work on alternating current. In an 1897 speech celebrating the power generation at Niagara Falls, he first expressed his hope that one day "the transmission of power from station to station without the employment of any connecting wire" might be possible.[31] This speech marked a serious transition in Tesla's career and a transition that resonates through several of the themes in this dissertation. Alternating current was no longer was Tesla's focus; instead, he began pursuing research on wireless technology. This shift marked not only a change in his inventive focus, but also a change in how he sought to integrate his inventions into society. Unable to achieve the same success with his wireless work as with his alternating current work, he began promoting the potential benefits to the public. Toward the end of his speech, Tesla spoke primarily of the potential that future applications of electrical technology offered to mankind and explained that his interest in pursuing these applications was a "humanitarian" effort. This pursuit of wireless transmission led to the telautomaton.

Figure 3 Westinghouse/Tesla generators at Niagara Falls (See Image Note 3)

[31] Nikola Tesla, "Tesla on Electricity," *Electrical Review* 30, no. 4 (1897).

Tesla and Wireless

Tesla began new research on the wireless transmission of power after finally being successful in designing his system for transmitting alternating current over long-distance wires and in seeing its implementation. The speech at Niagara Falls reflected his work from the early 1890s and articulated the theories that dominated his research for the next thirty years. He believed that the luminferous ether, the medium that theoretically permeated all space, might be able to transmit electrical power across great distances. This would be the next step in his work to transmit alternating current and would eliminate the need for wires. Physicists and engineers commonly believed that the ether was the medium that transmitted light and electromagnetic energy, so Tesla's idea that the ether could be harnessed to transmit electrical power seemed plausible. The connection between Tesla's inventions and physicists' ideas on the ether will be discussed in greater detail in Chapter 3. Tesla demonstrated a product of this theory in 1891 at a lecture at Columbia College (which became Columbia University five years later) where he was able to show how "exhausted tubes could be made to glow in an electrostatic field."[32] By using two sheets of zinc and creating an electrostatic field between them, Tesla also demonstrated that a tube, moved freely between the sheets, would glow brightly. To him this indicated that electricity could be effectively transmitted without wires, using only the ether. He believed that this method could be used more widely to provide wire-free lighting and he had already managed to create a large enough electrostatic field to be able to accomplish this in a room by "creating a powerful, rapidly alternating electrostatic field."[33] Tesla's demonstration appeared in *Harper's*

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[32] Nikola Tesla, "Experiments with Alternating Currents of High Frequency," *The Electrical Engineer*, March 18, 1891.

[33] Nikola Tesla, "Experiments with Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination," *American Institute of Electrical Engineers- Transactions*, May 20, 1891.

Weekly in an article advertising “Electric Lamps: Fed from Space” and boasted that with this type of lamp “effects may be produced which will bring fairy-land within our homes.”[34]

Tesla’s magical demonstration of his invention concealed its underlying mechanism. He patented the wireless lighting system on April 25, 1891, one month before the demonstration at Columbia College. The demonstration was remarkable not only because it showed lit bulbs without any connecting wires, but also because Tesla exhibited that the system could be operated without any risk of electrical shock. His lighting system depended on a new kind of electrical power that differed from that which was widely available, high potential difference, or voltage, and electrical current at a very high frequency. He believed that in order for transmission to be successful, the minimum potential difference should be about 20,000 volts and the minimum frequency between 15,000 to 20,000 hertz. Because of the specificity of current and potential difference that the system required, the patent protected not only the “light-giving appliance” but also the apparatus used to create such high potential differences and frequencies. As with the lighting demonstration at the electrical exhibition, Tesla needed a way to convert the power supplied by

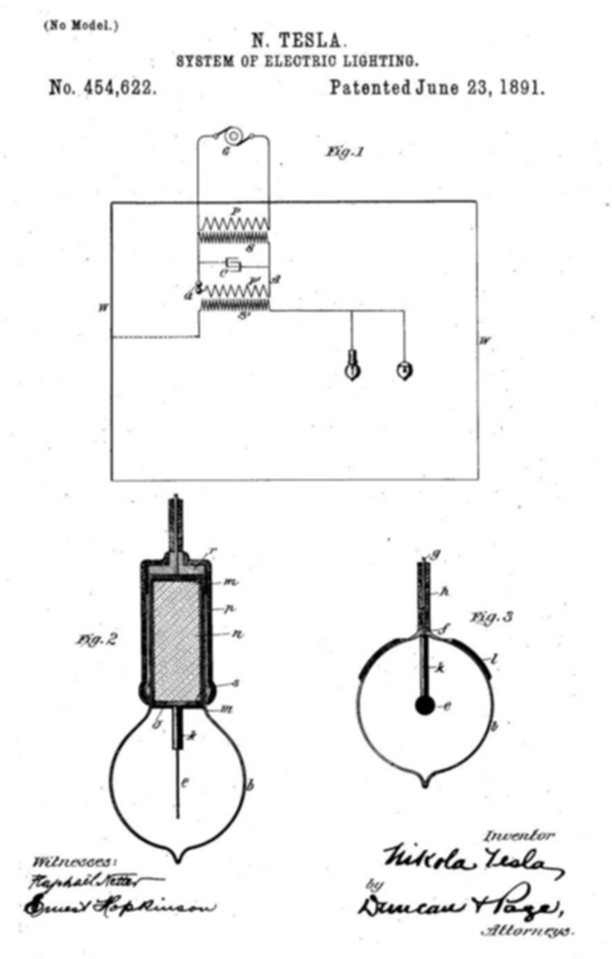

Figure 4 Tesla's system of wireless lighting patent. (See Image Note 4)

[34] Joseph Wetzler, “Electric Lamps,” *Harper’s Weekly*, July 11, 1891.

the Edison power mains into something useful. Fundamentally, Tesla's system took an input current from a typical direct-current generator, and then, as described in the patented, it used the disruptive discharge of a capacitor in conjunction with "proper relations of self-induction, capacity, resistance, and period in well-understood ways" to generate a high frequency alternating current in a secondary circuit.[35] Tesla admitted that there were not many applications for this type of high frequency current and high potential. Prior to his invention this type of electrical output was not available. Perhaps it was simply a matter of inventing new products that could utilize the coil. His system of wireless light depended on this type of power input. The patent explained that "with a source of currents of enormous frequency and excessively high potential," incandescent light bulbs could be "connected directly or inductively to one pole or terminal of the source of current" and a conducting body in the vicinity of the bulbs would complete the circuit. He developed a few light bulbs particularly suited for wireless lighting, but claimed that any incandescent bulb would suffice.

Tesla's wireless lamp exemplifies the type of system that Tesla continued to pursue in his later work. In his Columbia lecture he spoke of his hope that one day it would be possible to run current through a room and freely move lighting devices about the room. *Electrical Review*, *Engineering*, *Harper's Weekly*, *The Electrical Engineer, The Telegraphic Journal and Electrical Review* and *The New York Times* all reported his lecture. An editorial in *Electrical Review* boasted that "even studious men who follow carefully every advance made in the study of our science must have felt astounded at the strides which Mr. Tesla has made in the comparatively unexplored fields in which he is so able a pioneer."[36] Reviews in *The Electrical Engineer* immediately after the talk and a month later after its publication praised Tesla's talk. The

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35 Nikola Tesla. System of Electric Lighting. US Patent 454622, filed on April 25, 1891, and issued June 23, 1891.

36 "Editorial: Tesla Lecture," *Electrical Review*, May 30, 1891.

articles both applauded Tesla's vision and expressed a belief that wireless lighting would become possible in the near future through the perfection of high frequency currents.

Instrumental in his later wireless systems was the circuit from his wireless lighting system containing the capacitor; this would later be known as the "Tesla Coil." Although the circuit drew on elements familiar in nineteenth-century electrical science, it sought to generate high potential and high frequency, something that other investigators had not fully explored. Tesla's early radio transmitters were simply modified Tesla coils. The coil's adaptability made it a desirable power source for many more of his and other researcher's inventions. He exchanged a series of letters with British physicist William Crookes on how to construct a Tesla Coil. Crookes used the coil to illuminate his well-known "Crookes Tubes." These tubes, similar to Moore's lights, were partially evacuated tubes filled with a gas. A high voltage was applied between the two electrodes causing the gas inside to fluoresce. The Tesla Coil is perhaps the device most associated with the inventor. It is still used today and is capable of not only producing beautiful electrical effects and arcs but also supplying high voltage to various devices.

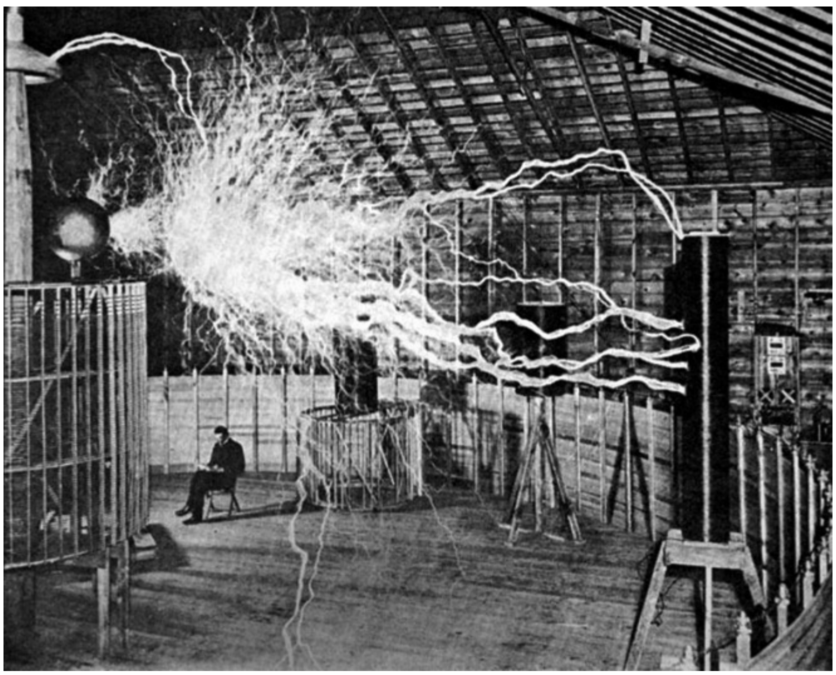

Figure 5 A particularly spectacular image of Tesla featuring coronal electric discharge. The image was taken using two exposures. (See Image Note 5)

Tesla continued to research the viability of wireless electrical lights and gave several talks internationally on the subject. In an important talk for the Institution of Electrical Engineers in London he heavily featured his new wireless lighting system. Because of the promised attendance, the talk had to be relocated to a larger venue at the Royal Society. His audience included some of the foremost physicists in the nineteenth century: William Crookes, Oliver Lodge, Lord Rayleigh and William Thomson among others. In the talk, he discussed his further research on brush discharge, a type of coronal electric discharge (Figure 5). He hoped that one day the discharge could be transmitted without sparking, resulting in an non-visible transmission of electricity. Additionally he expressed his belief that it should one day be possible to produce light without the use of a vacuum tube, at ordinary air pressure, using the example of the *aurora borealis*. At the conclusion of the talk, Tesla daringly suggested to the audience how the transatlantic telegraph cable might be improved. The audience included many involved in the design and implementation of the transatlantic cable project, most notably Thomson who worked extensively on the transatlantic telegraphic project. The comments were offhand and could have easily have offended his audience, but this was not his goal. Tesla moved beyond such suggested improvements to a more radical idea:

> Such cables will not be constructed, for ere long intelligence—transmitted without wires will throb through the earth like a pulse through a living organism. The wonder is that, with the present state of knowledge and the experiences gained, no attempt is being made to disturb the electrostatic or magnetic condition of the earth, and transmit, if nothing else, intelligence.[37]

Tesla's research and the wireless lighting system fascinated European scientists. After London he traveled to Paris, lecturing before the Société International des Électriciens. Ultimately

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[37] Nikola Tesla, "Experiments with Alternate Currents of High Potential and High Frequency," *Journal of the Institution of Electrical Engineers* 21, no. 97 (February 3, 1892).

exhausted by the trip, he traveled to visit his family in Gospic to rest and recover. Unfortunately his mother, Djuka, had fallen ill and she died during Tesla's stay.[38] This event made Tesla think more seriously about life after death, an issue explored further in Chapter 4. His return from Serbia took him through Germany where he visited Hermann von Helmholtz and his former student Heinrich Hertz. Hertz provided the experimental evidence that confirmed James Clerk Maxwell's conclusion that light consisted of an electromagnetic wave. This tour of Europe exposed Tesla to some of the foremost physicists in the late nineteenth century and his writing after 1892 reflects a greater awareness of the work of these scientists and the wider debates in physics. But the wireless system seems to have been set aside soon after his return to the United States. His focus shifted instead to installing alternating current generators at Niagara Falls, only later returning to wireless.

As Tesla's work on alternating current neared completion, the rivalry between him and other inventors intensified. In particular, there was fierce competition to transmit the first wireless signal across the Atlantic Ocean. Newspapers closely followed the race to be the first to transmit a wireless signal. Tesla, Edison and Marconi all sought to be the first to patent a device that would radically change worldwide communication. An article in January 1897 addressed the different methods each inventor sought to utilize, but indicated that "as yet wireless telegraphy is in its infancy."[39] In August 1897, *The New York Journal* excitedly announced "Tesla Electrifies the Whole Earth" and similar articles appeared in the *New York Herald* and *Electrical Review.* The articles announced that a demonstration in Tesla's laboratory indicated promise in the transmission both of wireless power and wireless communication (Figure 6). The demonstration

[38] Carlson, *Tesla: Inventor of the Electrical Age*, 154.

[39] "To Telegraph Around the Great World Without Wires," *The New York Herald*, January 31, 1897.

featured a large metal sphere with an electrode at the center: "Serpent-like flames shot from the electrode" and then disappeared—"Tesla said the electrical disturbance created was felt throughout the globe."[40] The device that the article described bore no similarity to the 1897 patent. This was peculiar because Tesla was already aware that this method could be used for short distance wireless transmissions. Despite this difference, the described demonstration emphasized that the signal could be detected throughout the world, indicating that Tesla had produced a completely new and different system. But *The New York Evening Sun* published an

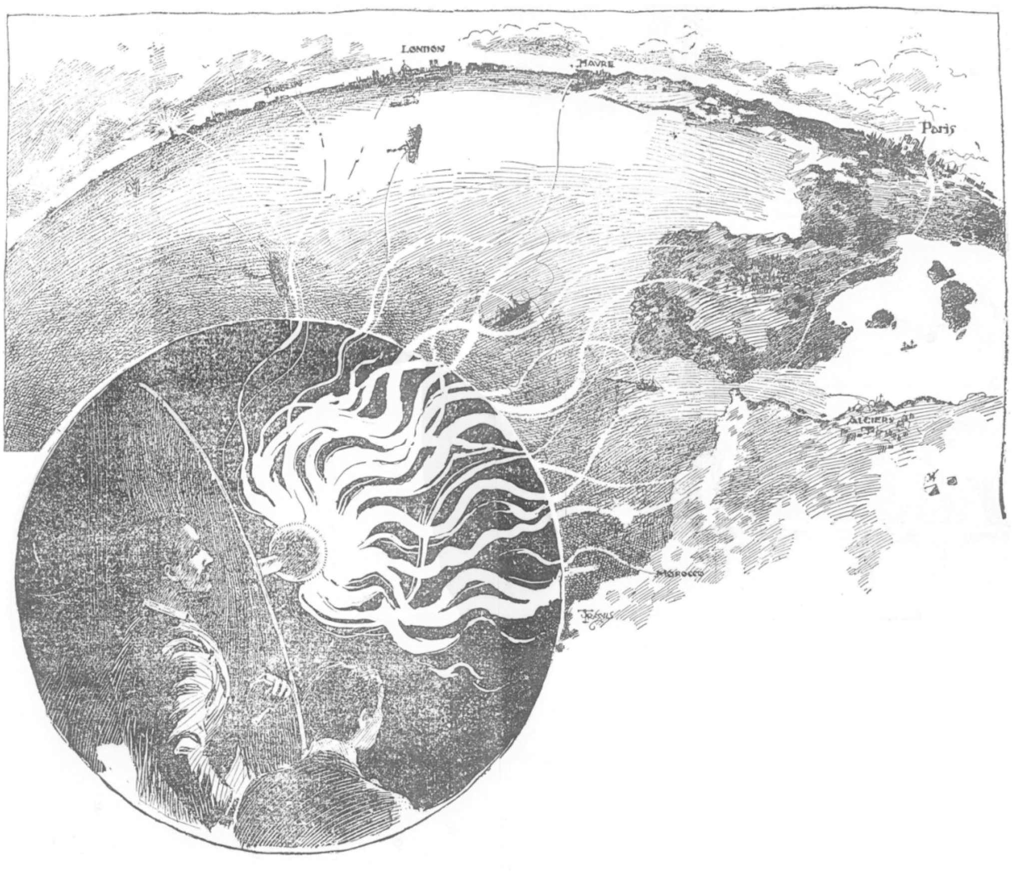

Figure 6 New York Journal article announcing a major wireless transmission in the Tesla laboratory. (See Image Note 6)

[40] "Tesla Electrifies the Whole Earth," *The New York Journal and Advertiser*, August 4, 1897.

article on the same day in which Tesla announced that "no experiments were made at the laboratory yesterday" and that progress on wireless was extremely slow. Tesla emphasized that any demonstrations that occurred had been shown only to a few friends in the strictest confidence. Despite the secrecy surrounding his research, he was willing to reveal some of the fundamental principles of his new system. "An electrical oscillator is connected by one of its terminals to earth" and it acted as a suction pump that altered the "electrostatic potential in the earth as well as in the air."[41]

Finally, in June 1897 Tesla suggested that he had made minor progress and might realize some success from his patent. The system did not seem to provide much promise in the transmission of large amounts of power wirelessly, though it did seem to offer a new way to approach wireless telegraphy. In June 1897, he announced success in sending signals up to 20 miles.[42] By December he announced that by constructing a transmitting and a receiving apparatus, both using a small amount of power, the system "disturbs at one point, making signals which can be distinguished at one or more distant points."[43] The mechanism would also serve to control the telautomaton, demonstrated one year later.

In 1899, Nikola Tesla relocated his laboratory from New York City to Colorado Springs. The move resulted from a change in funding; he had persuaded John Jacob Astor to fund his research. Astor had served as a Colonel in the Spanish American War and was a member of one of the wealthiest families in the United States; when he died on the *Titanic* in 1912, he was perhaps the wealthiest man in the world. Tesla believed that Colorado offered several distinct

41 "Nikola Tesla's Experiments: Denies That He Announced Completion of His Wireless Telegraphy Tests," *The New York Evening Sun*, August 4, 1897.

42 "Tesla's Transmission without Wires," *The Electrical Review* 40, no. 1022 (June 25, 1897).

43 "Telegraphy Without Wires," *Journal of the Franklin Institute* 144, no. 6 (December 1897): 463–464.

advantages for his wireless research. The first was the scenery and isolation, which he believed was generally essential to making scientific progress. But more important, "Colorado is a country famous for the natural displays of electric force" and it had a "dry and rarefied atmosphere." He believed that in an area with less interference and a less dense atmosphere his experiments attempting to transmit power wirelessly would be more fruitful than those performed in New York City. On July 3, at his new Colorado laboratory, Tesla had a significant breakthrough: an incoming thunderstorm indicated that electrical effects passed through the ground. He was able to detect lightning strikes through the earth's crust long before the storm reached his laboratory. This confirmed to Tesla that

> not only was it practicable to send telegraphic messages to any distance without wires […] but also to impress upon the entire globe the faint modulations of the human voice, far more still, to transmit power, in unlimited amounts, to any terrestrial distance and almost without loss.[44]

Although he realized the potential applications in communication, electrical power remained his primary goal.

At the opening of the Niagara Falls power plant in 1897 Tesla had promoted a grander vision of his wireless lighting system. He expressed his hope that one day electrical power, like that produced at Niagara, would be transmitted without wires. His research at Colorado Springs was an attempt to realize this dream. He had suggested this idea in the past, both in his lecture in London and in a letter to the editor of the *New York Herald*. In this letter to the newspaper, he explained that power without wires would bring "millions of miserable creatures from the darkness of the coal pits to the light of day."[45] In the past, Tesla had thrived on providing

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[44] Nikola Tesla, "The Transmission of Electric Energy Without Wires," *Electrical World and Engineer*, March 5, 1904.

[45] Nikola Tesla, "Electricity Without Wires," *The New York Herald*, January 1, 1896.

demonstrations, or offering concrete explanations on how his grand ideas could be achieved. He had earned himself the title of "magician" and "wizard" because of the pizazz in his demonstrations. But at Niagara, he offered no concrete examples, only an expression of his goal.

The research at Colorado Springs focused on exploiting a patent he had filed in 1897, granted in 1900. The patent was for a "System of Transmission of Electrical Energy" and used a Tesla coil as a transmitting device. The electrical current generated by the Tesla Coil would pass through the upper atmosphere to a receiving coil. Tesla suggested that "atmospheric or other gases, even under normal pressure" were able to "assume conducting and other qualities which have been so far observed only in gases greatly attenuated or heated to a high temperature."[46] He hoped that he might be able to exploit this property by passing large amounts of electrical power through the air. The patent itself indicates why Tesla chose Colorado Springs as a research location. He identified three variables that increased the distance at which electricity was

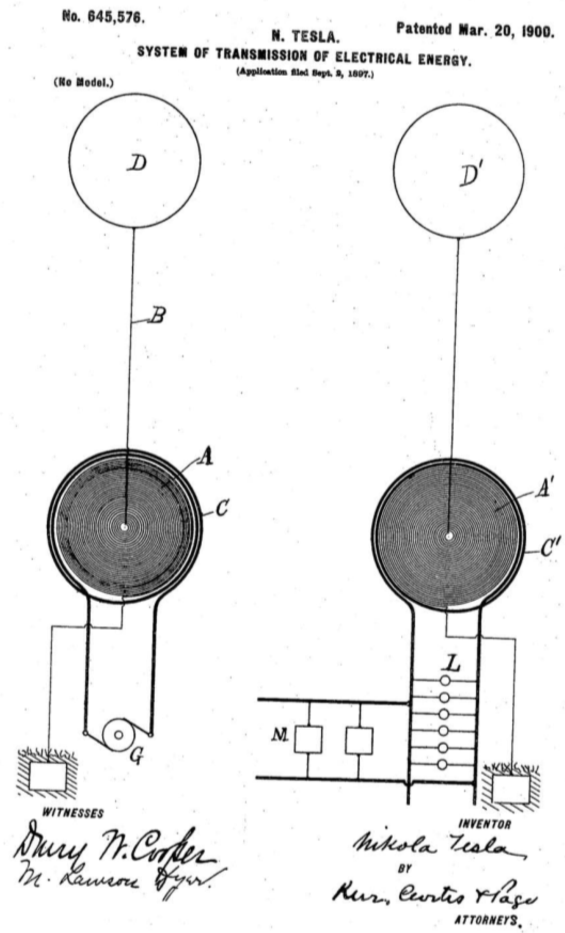

Figure 7 Tesla's patent for a system of wireless energy transmission. (See Image Note 7)

[46] Tesla, Nikola. System of Transmission of Electrical Energy. US Patent 645576, filed on September 2, 1897, and issued March 20, 1900.

transmitted: decreased atmospheric pressure, greater height of the transmitter and reduced moisture in the atmosphere. The Colorado Springs laboratory offered a dry and thin atmosphere that allowed greater transmission. Yet despite the advantages of Colorado Springs, Tesla realized that in order to transmit energy on a large enough scale, receiving terminals would have to be maintained "fifteen miles or more" above sea level. His patent suggested that captive balloons might allow terminals to be maintained at those heights. In addition to the difficulty that maintaining a receiving station on a balloon might present, the transmission of power would need to create an ionized path to the receiver. This ionized path in the upper atmosphere would need to be maintained by both the receiving and transmitting stations, which would require power to maintain the stations. The patent expressed Tesla's hope that the system would be able to transmit "on an industrial scale—as, for instance, for lighting distant cities or districts from places where cheap power is obtainable."[47] Although power transmission was his primary goal, he maintained that the same system could be used to "transmit intelligible messages to great distances." Ultimately the patent revealed the major hurdles that Tesla faced in making his power transmission system a reality. The goal was still largely theoretical and without overcoming the very apparent obstacles, it would remain so.

Tesla's success in detecting stationary electrical waves in the earth's crust depended heavily on his ability to detect weak electrical signals. He developed extremely sensitive detection devices for precisely this purpose. One of these devices allowed him to detect what he believed were signals from Mars during his time in Colorado. He received signals at regular intervals and believed they were not of terrestrial origin. But he did not detect them again, and concluded his research in Colorado Springs and returned to New York in January 1900.

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[47] Tesla, Nikola. System of Transmission of Electrical Energy. US Patent 645576, filed on September 2, 1897, and issued March 20, 1900.

Astor was disappointed in Tesla's results from Colorado and so after returning to New York, Tesla had to immediately begin seeking new investors for his wireless project. Biographer Marc Siefer suggests that Astor did not approve of Tesla's decision to pursue his wireless research in Colorado instead of exploiting fluorescent lighting and oscillators that were practically ready for production.[48] Tesla was finally able to convince J.P. Morgan to provide $150,000 in return for 51% of Tesla's patent rights.[49] It appears that Tesla had hoped that Morgan might be a more involved investor and work to help market some of his ideas, but Morgan kept his distance from the project.[50] Nevertheless, Tesla launched into work on his newest project and began the process of constructing a laboratory at Wardenclyffe on Long Island in New York. A major feature of the laboratory was a tower designed for the wireless transmission of power. Tesla originally planned a six-hundred foot tower that would allow wireless transmission to a great distance, but the cost of the building was too high and Morgan would not provide additional funds. All of these plans were in the hope that Wardenclyffe would provide the laboratory Tesla required to complete his research and achieve wireless power transmission.

In the midst of the construction of Wardenclyffe, Guglielmo Marconi sent a wireless telegraph signal across the Atlantic. On December 12, 1901 he detected the three Morse code dots of an "s" and by December 15 national newspapers were praising him as the "Wizard of Wireless Telegraphy."[51] Although Marconi's project was the transmission of a telegraphic signal and Tesla's goal was the transmission of electrical power, the mechanism and goal were

[48] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*, 244.

[49] Hughes, *Networks of Power: Electrification in Western Society, 1880-1930*, 86.

[50] Carlson, *Tesla: Inventor of the Electrical Age*, 318.

[51] "Wizard of Wireless Telegraphy," *Chicago Daily Tribune*, December 15, 1901.

fundamentally the same. By examining Marconi's system, Tesla realized that "all the essential elements of these [new] arrangements are broadly anticipated by my patents of 1896 and 1897."[52] In order for either to be successful, they sought to transmit electromagnetic energy; telegraphy did not require as strong a signal as electrical power. In fact, Tesla believed that the patent he sought for his wireless power transmission guaranteed his priority over Marconi for the invention of wireless telegraphy. This patent became known as the "radio patent." It took Tesla some time to exploit "radio" because his focus was on wireless power. Nevertheless, the similarity in their work still made Marconi a major competitor for funding. Tesla countered Marconi's demonstration by assuring Morgan that his own idea had far greater promise:

> The whole earth is like a brain, as it were, and the capacity of this system is infinite, for the energy received on every few square feet of ground is sufficient to operate an instrument, and the number of devices which can be so actuated is, for all practical purposes infinite.[53]

Tesla's radio patent had received approval in 1900, and Marconi's attempts to patent his own system initially were unsuccessful because they relied heavily on Tesla's inventions. The patent office said Marconi's "pretended ignorance" of the Tesla oscillator, a steam powered electric generator, was "little short of absurd."[54] Marconi's company nevertheless managed to gain a monopoly on the market but Tesla seemed unconcerned by this. When asked about it, he replied "Marconi is a good fellow. Let him continue. He is using seventeen of my patents."[55] Yet although Tesla may have had most of the components for the development for wireless

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[52] Carlson, *Tesla: Inventor of the Electrical Age*, 388.

[53] Ibid., 339.

[54] Margaret Cheney and Robert Uth, *Tesla: Master of Lightning* (New York: Barnes & Noble Books, 1999), 68.

[55] Don Duncan, "Edison, Twain, Ford, Wrights, Marconi-- He Knew Them All," *The Seattle Times*, July 16, 1972.

transmission at his disposal, he did not develop them. So although he might have been able to develop wireless radio, he did not combine the required elements.[56]

Unfortunately, Tesla's plans began to unravel. In 1903, Morgan ended his funding of Tesla's research as the economy became more unstable, and the progress Tesla had made in his research was not promising. Wardenclyffe was still under construction and he had not produced any new research during its construction. Although Tesla continued seeking investors to help him complete the laboratory at Wardenclyffe for several more years, ultimately the site had to be closed in 1905, with foreclosure coming in 1908. Despite the Patent Office's early comments that indicated the security of the original Tesla radio patent, it approved a Marconi patent in 1904. Tesla's financial difficulties after losing Morgan as an investor prevented him from successfully suing Marconi for patent infringement, further exacerbating his financial problems. In 1911 Marconi and Karl Braun were awarded the Nobel Prize in Physics for their contributions to radio communication. Meanwhile, the United States government decided to demolish the tower at Wardenclyffe over fears that it was being used by German spies in World War I (Figure 8).

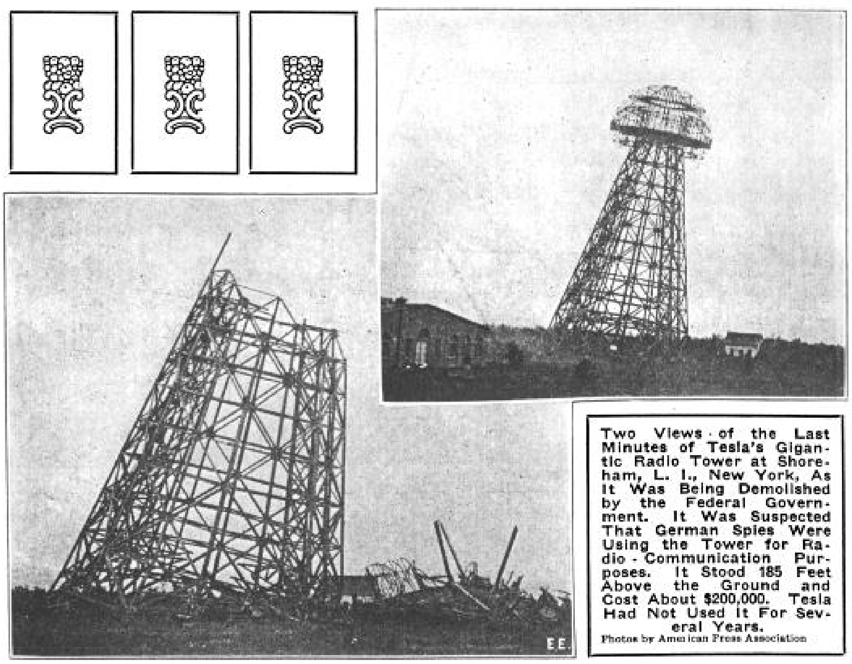

Figure 8 Wardenclyffe tower destroyed during WWI. (See Image Note 8)

[56] Sungook Hong, *Wireless: From Marconi's Black-Box to the Audion* (Cambridge, Massachusetts: The MIT Press, 2001), 199.

In 1916 Tesla had to declare bankruptcy. He continued to write articles describing his great plans for his inventions but the pace of his invention slowed considerably. His most notable inventive work between 1916 and his death in 1943 was a particle beam weapon, his "death ray." Although he attempted to sell the plans for the device to several countries, only the Soviet Union indicated any interest. He was never able to demonstrate or build the device and plans are all that remain. Tesla died on January 7, 1943. Following his death, the Federal Bureau of Investigation collected many of the papers relating to the particle beam weapon. They revealed little about how to construct such a device. Subsequent attempts to gain support to build a particle beam weapon failed.

The Telautomaton

The articles that Tesla wrote in his later life often promised great achievements that were far outside his control. But most of these articles relate back to the wireless system and the potential that it might offer if properly implemented. It is necessary, first, to understand not only Tesla's tremendous dreams for his device but also its fundamental mechanical achievements. Tesla filed his patent for his telautomaton on July 1, 1898. It differed from any other invention because it "required no intermediate wires, cables or other form of electrical or mechanical connection with the object save the natural media of space." Despite no physical connection, he was able to control a moving vessel from a distance. Although Tesla's original radio patent application focused primarily on the transmission of energy, by the time he invented the telautomaton, he seemed to have realized its real strength was also in the transmission of radio signals. He also described in his telautomaton patent several different ways a receiver and transmitter could be constructed and used to transmit radio waves.

Tesla explained that the device controlled did not matter; it was simply a matter of adapting the same internal mechanism to another device. It could be “a boat, a balloon, or a carriage.”[57] Inside the boat (Figure 9) there was a small, battery (E) powered electromagnetic propelling motor (D) as well as a steering motor (F). A receiving circuit controlled these motors. Its outputs depended on wireless transmissions received by the center antenna. The lights on the other two masts provided a further demonstration of the number of circuits that could be controlled by the receiving and transmitting circuits.

The control of the telautomaton was achieved through a complicated control circuit. The circuit relied heavily on an electromagnet triggered by a highly sensitive circuit tuned to receive signals from the remote operator. The control circuit would then be able to direct the rudder by

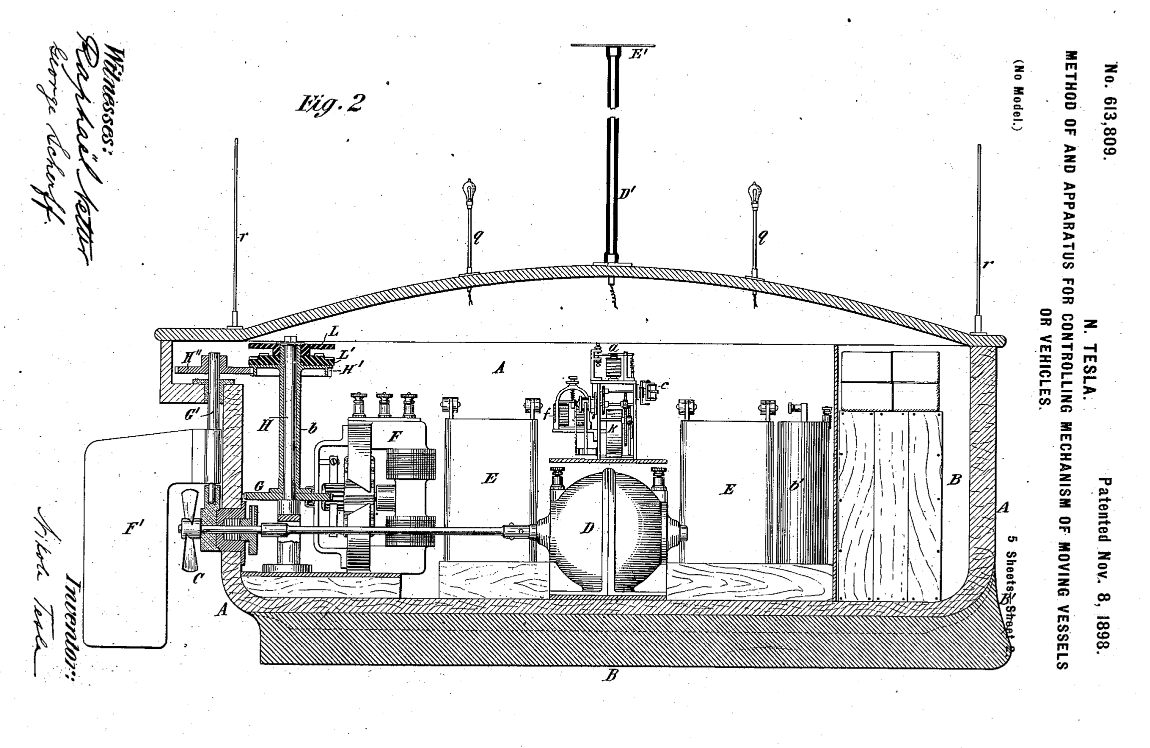

Figure 9 Tesla's Telautomaton patent. (See Image Note 9)

[57] Tesla, Nikola. Method of and Apparatus For Controlling Mechanism of Moving Vessels or Vehicles. US Patent 613809 filed on July 1, 1898 and issued November 8, 1898.

using two relays, one which closed a circuit directing the rudder to port, the other to starboard. The telautomaton was meant to be a generic example of how any device or vehicle could be operated remotely, and so his major concern was showcasing not only that these circuits could be triggered remotely, but also that they could work together. Several circuits in the telautomaton were designed with showcasing this interconnection. A series of brushes that connected to the battery that powered the propelling motor were able to restrict the motor from being reversed when the position of the rudder was less than 45 degrees, preventing the ship from turning backwards in circles. Another circuit prevented the rudder from being turned too far in either direction. Tesla also made certain to demonstrate that additional systems could be included in the device and controlled. A third motor, which rotated an armature, would complete a circuit for lights on the rear and the forward antenna. The transmitting device (seen only in Figure 11) receives a brief description. The transmission could be "any sort of electrical disturbance or oscillation" and Tesla only described the device for controlling and interpreting those

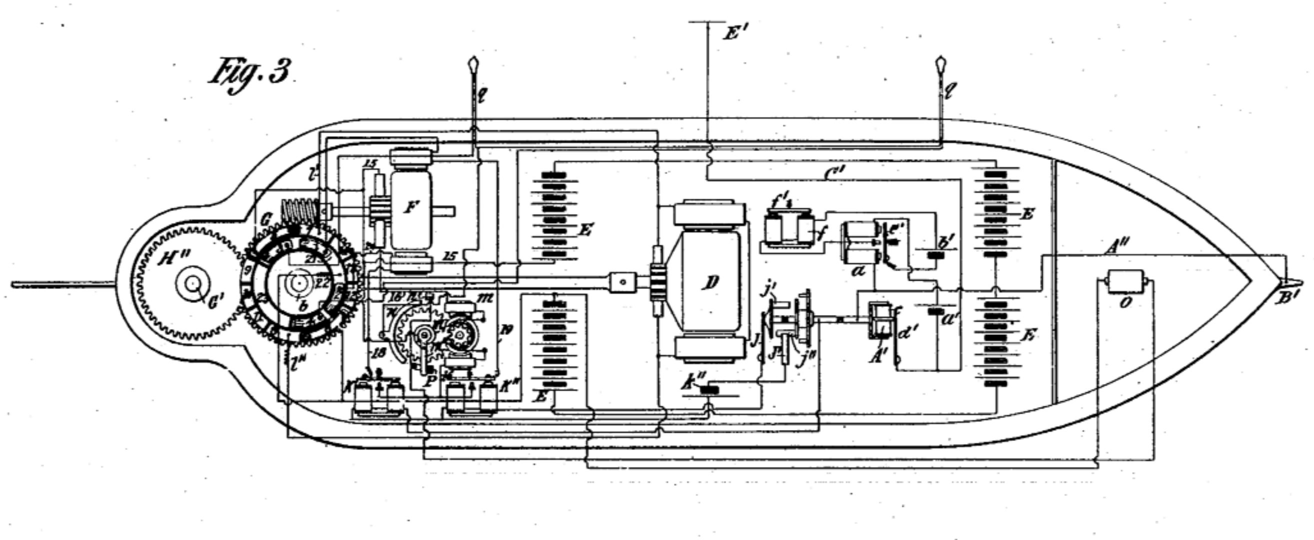

Figure 10 Top down diagram of the telautomaton's internal circuitry. (See Image Note 10).

transmissions. He provided detail on the switch positions and the subsequent changes that would be caused in the motion of the rudder

The Electrical Exposition

Tesla designed his telautomaton to showcase the remote control system that he boasted could, without wires, control nearly any machine.[58] At the Electrical Exposition he chose to demonstrate the system's effectiveness using a three foot long boat, likely due to increased interest in naval technology because of the Spanish-American War. Visitors went expecting to see the newest wonders in electricity, but the wireless transmission of signals seemed like something out of a work of fiction. In fact, Tesla's telautomaton had effectively been described previous to his work. Edward Bulwer-Lytton imagined similar devices in *The Coming Race,* a science fiction novel. In the novel automata responded to the energy transmitted by their controllers.

> In all service, whether in or out of doors, they make great use of automaton figures, which are ingenious, and so pliant to the operations of vril, that they actually seem gifted with reason. It was scarcely possible to distinguish the figures I beheld, apparently guiding or superintending the rapid movements of vast engines, from human forms endowed with thought.

The narrator explained vril as "electricity, except that it comprehends in its manifold branches other forces of nature, to which, in our scientific nomenclature, differing names are assigned such as magnetism, galvanism, &c."[59] In Tesla's telautomaton, electricity replaced vril, but his descriptions otherwise were strikingly similar to those in the novel. Bulwer-Lytton's book, published in 1871, appeared twenty-seven years before Tesla's work on his telautomaton. Still,

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[58] Tesla and Anderson, *Nikola Tesla on His Work with Alternating Currents and Their Application to Wireless Telegraphy, Telephony, and Transmission of Power*.

[59] Edward Bulwer-Lytton, *The Coming Race* (London: George Routledge and Sons, 1886), 53.

two years after the display at the Electrical Exposition, he insisted in a letter to Robert Johnson that he had not been inspired in his work by Bulwer-Lytton's novel. [60] While no early descriptions of his hope of assembling a telautomaton exist, Tesla maintained that he imagined creating one in his youth, partly because of the visions he experienced. It remains unclear if Tesla ever read *The Coming Race*. Yet, in an article published in 1907 he referred to the telautomaton as "Bulwer's dream."[61]

Tesla promoted a sense of mystery and showmanship in the way he displayed the Telautomaton. Although he encouraged the audience to ask questions, the questions were directed at the Telautomaton as though it could hear the audience, not its inventor. The Telautomaton was only able to offer a response of blinking lights so the questions were limited to the mathematical. Thus there were no explanations of the system of control offered. In many ways, his demonstration was reminiscent of the displays of early automata such the Chess

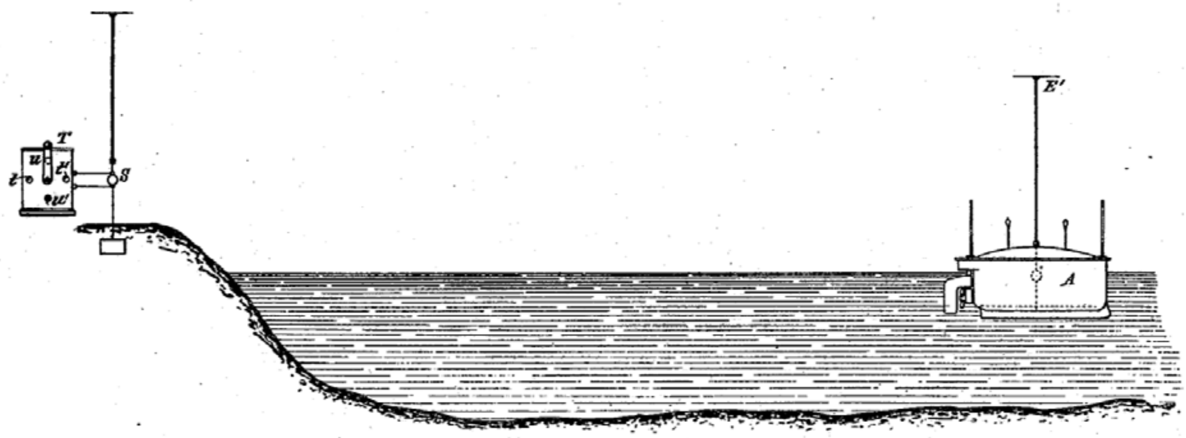

Figure 11 Image from Tesla's patent of the telautomaton showing the transmitter and telautomaton in operation (See Image Note 11).

[60] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*, 193.

[61] Nikola Tesla, "Tesla Tidal Wave to Make War Impossible," *The New York World*, April 21, 1907.

Playing Turk.[62] The Chess-Playing Turk was an automaton that was able to beat some of the greatest chess experts in Europe. The automaton concealed an automatic electronic controller in its case and although Tesla never denied the device was controlled remotely, he certainly concealed that control at its demonstration. Much of the authenticity was related to the sense of mystery instilled in the audience about the inner workings of the devices. Tesla opened the case of the telautomaton to demonstrate that the case did not conceal any human or animal controller. There was a production to the display of the automaton that made a point to show the audience that the case was empty. Tesla's Telautomaton relied on a similar sense of mystery. While articles published in the local paper on the remote mine detonation system featured an explanation of how the mines were triggered, Tesla gave no explanation for the telautomaton. The Patent Office did not approve the application until November 8, 1898, which might have explained Tesla's secrecy about the internal mechanism.

In fact, the demonstration of the mines was purposely designed to be transparent. The *New York Times* featured a detailed interview with Clarke, the designer of the system.

> The transmitter cannot be briefly described so as to be understood by one unacquainted with electrical contrivances. What it does is to create electrical sparks, which pass between metallic balls and produce violent electrical oscillations, which in turn generate electric waves which go out into space in the form of ever-increasing spheres. These spheres have the power of passing through any material, the walls of a building or a crowd of people presenting no appreciable impediment to the passage of the waves.[63]

The signal transmitted to the mine caused it to detonate but also caused a bell to ring. The bell rang through the same mechanism that triggered the explosion. This demonstrated to the audience that the detonation system was not only a destructive force, but also that it could be

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[62] Adelheid Vokshul, "Motions and Passions: Music-Playing Women Automata and the Culture of Affect in Late Eighteenth-Century Germany," in *Genesis Redux*, ed. Jessica Riskin (Chicago: University of Chicago Press, 2007), 300. Gaby Wood, *Edison's Eve* (New York: Anchor Books, 2002), 60.

[63] "New Way to Fire Mines," *New York Times*, 1898.

used to perform other more mundane tasks. Although he only briefly described the transmitter, Clarke outlined the construction of the receiver in detail. Clarke's full description appeared in the *Times* article.

In contrast to the enthusiasm in the newspapers' reception of the mine demonstration, the telautomaton appeared only in a *Los Angeles Times* article and the article offered no details from the display at the exhibition. There was no mention in the article of the demonstration specifically; instead, it emphasized the general possibility of remotely controlled torpedo boats. The article focused solely on the hypothetical development of harbor and torpedo boats. There was no mention of Tesla. Given the contrast in the transparency of the remote-detonated mines and other displays at the Electrical Exhibition compared to the telautomaton, it is unsurprising that newspaper reporters and the public were unsure of what to make of it. Eventually trade journals did provide an analysis of Tesla's invention but not until November, after he performed laboratory demonstrations of the device for reporters.

What Tesla suggested to reporters in November was much grander than what he had displayed at the Electrical Exhibition six months earlier. He included a much more detailed discussion of the method of control, explaining that the range of control was limited only by the vision of the controller. He provided the papers with general descriptions of the internal mechanisms, explaining that the device was controlled by electrical oscillations. He also explained that electrical oscillations could be transmitted in a variety of ways: either through the ground, through air, or by using a conductor. Tesla said that the technology implemented in his small model could easily be fitted to a submarine boat that could be controlled remotely and equipped with thirteen-foot torpedoes. He argued that the Spanish-American War had demonstrated the necessity of such a device because the submarine boats had proved to be "death traps for men" while the torpedo boats were frail and "an easy target for land batteries and rapid-fire guns of opposing war ships."[64] His telautomaton, which he now called a submarine boat, offered a distinct advantage because it could perform dangerous maneuvers that a manned submarine could not perform without risking loss of life. Best of all it could perform these tasks with a human controller at a safe distance. Although this description of the telautomaton offered by Tesla relied far less on showmanship than his earlier display at the electrical exhibition, he could not resist including a grand claim: that it would "render useless the navies of the world" and end warfare.[65]

Reception of the Telautomaton

Tesla's telautomaton ultimately failed to gain the recognition that he had hoped it would. Instead, his November articles drew criticism from his colleagues. Much of this criticism played out in a series of articles published in *The Electrical Engineer*. The November 17, 1898 issue featured a three-page article on the telautomaton. As was typical of the journal, it offered a technical discussion of the invention, dissecting the images from his patent application and detailing the reception of the signal and the circuits that directed it. The displays at the Electrical Exhibition appeared briefly in the article but without any description of Tesla's telautomaton. Either the author was ignorant of Tesla's display or purposely ignored mentioning it. Instead, the comparison was to the remote mine detonation system demonstrated by Clarke at the exhibition. The article also suggested that Tesla was facing difficulty in finding "immediate practical utilization of the idea" because his only immediate plans for the device were to attend

64 Nikola Tesla, "My New Submarine Destroyer," *The New York Journal and Advertiser*, November 13, 1898.

65 "Tesla Declares He Will Abolish War," *New York Herald*, November 8, 1898.

an exhibition in Paris.[66] In the past, *The Electrical Engineer* had lauded Tesla's genius and ingenuity, but the description of the telautomaton implied the invention was not as impressive or as original as his earlier work.

The telautomaton and Tesla's claims about ending war also drew criticism from a pair of professors interviewed by the *New York Herald*. Professor Cyrus Fogg Brackett of Princeton University blustered: "what is new about it is useless, while that which is useful had all been discovered by other scientists long before Tesla made this startling announcement."[67] He claimed that any circumstances in which the device might be successfully implemented would be a complete failure; that enemies would have to remain stationary as the device approached. He also suggested that Tesla was a theorist and that most of his discoveries were useless. Professor Amos Dolbear of Tufts College also dismissed Tesla for lack of ingenuity and for his grand claims that the telautomaton would revolutionize warfare. He wrote that

> The announcement is most amazing, and coming as it does from Tesla, scientists are all the more chary about accepting it. During the last six years he has made so many startling announcements and has performed so few of his promises that he is getting to be like the man who called 'Wolf! Wolf!' until no one listened to him. Mr. Tesla has failed so often before that there is no call to believe these things until he really does them.[68]

Dolbear's skepticism possibly arose from the optimistic press coverage of the race to achieve wireless transmission. *The Electrical Engineer* also published an opinion piece that critiqued Tesla's grand claims and directed the reader toward some of his more promising and less

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[66] "Tesla's Electrical Control of Moving Vessels or Vehicles from a Distance," *The Electrical Engineer*, November 17, 1898.

[67] Ibid.

[68] Ibid.

impressive inventions, like his work in electro-therapeutics described in a speech published in the same issue.

Tesla responded to the criticisms in *The Electrical Engineer* in the following issue but focused mostly on the periodical's unauthorized publication of his speech before the "Electro-Therapeutic Society." Then he argued that the publication has "dared to cast a shadow on my honor." He requested tangible proof of the dishonesty that Dolbear and Brackett accused him of and demanded a formal apology from *The Electrical Engineer*. The publication refused his requests and in issues published in 1899 there is a marked decrease in the articles on Tesla's inventions.

Military Applications

Tesla's telautomaton faced criticism not only from his colleagues, but also from those from whom he attempted to secure funding. Early in the invention process Astor had tried to convince Tesla to accept funding to develop the device for military purposes, but he had responded that he envisioned a "higher duty."[69] He did later seek military funding but was unable to persuade Congress. In 1916, speaking of the telautomaton, he stated, "everybody said it is impracticable, and after my patent expired only a few months ago, Congress appropriated this sum [$750,000] and I have now the pleasure of simply looking on when others are using my inventions, which I could not persuade people to adopt."[70]

The $750,000 dollars that Congress appropriated was to support the work of John Hays Hammond, Jr. And that was not until 1914, over a decade after Tesla's remotely operated

[69] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*.

[70] Tesla and Anderson, *Nikola Tesla on His Work with Alternating Currents and Their Application to Wireless Telegraphy, Telephony, and Transmission of Power*.

automaton. In both 1914 and 1915, *McClure's Magazine* featured articles on the wireless control of a full size boat by John Hays Hammond, Jr. in Gloucester harbor. Initially Hammond had worked on his invention independently and all of his remote control tests were performed on a houseboat. After encountering difficulty with his wireless receivers, he sought out the assistance of the U.S. military. This assistance motivated him enough to design his own wireless receivers, and a year later he demonstrated the *Radio*, a new ship, to the U.S. military. He described the ship as a precursor to "a terrible new weapon for the navies of the world: a new kind of torpedo, so sure and deadly that it will revolutionize warmaking."[71] The *Radio* was capable of independent navigation at a distance of up to seven miles, a distance dictated by the distance of human sight and visibility. *Radio* was limited, as the telautomaton had been, by the vision of the controller and so it was necessary for the controllers to visually navigate from shore or another ship. At the time Hammond hoped to develop the radio control to be used in a shore-based torpedo defense system. Although Hammond's project was promising there is no indication that any form of remote controlled torpedo defense system was ever implemented.

As a military device Tesla's telautomaton was a failure. Tesla's contemporaries criticized the work as unoriginal. But his interest went beyond its application in warfare. The "higher purpose" that Tesla explained to Astor that the telautomaton was destined for does not become clear until his later writings. In the twentieth century, Tesla's focus on invention waned and he began to write at length about his views on philosophy and physics. The telautomaton, the wireless system, and automatism appeared frequently and these writings suggest Tesla considered the device to be a primitive form of life. The "higher purpose" is apparent in his explanation of the future utopia that his wireless system would establish. This utopia would be founded on the peace established by the telautomaton's use as a weapon. Although this idea

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[71] Clevland Moffett, "Steered by Wireless," *McClure's Magazine* XLII, no. 5 (March 1914).

seemed outrageous to some of Tesla's contemporaries, the intellectual context in which Tesla invented the telautomaton suggested its plausibility to a variety of scientists.

The wireless system that Tesla proposed represented what he considered the ultimate triumph of science. Yet he struggled to find support for this system. As outlined within an inventive and engineering context, the telautomaton and the wireless system were difficult to situate. Investors were unsure how to market and employ these inventions and so they were largely ignored. The importance and value of the wireless system rests instead in how it provides a concrete connection between the major issues in nineteenth-century science like physiology, physics, psychology, and psychical research and to the history of technology. The telautomaton as a representative invention of the wireless system provides a concrete and fascinating connection between an inventor and the major theories of nineteenth century.

Chapter 2
"I see, therefore I am":
The Automata Debates in the Nineteenth Century

"Whether the automaton be of flesh and bone, or of wood and steel, it mattered little, provided it could perform all the duties required of it like an intelligent being."

Nikola Tesla, "The Problem of Increasing Human Energy"

Nikola Tesla demonstrated his telautomaton at a time when physiologists, physicists, and psychologists debated the extent of human automatism. In the nineteenth-century advances in physiology and biology, particularly research into reflex action, provided scientists with a new perspective on the degree to which humans are automata. To Tesla, the degree of automatic action in a human was particularly important because this determined how human-like the automaton he constructed would be. Although the device was remote controlled, he sought to replicate systems from the human automaton. How exactly did the telautomaton demonstrate the principles of nineteenth-century physiology and psychology? In demonstrating these theories, how did the role of the telautomaton as an object change? Why were these principles of any concern to an inventor? Relying heavily on a particularly unique interpretation of Rene Descartes's *Treatise on Man*, Tesla attempted to detail how his invention represented a new form of life and a significant experimental contribution to nineteenth-century discussions on human automatism. Descartes theorized that animals were automata but that humans possessed a rational soul. Reflex action factored heavily into Descartes's argument and into nineteenth-century theories on mind-body dualism. But, with the discovery that reflex functions occurred in the spinal cord, independently of the brain, scientists began to scrutinize the degree of automation in human actions.[1] A central figure in the discussion was the British physiologist and popular lecturer Thomas Henry Huxley. In a lecture in 1874, Huxley suggested that humans were "conscious automata" and that the actions Descartes attributed to the rational soul could be explained solely using principles in physiology and chemistry. Huxley's theories elicited a wide range of responses from his contemporaries. Tesla's research, and the construction of the telautomaton in particular, responded to these ideas. Tesla lacked Huxley's scientific training and background but nevertheless he attempted to construct a device to develop and demonstrate the degree of human automatism. He explained:

> A scientific man, in order to prove his theory, must be able to substantiate it in some or other way. He may bring forth logical arguments or show by calculations the truth of his contentions, but the best way to demonstrate it is by a practical working machine. If it be true, that we are automatic engines, why not, then, endeavor to construct such an engine?[2]

Unlike the physiologists who debated how automatic human actions were, he constructed an automaton that would respond in some limited respects like a human.

Tesla's theories relied primarily on Huxley's remarks, but those remarks reflected a much longer dialogue between scientists. William Benjamin Carpenter, a physiologist, was one of the first to grapple with the ramifications of reflex action and automatic actions. In 1852, he introduced the term "ideo-motor reflex," when a thought or idea brought about a reflex response.[3] According to Carpenter, humans were capable of a wide range of both automatic and voluntary actions. But it was Huxley's polarizing speech, *On the Hypothesis that Animals are Automata* that drew on these same principles, which elicited the greatest response from the

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[1] J M Pearce, "Marshall Hall and the Concepts of Reflex Action.," *Journal of Neurology, Neurosurgery, and Psychiatry* 62, no. 3 (1997): 228.

[2] Tesla, Nikola, Box 4, DOI 333-1, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[3] Franklin Fearing, *Reflex Action: A Study in the History of Physiological Psychology* (New York, New York: Hafner Publishing Company, 1964), 156.

public and his contemporaries including William Carpenter, John Tyndall, William Thomson and James Clerk Maxwell. These responses originated from a variety of fields, including physics, psychology, and physiology. They also presented a wide spectrum of theories on human automatism that ranged from complete automatism to a human body in possession of free will. These theories followed from research in individual fields. Physiologists studied the impact of reflex action, while physicists drew on the new theory of energy conservation in order to substantiate claims about free will. The wide range of these theories is reflected in Tesla's writings on his telautomaton. I will use the telautomaton to explore the theories that it was designed to demonstrate. Tesla used these theories, in combination with his telautomaton, in an attempt to understand his own automatism and to construct a device that might demonstrate the scientific principles.

Most of Tesla's contributions to automata theories were writings that appeared in newspapers and professional journals in the late nineteenth and early twentieth centuries. Despite Tesla's hope that demonstrating automatic principles would help to clarify the debate, to physiologists it was impossible to determine the degree of human automatism experimentally. The brain, although gradually becoming better understood, remained largely a mystery. Instead of attempting to talk or theorize his way into a solution like so many of the British scientists he admired, Tesla attempted to demonstrate and through demonstration gain a better understanding of automatism.

The group whose work Tesla seemed to emulate and study most closely was the "scientific naturalists" including Huxley, John Tyndall, William Kingdon Clifford and Herbert Spencer. This term, originally coined by Huxley, has provided a useful category for historians.[4]

[4] Gowan Dawson and Bernard Lightman, eds., *Victorian Scientific Naturalism: Community, Identity, Continuity* (Chicago: University of Chicago Press, 2014), 1.

Frank Turner's *Between Science and Religion* (1974), offered the earliest complete discussion of the origin and importance of "scientific naturalism."[5] Originally coined by Huxley as a term to stand opposite to supernaturalism, the "scientific naturalists" have evolved for historians to encompass a group of educated men intent on promoting a rational and empirical approach to science. Although Tesla hardly fits as a member of the scientific naturalists, he happened to rely, almost exclusively, on their accounts of nineteenth-century physiology and psychology. Most of the work of the scientific naturalists was focused in the mid nineteenth century, and by the time Tesla began interjecting his own theories on automatism, these theories were widespread. It is likely their work was attractive to him because he shared their hesitation to incorporate nonmaterial considerations.[6] John Tyndall, a public lecturer, physicist and scientific naturalist, explained the difficulty scientists faced in the nineteenth century.[7]

> A man, for example can say I feel, I think, I love: but how does consciousness infuse itself into the problem? […] Were our minds and senses so expanded, strengthened, and illuminated as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, 'How are these physical processes connected with the facts of consciousness?'[8]

Huxley's own theory of "conscious automata" emphasized that consciousness was fundamentally a chemical process and refused to suggest there were supernatural forces involved.

These scientists were frequently at odds with those concerned with understanding new scientific discoveries alongside religion. Largely this was tied to the uncertainty on the role of

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[5] Frank Miller Turner, *Between Science and Religion* (New Haven: Yale University Press, 1974), 8.

[6] Theodore M. Porter, "The Fate of Scientific Naturalism," in *Victorian Scientific Naturalism: Community, Identity, and Continuity*, ed. Gowan Dawson and Bernard Lightman (Chicago: University of Chicago Press, 2014), 249.

[7] Turner, *Between Science and Religion*, 10.

[8] John Tyndall, "Address to the Mathematical and Physical Science Section," *Chemical News* 18, no. 456 (August 28, 1868): 101–104.

free will and the soul, an uncertainty reflected in Tesla's writings on the subjects. Discoveries in reflex action and observation of victims of brain damage in the nineteenth and twentieth centuries provided researchers with a mechanized understanding of the brain.[9] The theories that attempted to explain these observations left little room for metaphysical concerns. Tesla was "not a believer in the orthodox sense" so his writings offered little to reconcile science and religion.[10] He believed, however, that he could contribute to nineteenth-century discussions through demonstration.

Despite Tesla's claim that he was convinced of his own automatism in his youth, the demonstration of the telautomaton marks the public emergence of his theories on automatism. Although his aim was to demonstrate scientific theory with the telautomaton, his own interpretations of these theories appeared in popular magazines and newspapers, not in scientific journals or at presentations at scientific societies. In these articles, he emphasized a variety of major themes from the nineteenth-century debates: memory, sensation, free will and automatism. His writings show that he profoundly misunderstood some of the theories he attempted to demonstrate. For example, Tesla's interpretation of Cartesian automatism was problematic. Although he showed familiarity with much of the argument from *Treatise on Man*, he misunderstood the fundamental premise. He believed that Descartes argued that humans were entirely automata, an interpretation that was likely based on a misreading of Huxley's work. Tesla's reading, and sometimes intentional misreading of the work of the scientific naturalists, served to position the telautomaton as a significant contribution to science and the discussions on

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[9] Laura Salisbury, "Linguistic Trepanation: Brain Damage, Penetrative Seeing and a Revolution of the Word," in *Minds, Bodies, Machines, 1770-1930*, ed. Dierdre Coleman and Hilary Fraser (New York: Palgrave Macmillan, 2011), 183.

[10] Nikola Tesla, "A Machine to End War," *Liberty Magazine*, February 9, 1935.

human automatism. By positioning the telautomaton and his later wireless inventions in this way, Tesla attempted to legitimize his inventions as scientific discoveries.

Thomas Henry Huxley

In 1874 Thomas Henry Huxley, gave a speech before the British Association for the Advancement of Science. Huxley, a popular lecturer, is most remembered for his fierce promotion and defense of Darwin's theory of evolution, for which he earned the nickname "Dariwn's Bulldog." In his 1874 speech, *On the Hypothesis that Animals are Automata,* Huxley outlined Cartesian automatism and his own theory that humans were conscious automata. This implied that although humans were conscious, actions were purely reactive and that consciousness originated in a molecular state in the brain. Volition was an illusion representing an elaborate series of cause and effects. Consciousness and free will were frequently discussed in the nineteenth century, but what he suggested was a far more materialist theory than that proffered by many of his contemporaries. Huxley particularly praised René Descartes as a "physiologist of the first rank."[11] He argued that the later physiologists and even his nineteenth-century contemporaries had done "little more than reproduce and enlarge upon the ideas of Descartes."[12] His promotion of Descartes was not wholly an effort to praise the work of the seventeenth-century physiologist. Huxley selected portions of *Treatise on Man* that supported his theory of human automatism and furthered his goal of promoting scientific naturalism. Since Descartes very deliberately emphasized that humans were not automata , but ultimately governed by a rational soul, it is interesting that Huxley chose this theory to underline his own.[13]

[11] Thomas Henry Huxley, "On the Hypothesis That Animals Are Automata, and Its History," in *Science and Culture and Other Essays* (London: Macmillan and Co, 1881), 201.

[12] Ibid., 202.

[13] Rene Descartes, *The World and Other Writings*, ed. Stephen Gaukroger (Cambridge: Cambridge University Press, 1998), 168.

Perhaps the most notable example of a nineteenth-century physiologist "reproducing and enlarging" on Descartes's work was the recent discoveries in reflex action. Descartes in *Treatise on Man*, originally published posthumously in 1662, had described something similar to reflex action in the working of "animal spirits." Descartes described an early version of what Stephen Gaukroger labels "the reflex arc," which occurs independently of the pineal gland.[14] The primary strength in Descartes's reflex theory is his description of the human body as an automaton directed by a rational soul and his elaboration on this, not on any experimental proof.[15] In the 1830s and 1840s, many physiologists were seeking to develop a deep understanding of reflex action.[16] The British physiologist Marshall Hall set his own work apart from these scientists because he refined the idea that reflex action originated in the spinal cord and developed research that led to the modern concept of the reflex arc. His paper *On the Reflex Function of the Medulla Oblongata and the Medulla Spinalis*, published in 1832, described that the reflex arc allowed reflexes to occur through the spinal cord instead of routing the reflex through the brain. This allowed a reflex to occur before the sensory information was transmitted to the brain. The significance of Hall's work lay in its material explanation. Unlike previous theories, his conception of reflex action did not rely on the soul as the acting agent and he specifically excluded sensation as a necessary cause of reflex action.[17] Although other physiologists had made significant strides in deepening understanding of reflex action, it was Hall who was the first to develop a complete theory, in part through a synthesis of the existing theories. His research complicated the role of volition and posed difficulties to those seeking an

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[14] Ibid., xxv.

[15] Fearing, *Reflex Action: A Study in the History of Physiological Psychology*, 28.

[16] Diana E. Manuel, *Marshall Hall (1790-1857): Science and Medicine in Early Victorian Society* (Atlanta, GO: Rodopi, 1996), 239.

[17] Ibid., 248.

explanation that might provide a physiological explanation of reflex action that allowed a connection to the human soul.

Huxley's 1874 account of Descartes focused on the physiological ideas described in *Treatise on Man* and how new research, like Hall's, modified these ideas. Descartes argued that the human was an automaton governed by the rational soul, whereas Huxley suggested that consciousness itself was automatic. Daston suggests that this argument was, in part, a matter of consistency and that Descartes's argument that animals lacked consciousness was counterintuitive.[18] Huxley's argument remedied this discontinuity, but at the expense of human volition. With this drastic difference in mind between these two philosophies, it is particularly telling what points of Descartes's original theory Huxley chooses to emphasize. In his speech, he divided Descartes's argument into five main points. Although this articulately summarized major concepts in Descartes's work, Huxley did select points that best supported the argument he wished to carefully advance, that humans were automata. The first point he highlighted was Descartes's conviction that the brain was the seat of consciousness. Huxley explained that current physiological research confirmed Descartes's suggestion that states of consciousness were the direct outcome of changes in the brain. The second conception related to the relationship between motion, nerves and muscle. Descartes originally suggested that muscles were contracted or relaxed by the motion of "animal spirits" through the nerves. Huxley reasoned that the "animal spirits" that Descartes described were an early explanation of the "molecular motion of nerve-substance."[19] This explanation of Cartesian theory served two purposes: it lent credence to Descartes's original theories as "ahead of their time" and simultaneously promoted modern physiological theories that eschewed mysterious explanations

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[18] Daston, "The Theory of Will versus the Science of Mind," 101.

[19] Huxley, "On the Hypothesis That Animals Are Automata, and Its History," 207.

relying on concepts like "animal spirits." The third conception described the relationship between sensation and the nerves. Descartes argued that sensations were caused by the motion of the animal spirits between the nerves and the brain. Huxley used this to introduce his discussion on consciousness. He suggested that "either consciousness is the function of something distinct from the brain, which we call the soul" or "there is no soul, and sensation is something generated by the mode of motion of a part of the brain."[20] Huxley's final two points described the theories of reflex action and memory. Huxley enthusiastically outlined the Cartesian theory on involuntary action, which he considered a precursor to reflex action. Finally, Huxley outlined the Cartesian theory of memory without any caveats or additions. There were no significant advances in physiology that allowed a more nuanced understanding of memory.

Although Huxley considered each of these propositions as pivotal in Cartesian physiology, he explained that animal automatism became one of the most quintessentially Cartesian arguments resulting from *Treatise on Man*. He considered the animal automatism theory to be very promising and although modern research had not provided evidence to fully support it, it was "far more defensible than it was in his [Descartes's] day."[21] The importance of animal automatism rested largely in its strength in explaining animal action in scientific terms and according to the principles of scientific naturalism that Huxley sought to promote. The scientific evidence that Huxley considered most essential focused on a series of studies on frogs. These studies suggested that a frog deprived of the optical region of the brain still would respond to external stimuli in much the same way as before. Huxley compared this to the case of a man who had suffered a similar brain injury and demonstrated similar automatic reactions. To

[20] Ibid., 209.

[21] Ibid., 217.

Huxley the frog offered an excellent comparison to the man and this indicated that "in the abnormal state, the man is a mere insensible machine."[22] Despite this evidence, he refrained from absolutely concurring with Descartes's theory and instead argued that animals are "conscious, sensitive, automata."[23]

But what was consciousness to Huxley? In 1874, this was tangled up with the emerging theories on reflex action, particularly Hall's. The work of Hall in 1832 further bolstered Descartes's argument of animal automatism. The reflex arc theory of Hall impressed Huxley with how tantalizingly close Descartes was to articulating nineteenth-century reflex action theory several hundred years prior. To demonstrate the concept of consciousness, Huxley used the example of a frog to explain in greater detail. For Huxley, the responses and reflex action present in the frog, even after significant and specific brain damage presented convincing proof that animals were automata. Here an animal was able to interact with its environment without the intervention of consciousness, for if there was no vision of the surroundings an animal could not consciously react to them. Consciousness, or what we perceived as consciousness, was nothing more than molecular changes in the brain and changes in "mental conditions are simply the symbols in consciousness of the changes which take place automatically in the organism."[24] Free will was an illusion, and although there existed the illusion of choice, choices were determined completely within the natural science in the mind.[25] Although Huxley credited Descartes with the theory of animal automatism, this argument differed drastically from the Cartesian theory. Huxley's interpretation left little room for nonmaterial explanations of

[22] Ibid., 220.

[23] Ibid., 234.

[24] Ibid., 239.

[25] Matthew Stanley, *Huxley's Church and Maxwell's Demon: From Theistic Science to Naturalistic Science* (Chicago: University of Chicago Press, 2015), 212.

consciousness or the soul. More importantly, the theory could be easily applied to the human automaton as well as the animal. Ultimately Huxley did just this and extended his reasoning. He concluded that

> We are conscious automata, endowed with free will in the only intelligible sense of that much abused term–inasmuch as in many respects we are able to do as we like–but none the less parts of the great series of causes and effects which, in unbroken continuity, composes that which is, and has been, and shall be–the sum of existence.[26]

Here Huxley is particularly careful with his word choice as he was hesitant to state definitively that humans were automata, a conclusion that Descartes would not have supported. Despite his care, his speech offered little room for any other interpretation. Although he tried to qualify his statement in later writings, explaining for instance that

> Volition is the impression which arises when the idea of a bodily or mental action is accompanied by the desire that the action should be accomplished. It differs from other desires simply in the fact, that we regard ourselves as possible causes of the action desired. [27]

Although here he suggests volition exists, it is only as far as explaining why we might regard ourselves as "possible causes of the action." Fundamentally he refused to allow any explanation for volition or free will that might leave room for a more mysterious or religious explanation. In the conclusion of his speech on animal automatism, there is some indication of why he hedged on his explanation of consciousness and volition. Here, he focused on constructing a defense against those that might call him an atheist, a materialist or a fatalist. By drawing on historical examples of other scientists who held the view that man was an automaton and describing their spiritual or philosophical devotion, Huxley attempted to show that these views were not mutually exclusive. Tesla demonstrated a similar inclination, suggesting religion offered necessary ideals

[26] Huxley, "On the Hypothesis That Animals Are Automata, and Its History," 239.

[27] Thomas Henry Huxley, *Hume* (London: Macmillan and Co, 1879), 184.

and "wise prescriptions."[28] Huxley's defensiveness was justified because his speech ignited a wide range of responses on the question of human consciousness.

Nikola Tesla and Huxley

Nikola Tesla was certainly aware of the dialogue on human automatism in the nineteenth century, particularly given his long-term preoccupation with the subject and his childhood conviction that he himself was an automaton. Although it is unlikely that this conviction dates as far back as Tesla claimed, his rewriting of his childhood to incorporate these ideas indicates his devotion to them in his later life. In 1915, an article published in *New York American*, titled "How Cosmic Forces Shape Our Destinies," Tesla, drawing from his own interpretation of Descartes as read by Huxley, stated with profound confidence that humans were automata. Offering no specific examples, he cited advances in physiology and anatomy as elucidating the internal workings of the man-machine and declared that these advances further confirmed its complete automation. The very structure of this article suggests that much of Tesla's familiarity with Cartesian philosophy developed because of Huxley's speech on animal automatism, not from reading Descartes's original work. Although Tesla may have read Descartes, his argument indicated his understanding of these theories were developed solely through his reading of Huxley's work. Just as Huxley deliberately summarized the portions of Descartes's argument that were most relevant and supportive to the argument he sought to advance, Tesla selected the portions of Huxley's work that bolstered his position.

Tesla introduced his 1915 article by summarizing what he called Descartes's "mechanistic theory of life."[29] That he believed Descartes's theory could be described as

[28] Tesla, "A Machine to End War."

"mechanistic" demonstrates the depth of his ignorance in the original theory, because although at its surface Descartes promotes a mechanical understanding of the human body at its core he depends on the soul. Tesla explained that from a historical perspective Descartes provided a description of the human body that offered a far more mechanistic account than previously existed. Huxley made a similar claim that Descartes "opened up that road to the mechanical theory of [physiological] processes."[30] Tesla also professed that he admired Descartes's work because his true triumph was that "his mind had to free itself from the influence of delusive appearances." These delusive appearances were caused by humans' "deficient and deceptive" senses. These senses were the only way that humans received impressions of the external world. Tesla shared this emphasis with Descartes and Huxley: that the human automaton was governed from without by impressions on the senses and that the "phenomena of the senses are purely spiritual affections."[31] As argued below, Tesla, like Huxley, promoted these theories because they lent further credence to his own work.

Despite his professed admiration for Descartes, Tesla misunderstood the Frenchman's theory of animal automatism. In an article published in 1919, he explained that his belief that Descartes suggested, "the human being is an automaton, governed by external influence."[32] This claim directly contradicts Descartes's own writings that clearly differentiated humans from animals, since humans were governed by a rational soul. By calling Descartes's theory a "mechanistic theory of life" in an earlier article published in 1915, it is clear that Tesla was specifically interested in applying Descartes' doctrine on animal automatism to humans, as

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[29] Nikola Tesla, "How Cosmic Forces Shape Our Destinies ('Did the War Cause the Italian Earthquake?')," in *The Nikola Tesla Treasury* (Radford, VA: Wilder Publications, 2007), 505.

[30] Huxley, "On the Hypothesis That Animals Are Automata, and Its History," 200.

[31] Ibid., 209.

[32] Nikola Tesla, "Famous Scientific Illusions," *Electrical Experimenter*, 1919.

Huxley did. Summarizing what he labeled as Descartes's "Mechanistic Theory of Life," Tesla said:

> [Descartes] held that animals were simply automata without consciousness and recognized that man, though possessed of a higher and distinctive quality, is incapable of action other than those characteristic of a machine.[33]

Although here Tesla acknowledged the "higher and distinctive quality," presumably the rational soul, his later arguments failed to mention the rational soul at all. Tesla's failure to emphasize the role of the rational soul cements the argument that he misunderstood the very core of Descartes's philosophy. But lends further evidence that most of his understanding of Cartesian philosophy developed from Huxley's *On the Hypothesis that Animals are Automata*, where the soul is less emphasized, not from reading Descartes's original works. Tesla also deliberately selected the portions that best supported his own work, legitimizing his research and establishing himself as a scientist.

The parallels between Huxley's speech in 1874 and Tesla's 1915 article are particularly evident in their introduction of Descartes's theories and impact. In his introduction of Descartes, Tesla cited several ideas that were emphasized in Huxley's speech.

> It was **Descartes**, the great French philosopher, who in the seventeenth century, **laid the first foundation** of the **mechanistic theory of life**, not a little assisted by **Harvey**'s epochal discovery of blood circulation. […] He also made the first attempt to explain the physical mechanism of memory. But in this time many functions of the human body were not as yet understood and in this respect some of his assumptions were erroneous. **Great strides have since been made in the art of anatomy, physiology** and all branches of science, and the workings of the man-machine are now perfectly clear.[34] [emphasis added]

Similarly, Huxley's introduction of Descartes begins by describing Harvey's work and its relationship to Descartes's *Treatise*.

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[33] Tesla, "Did the War Cause the Italian Earthquake?"

[34] Ibid.

> In the seventeenth century, the idea that the physical processes of life are capable of being explained in the same way as other physical phenomena, and, therefore, **that the living body is a mechanism** […] **Harvey** solidly **laid the foundations** of all those physical explanations of the functions of sustentation and reproduction which **modern physiologists have achieved**. The attempt to reduce the endless complexities of animal motion and feeling to law and order is, at least, as important a part of the task of the physiologist as the elucidation of what are sometimes called the vegetative processes. Harvey did not make this attempt himself; but the influence of his work upon the man who did make it is patent and unquestionable. This man was **René Descartes.**[35] [emphasis added]

This connection between Harvey and Descartes was particularly notable because Harvey hardly supported a mechanistic theory of life, and incorporated his ideas on the role of spirits in the circulation of blood.[36] Both Huxley's and Tesla's introductions vaguely alluded to new developments in physiology since the seventeenth century that supported Descartes' theories, similarly emphasizing that Descartes' theories were ahead of observable science during that time. Tesla was hardly an expert in the physiological developments in the nineteenth century and none of his other writings indicate any particular physiological theories of which he was aware. There are additional similarities that emerge in the very structure of Tesla's argument: it mirrors the form of Huxley's speech. Both reduced the ideas in Descartes's *Treatise* to five main conceptions. These differ as each writer emphasized the aspects of Cartesian philosophy that were most directly relevant to his work. Huxley highlighted physiological ideas whereas Tesla emphasized those that related to his mechanical research. Despite the difference in emphasis, Tesla's argument never strayed beyond the Cartesian concepts contained in Huxley's speech. Although there are significant discontinuities in the five major conceptions, the core of Tesla's argument can still be found in Huxley's work.

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[35] Huxley, "On the Hypothesis That Animals Are Automata, and Its History," 199.

[36] Robert Gregg Frank, *Harvey and the Oxford Physiologists: A Study of Scientific Ideas* (Berkeley: University of California Press, 1980), 19.

This is not to say that Huxley's only source was Descartes and Tesla's only source was Huxley; both were very well read and highly aware of nineteenth-century theories. The ideas and philosophical approach to science of the group scientists that Frank Turner defined as the scientific naturalists: Huxley, Tyndall, Clifford and Spencer, permeated Tesla's work.[37] As Huxley explained, it was the "principle in which the intellectual movement of the Renascence has culminated, and which was first clearly formulated by Descartes."[38] Scientific naturalism by Huxley's definition stood in opposition to supernaturalism, but as a historiographic category the term is a bit more fluid. Sometimes the term stands as the counterpoint to the Victorian religious arguments and other times, as in Turner, referring to the group of scientists deeply involved in the promotion and theories from Darwin's *On the Origin of Species.*[39] Yet, Tesla held the ideals promoted by these scientists even as the popularity of scientific naturalism waned well into the twentieth century.[40] Perhaps this is because Tesla stood to gain more from the type of public science the Victorian scientists sought to promote and that began to diminish at the turn of the century.

In his 1915 article, Tesla provided an alternative interpretation of the same Cartesian treatise from Huxley's address. Tesla's first "main fact" was that "the human being is a self-propelled automaton entirely under the control of external influences."[41] With this first point Tesla directly contradicted the very core of *Treatise on Man*, because this precluded the existence of the rational soul. Instead, he stated that although human action may appear to be

[37] Turner, *Between Science and Religion*, 12.

[38] Thomas Henry Huxley, *Essays upon Some Controverted Questions* (London: Macmillan and Co., 1892), 35.

[39] Dawson and Lightman, *Victorian Scientific Naturalism: Community, Identity, Continuity*, 1.

[40] Porter, "The Fate of Scientific Naturalism," 282.

[41] Tesla, "Did the War Cause the Italian Earthquake?"

executed by a rational soul or free will, this was impossible: "his actions are governed not from within, but from without."[42] Tesla's insistence that his own actions, even the inspiration for some of his most revolutionary ideas, were governed solely by reactions to external influences underlined his conviction of this concept. In a 1931 interview, Tesla emphasized his belief that "every thought I conceive, every act I perform, is the result of external impressions on my senses."[43] He was far less careful about statements that might imply materialism than Huxley, partly because a materialistic theory was precisely what he sought to promote.

Tesla devoted far more attention to the concept of memory than Huxley did. He devoted his second and third premise to a subject that Huxley mentioned only long enough to praise Descartes's theory. Tesla's second premise was "there is no memory or retentive faculty based on lasting impression." He instead claimed that memory is not the product of impressions on the brain but "increased responsiveness to repeated stimuli." His third argument was "that the brain is not an accumulator" and that there is no stored knowledge.[44] He believed that in order for memory to occur there must be a disturbance that calls forth the knowledge. An echo, for example, requires an initial sound to occur and this was precisely how he suggested memory might work. Fundamentally, this understanding of memory permitted the construction of an analogous structure within an electrical circuit. He only wrote about memory on one other occasion, once again comparing it to a mechanical system that could potentially be replicated in an electrical circuit. Tesla's understanding of memory is understood best in the context of his telautomaton, a topic examined more closely later in this chapter.

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[42] Ibid.

[43] Harry Goldberg, "Great Scientific Discovery Impends," *The Sunday Star, Washington D.C.*, May 17, 1931.

[44] Tesla, "Did the War Cause the Italian Earthquake?"

The other two points of Tesla's theory emphasized the organ of the eye, a topic on which he placed far greater importance than either Huxley or Descartes. Although Descartes and Huxley mentioned the sense, neither gave sight any particular emphasis over any other sense. Nor did Huxley offer any discussion of how new discoveries might change Descartes's original theories. But Descartes reached a very different conclusion on vision than Tesla. Tesla, however, was not at all hesitant to engage in discussions of vision. He explained that all "knowledge or form conception is evoked through the medium of the eye" and that other sense organs only called forth feelings, not true form.[45] In an unpublished and undated excerpt, he reiterated that he discovered that just as "images and thoughts were suggested by impressions received through the eye, so motions also were caused by what I saw."[46] His last point asserted that "contrary to the most important tenet of Cartesian philosophy that the perceptions of the mind are illusionary, the eye transmits to it the true and accurate likeness of external things." This also appears in unpublished writings, where he explained that sight was of the greatest importance in the evolution of any intelligent species. To Tesla, then, sight was **the** only true sense, an issue that will be examined more thoroughly later in this chapter.

Tesla's interpretation of perception differed radically from the Cartesian understanding. Tesla emphasized the eye's role as being able to detect the true form of an object. Conversely, Descartes suggested that perception represents not the object's pictorial representation but our verbal understanding of the object, instead emphasizing the role of human interpretation in perception.[47] Although the optic nerve and its connections to the brain were well understood

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[45] Ibid.

[46] Tesla, Nikola, "The Human Being is An Automaton" Box 4, DOI 333-1, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[47] Descartes, *The World and Other Writings*, xiii.

physiologically in the nineteenth century, the topic of human perception was still the subject of significant research, most notably the research by German physicist and physiologist, Hermann Von Helmholtz. Helmholtz argued for an empiricist interpretation of visual perception, in contrast to the nativist argument.[48] The empiricist argument maintained that visual perception is developed through experience and repetition; in contrast, the nativist argument suggests that the human mind is born with innate knowledge. Although Tesla never explicitly engaged with this debate, his views, which are explored in more detail later, line up best with the nativist theory of perception. His emphasis on the ability of the eye to transmit the true likeness of objects suggests that perception did not depend on the accumulation of knowledge.

Tesla's writings suggest that he deeply considered what his telautomaton might imply about human and animal automatism and what he hoped the construction of the automaton might demonstrate about the human machine. Tesla understood the difficulties that Huxley and other nineteenth-century physiologists faced in reaching a definitive understanding of human consciousness. They were unsure how to determine if there was consciousness in humans. As Huxley explained, "it is wholly impossible absolutely to prove the presence or absence of consciousness in anything but one's own brain."[49] And so, for some, like Huxley, consciousness was not simply a scientific question. Were humans simply automatons governed completely by external actions as Huxley implied and Tesla stated? Certainly, Tesla's approach simplified the requirements for the construction of an automaton. Although the telautomaton was undeniably

[48] Gary C. Hatfield, *The Natural and the Normative: Theories of Spatial Perception from Kant to Helmholtz* (Cambridge, Massachusetts: MIT Press, 1990), 167. and Timothy Lenoir, "Operationalizing Kant: Manifolds, Models, and Mathematics in Helmholtz's Theories of Perception," 3, accessed May 29, 2015, http://web.stanford.edu/dept/HPST/TimLenoir/Publications/Lenoir_HelmholtzKant.pdf.

[49] Huxley, "On the Hypothesis That Animals Are Automata, and Its History," 217.

an oversimplification of the human automaton, he thoroughly considered the capabilities of the human mind and the requirements of constructing a telautomaton to produce a similar effect.

Consciousness, Free Will and the Soul

Tesla, Huxley and other nineteenth-century scientists struggled to understand how free will might act in the human machine. Despite Huxley's praise and deep admiration for Descartes, the rational soul and the pineal gland that Descartes had suggested were the interface with the human soul broke down under scrutiny. Huxley proposed that there was no such division between mind and body and that instead, what we perceived as consciousness was a series of chemical reactions in the brain. This complicated the problem of free will; if consciousness was merely the outcome of chemical reactions in the brain, than volition was also a state in the brain.[50] This raised difficult philosophical and religious questions, many that Huxley sought to avoid. If there were no free will, then how did humans differ from animals? How could actions be judged by God? New theories in the domain of psycho-physiology sought answers to questions on consciousness and free will. William Benjamin Carpenter, Herbert Spencer and others grappled with the best way to incorporate free will into the new understanding of reflex action and the nervous system.[51]

One of the earliest publications that spurred the discussions on free will and consciousness was Charles Darwin's *On the Origin of Species*, published in 1859. Although the mechanism of inheritance was still unclear, Darwin's theory suggested that species evolved through a long process of natural selection. Although most biologists were convinced that a

[50] Daston, "The Theory of Will versus the Science of Mind," 102.

[51] Danziger, "Mid-Ninteenth-Century British Psycho-Physiology: A Neglected Chapter in the History of Psychology," 124.

process of evolution occurred, natural selection, sexual selection and common descent were less popular.[52] In the 1860s Thomas Henry Huxley formed a private dining club of scientists who supported this theory called the "X Club." The X-Club was particularly notable because it brought together many of the scientific naturalist scientists already discussed here. These scientists all supported the view that science, not organized religion, offered explanations for observable phenomena. These ideas were critical to Huxley's and Tyndall's assertions that the study of automatism and free will must depend on observable phenomena and consciousness is unobservable in others. Members included Joseph Tyndall and Herbert Spencer as well as Thomas Hirst, Joseph Hooker, George Busk, John Lubbock, William Spottiswoode and Edward Frankland; all were members of the Royal Society except Spencer.[53] The X-Club is the subject of significant historical study, but in this dissertation, the group is primarily of interest in demonstrating the connection between a group of scientists whose writings appear throughout Tesla's work.[54] The ideas promoted by Huxley, Spencer and to a lesser degree, Tyndall all appear in Tesla's writings. Spencer's work, although it promoted a different theory of evolution than Darwin, is particularly relevant because Tesla cited it directly on several occasions.[55]

In *Principles of Psychology*, published in 1855, Spencer emphatically expressed his determination that there was no such thing as "free-will." He explained that should "psychical changes […] not conform to law" then "no science of Psychology is possible" but if they did

[52] I. Bernard Cohen, *Revolution in Science* (Cambridge, Massachusetts: The Belknap Press of Harvard University, 1985), 297.

[53] Barton, "'An Influential Set of Chaps': The X-Club and Royal Society Politics 1864–85," 53.

[54] In addition to several articles by Barton, see also Roy M. MacLeod, "The X-Club a Social Network of Science in Late-Victorian England," *Notes And Records Of The Royal Society* 24, no. 2 (1970): 305 –322. John Holmes, "The X Club: Romanticism and Victorian Science," in *(Re)Creating Science in Nineteenth-Century Britain* (Newcastle: Cambridge Scholars, 2007).

[55] Tesla, "The Problem of Increasing Human Energy."

conform to law then "there cannot be such thing as free-will."[56] Spencer's views on evolution differed significantly from Darwin's because he depended heavily on the inheritance of acquired characteristics or Lamarckian inheritance. He argued that free will offered no evolutionary advantage to an organism in the interactions with its environment. If it offered no advantage to an organism then, there could be no possible evolutionary explanation for it. He suggested instead that free will would potentially complicate the process of evolution. It would cause an organism to interact with its environment unpredictably and would therefore interrupt the "grand progression which is now bearing Humanity onwards to perfection."[57] Again, the difference in evolutionary theories of Spencer and Darwin are clear as perfection played no part in Darwin's theory. But the progression of life from a state of chaos to a organized perfection was central to Spencer's theories.[58] Spencer also articulated a position similar to Tyndall because both believed that the question of free will could not be definitively determined because locating the seat of human consciousness was impossible with the scientific tools available. Yet he believed that scientists, philosophers and theologians would continue to pursue these questions because "continually seeking to know and being continually thrown back" was part of mankind's greatness.[59]

Tesla referenced Spencer's "rhythm of motion" theory from *Principles of Psychology* directly on one occasion, yet like Huxley's speech, aspects of Spencer's theories appear in his

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[56] Herbert Spencer, *The Principles of Psychology* (London: Longman, Brown, Green, and Longmans, 1855), 620.

[57] Ibid.

[58] C.U.M. Smith, "'Herbert Spencer: Brain, Mind and the Hard Problem,'" in *Brain, Mind, and Consciousness in the History of Neuroscience*, ed. C. U. M. Smith and Harry Whitaker (Dordrecht: Springer, 2014), 138.

[59] Herbert Spencer, *First Principles*, 4th ed. (London: Williams and Northgate, 1880), 113.

work.[60] In an unpublished and undated article, Tesla suggests that no answer will ever be found to what he calls "Spencer's Famous Question." The question asked "what is it that makes inorganic matter run into organic forms?"[61] In an article published in 1900, Tesla explained that Spencer's description of the human nervous system had a very useful application particularly in the transmission of wired and wireless signals.[62] He in fact credited Spencer's work as inspiring his research on what he called "individualization."[63] Engineers faced difficulties in designing a system that would allow the simultaneous transmission of multiple signals through the same wire. As part of his work on the telautomaton, Tesla patented a system for a transmitter and a receiver that eliminated the possibility of interference of signals. The transmitter would signal the receiver on two frequencies and the receiver would only respond to that combination of signals.[64] This is now recognized as the modern "AND" circuit. Tesla specifically suggested that Spencer's description of the human nervous system offered a new approach to the transmission of multiple telegraphic and electrical signals through the same channel.

The global telegraphic system and the human nervous system were frequently compared with one another, so Tesla's comparison was not new. In *First Principles* published in 1862, Spencer explored the possibility of understanding vital, mental and social phenomena using the same framework. To this end he described the telegraph network and how it served to organize society. Interestingly, he also explained that the sun's rays were responsible for all of the

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[60] Tesla, "The Problem of Increasing Human Energy," 175; Tesla, Nikola, "Partial Interview on World War" Box 133, DOI 252-1, Activity - High-Frequency Engineering- Miscellaneous, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia..

[61] Tesla, Nikola, "Spencer's Famous Question," Nikola Tesla Museum, Belgrade, Serbia..

[62] Tesla, "The Transmission of Electric Energy Without Wires."

[63] Ibid.

[64] Tesla, Nikola, 1903, Method of signaling, U.S. Patent 723188. Filed on June 14, 1901 Issued on March 17, 1903.

physical forces acting in society. This same problem appears centrally in an article published by Tesla in 1900, "On the Problem of Increasing Human Energy with special reference to the harnessing of the sun's energy." He was particularly concerned with the problem of human energy and with discovering new ways to utilize the total energy available in the most efficient manner.

In the same article, Tesla also referenced Spencer's "rhythm of motion," a theory proposed in *First Principles.* *First Principles* was Spencer's attempt to clearly articulate the principles that he considered to be the "Laws of the Knowable." This included a detailed discussion of the "Law of Evolution" as well as others like "The Indestructibility of Matter" and "The Continuity of Motion." For each principle, Spencer laid out an argument supporting the principle, often derived from some of the other principles. Spencer proposed the "Rhythm of Motion" as a separate concept from the other theories laid out in *First Principles*. Although treated as a separate principle, it was nothing more than a reconceptualization of an earlier principle in the book, "The Persistence of Force." Spencer's principle here was nothing more than a periodic alternation of action and reaction, of social, vital and mental phenomena, that repeated over time. According to Tesla, Spencer indicated that "every movement in nature must be rhythmical."[65] He in turn used this argument to support his conclusion that all humanity can be explained and modeled using equations of movement, something with which Spencer would have heartily agreed. He used these equations to reach an understanding of the social body, which is explored in greater detail in Chapter 5. Tesla embraced the portions of Spencer's work that suited his purpose. Unlike his detailed explanation of Descartes's philosophy, he did not significantly misunderstand any of the concepts in Spencer's writings.

[65] Tesla, "The Problem of Increasing Human Energy," 175.

The physiologist William Carpenter, like Tesla, credited Spencer's work in some of his early theories. Carpenter, author of one of the definitive texts in nineteenth-century physiology, gave one of his first accounts of human automatism in 1852 in a lecture at the Royal Institution. These theories were the basis of the debate that Tesla's inventions aimed to understand, and relied heavily on many of the concepts that Carpenter proposed. Carpenter's theories on the human mind explored the possibilities of reflex action in the brain.[66] They offered an exciting new understanding of the human nervous system, and Carpenter explored the possibilities of automatic responses in the human body.[67] In particular, he believed that the human reflex response could be triggered not only as a result of a physical stimulus but also due to ideas or emotions.[68] Similarly, Tesla suggested that his visions discussed in Chapter 1, which he theorized were the result of a reflex action from the retina and acting on the brain, were sometimes triggered by an emotional response. The vision he experienced following his mother's death ultimately served as one of his clearest examples showing that he was able to trace all of his visions to purely external causes. As early as 1846, Carpenter theorized that ideas and emotions could produce an automatic and involuntary response. He also argued that the same sensations that could excite pleasure and pain also could trigger "simple feelings" that were "instinctive" reactions to sensations.[69] This distinction between the functions dictated by automatic and voluntary actions were at the core of Tesla's, Huxley's and Spencer's attempts to

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[66] Adam Crabtree, "'Automatism' and the Emergence of Dynamic Psychiatry.," *Journal of the History of the Behavioral Sciences* 39, no. 1 (January 2003): 51.

[67] William Benjamin Carpenter, "On the Influence of Suggestion in Modifying and Directing Muscular Movement Independently of Volition.," *Notices of the Proceedings at the Meetings of the Members of the Royal Institution* 1, no. 10 (1852).

[68] Roger Smith, *Free Will and the Human Sciences in Britain, 1870-1910* (London: Pickering and Chatto, 2013), 21.

[69] Carpenter, "On the Influence of Suggestion in Modifying and Directing Muscular Movement Independently of Volition."

understand human automatism. Despite his promotion of the ideo-motor reflex and that many of his theories and discoveries formed the basis of arguments against free will made by the scientific naturalists, Carpenter continued to support the concept of human "will." Carpenter's writings continued to support these claims as late as his 1887 book *Principles of Mental Physiology*.[70] Carpenter was deeply religious and did not wish his theories on physiological psychology to be caught up with the determinism of Huxley.[71]

Carpenter also suggested that some of these habits or ideas could be inherited over the course of multiple generations. In his 1872 presidential address before the British Association, Carpenter promoted a theory on that the "intellectual intuitions of any one Generation are the embodied experiences of the previous."[72] In a series of cordial letters exchanged between Spencer and Carpenter in *The Popular Science Monthly,* Carpenter credited Spencer with being the first to "explicitly put forth" the doctrine of this type of inherited mental faculties. Carpenter Spencer replied and outlined his own perspective:

> Mind is dealt with as a product of evolution, and in which the inheritance of accumulated effects of experience is recognized, not simply as producing 'acquired peculiarities,' but as originating the mental faculties themselves, emotional and intellectual, including the 'forms of thought.'[73]

Spencer explained to Carpenter in the letter that he did not publish this doctrine until 1855 in *Principles of Psychology*. He did claim that he wrote about his ideas in articles as early as 1842. In *First Principles,* he outlined the core of his theory of evolution. He contended: "alike during the evolution of the Solar System, of a planet, of an organism, of a nation, there is progressive

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[70] Anne Stiles, "Cerebral Automatism, the Brain, and the Soul in Bram Stoker's Dracula.," *Journal of the History of the Neurosciences* 15, no. 2 (2006): 144.

[71] Stanley, *Huxley's Church and Maxwell's Demon: From Theistic Science to Naturalistic Science*, 218.

[72] William Benjamin Carpenter, "Inaugural Address of Dr. William Carpenter, F.R.S., President," *Nature* 6, no. 146 (1872): 309.

[73] *The Popular Science Monthly, Volume 1* (New York: D. Appleton and Company, 1872), 755.

aggregation." Spencer posited that evolution did not just occur on the scale of organisms, but also on the scale of galaxies and stars. Evolution, then, was the constant progress toward some ultimate equilibrium.[74] This perspective that "the degree of development is marked by the degree in which the several parts constitute a co-operative assemblage" shaped his understanding of evolution.[75] The inheritance of acquired characteristics and Lamarckism offered an explanation to later stages of evolution while he incorporated Darwinian theory in his later work as providing explanation for early development.[76] Spencer believed this treatment was essential to understanding evolution as continuous development.[77] A similar doctrine appears in some of Tesla's later writings: Tesla suggested that intelligent thought was inherited as a part of the organ of sight (discussed later in this chapter) and without the organ for sight no intelligent thought could exist.

Carpenter's theories offered a wider interpretation of reflex action. Yet, with the suggestion of the relationship between ideas, emotion and reflex actions, he still believed that there existed some voluntary actions and he divided human actions into three categories: reflex, secondarily automatic and voluntary. Secondarily automatic actions were those that at one point had been voluntary but over time became automatic. Carpenter used the particular example of a child learning to walk:

> When a child is learning to walk, every single effort has a voluntary source; but still its immediate dependence on the automatic mechanism is evident in the necessity for attention to the guiding sensations as the regulators of the voluntary effort. As the habit of movement becomes more and more established, however,

[74] J. Offer, "From 'Natural Selection' to 'Survival of the Fittest': On the Significance of Spencer's Refashioning of Darwin in the 1860s," *Journal of Classical Sociology* 14, no. 2 (2013): 160.

[75]Spencer, *First Principles*, 276.

[76] Valerie A. Haines, "Spencer, Darwin, and the Question of Reciprocal Influence," *Journal of the History of Biology* 24, no. 3 (1991): 415.

[77] John Benjamin Nichols, "Spencer's Definition of Evolution," *The Monist* 13, no. 1 (1902): 137.

> we are able to withdraw both the attention and the voluntary effort, to such a degree that at last it is only necessary for the will to start or commence the actions, and to *permit* their continuance.[78]

Tesla described a similar process in his description of his discovery of his own automatism. Through repeated practice of the same mental exercises, he reported that his mind "became automatic."[79] Not only does his explanation here bear some resemblance to secondarily automatic actions, but because these processes are occurring within his mind they are reminiscent of Carpenter's ideo-motor theory, that ideas and feelings could cause a reflex response. Nevertheless, according to Carpenter, human will was responsible for a limited number of voluntary actions. He suggested that the clearest evidence of voluntary action was that humans could perform otherwise automatic actions, like coughing, even in the absence of irritation.

In 1875, Carpenter responded to Huxley's speech, arguing that he had drawn more conclusions from animal automatism than he should. He rejected Huxley's argument and emphasized that what Huxley viewed as reflex action was secondary automatism and had therefore been put into action by conscious intention. He explained that all that could be inferred from Huxley's frog was that "the automatic apparatus is competent to perform this feat, and that when the conscious Ego executes it by what we call the mandate of his will, he uses the automatic apparatus as its instrument."[80] Instead of taking the presence of the automatic reaction as evidence that the will was not acting, he suggested that it merely meant that the will might initiate the automatic movement. Huxley and Carpenter were fundamentally at odds; one

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[78] Carpenter, "On the Influence of Suggestion in Modifying and Directing Muscular Movement Independently of Volition."

[79] Tesla, "The Problem of Increasing Human Energy," 184.

[80] William Benjamin Carpenter, "Doctrine of Human Automatism," in *Nature and Man* (London: Kegan Paul, Trench and Co., 1875), 279.

believed in the existence of voluntary action and the other did not but more importantly they were at odds over what scientists should be studying. This conflict demonstrates how scientists, sometimes examining the exact same demonstration, the frog, came to vastly different conclusions. Huxley wanted to promote scientific naturalism and his explanation of human automatism, based completely on direct evidence, did just that. Meanwhile, Carpenter sought to uphold Christian philosophy, necessitating the incorporation of "a will which, alike in the Mind and in the Body, can utilize the Automatic agencies to work out its own purposes."[81]

Tesla's understanding of free will reflected the diverse and contested range of theories on human automatism suggested in the nineteenth century. Frequently he mentioned his own "free will" in his writings. It is clear, however, that he was conflicted about the role of free will and his ambivalence on this topic was apparent through his writings throughout his life. In one instance, in his autobiography, he explained that he was an "automaton, devoid of free will." Yet, in the same text he also claimed to be able to exert his will when faced with an addiction to smoking and gambling.[82] In an interview in 1931, Tesla explained that "the vast majority of human beings are not observant sufficiently and that they live in the illusion of perfect choice and freedom in their thoughts and actions." Tesla, who saw himself as gifted with superior observational capabilities, was able to realize that his actions were not the result of volition, but instead responses to his environment. However, these sentiments on human will all appear to be at odds with one another. Although Tesla seems to embrace the concept of ideo-motor actions and secondary automatism put forth by Carpenter, his understanding of volition does not align with Carpenter's theories at all. His explanations of human will indicate that despite his vacillations on the subject, his views line up best with Huxley. Like Huxley, he believed that

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[81] William Benjamin Carpenter, "The Physiology of the Will," *Contemporary Review* 17 (1871).

[82] Tesla, "My Inventions," 626.

humans were nothing more than conscious automata and that consciousness was a series of chemical or electrical reactions to external causes. Although Tesla's views on human will seem to change frequently as outlined below, this theory seems to emerge most prominently from Tesla's writings.

In another example of Tesla's indecision, when asked directly in a 1931 interview with *The New York Times* if there was a soul or spirit, he responded that "there is no soul or spirit. These are merely expressions of the functions of the body. These life functions cease with death and so do soul and spirit."[83] But later when Tesla was interviewed about an attempt by scientists to "weigh the soul" in 1907 his conviction that there was no soul seemed hazy. First, he ridiculed that attempt, saying it was "altogether too absurd for discussion" and that "an aggregation of impressions, thoughts and feelings have no materiality." But then, as with much of his interest in psychical research, he evaluated the practicality of their experiment and explained that the researchers did not utilize a "fit instrument" for weighing the human soul.[84] If the human soul could not be weighed what difference would the apparatus have made? Several of his other writings suggest the existence of the soul. When discussing the growth of a human child, he argued that "the artist, the inventor and the man of science give expression to the longing of the soul."[85] Tesla wavered between a strong conviction that there was no soul and the belief that the soul presently stood outside the realm of scientific measurement.

What does become apparent from Tesla's writings is that he did not believe in the Christian idea of an eternal soul. Even his most speculative writing, which suggested that the

[83] "Tesla Seeks to Send Power to Planets," *The New York Times*, July 11, 1931.

[84] "Scientists Doubt the Human Soul Was Weighed," *New York World*, March 17, 1907.

[85] Nikola Tesla, "Nikola Tesla Shows How Men of the Future May Become as Gods," *The New York Herald*, December 30, 1900.

soul might be weighed, proposed that, at its core, the soul was a concrete physical phenomenon. It appears that he, like Huxley, believed that whatever appeared to act as the soul and spirit ceased with the death of the human body and could be explained by chemical reactions and physiological phenomena alone. These chemical and physiological reactions formed an "aggregation of impressions, thoughts and feelings" and this was the soul, or consciousness, or free will. Based on the writings examined in this section it also seems reasonable to conclude that if the human soul existed, Tesla believed it was nothing more than a passive observer that was only able to exert its will with great effort. Most of the time humans would act automatically and respond only to external causes. Moreover, the soul, or what an individual believed was his soul, was the result of chemical and physiological processes. This nuanced and apparently contradictory understanding of human automatism directly reflected the British scientific discussion on human automatism. Scientists hesitated to state publicly and definitively that there was no soul and that humans were nothing more than automata. Tesla, however, did not share the same concerns about being called "materialist" or "atheist" as many of his British contemporaries. He was profoundly convinced of his own automatism, but still struggled to consistently state that there was no free will. The language and indecision of the British scientists he so greatly admired permeated much of his writing.

The Telautomaton

Tesla lacked the education and rhetorical skill to engage with these scientists on a theoretical level, but as an engineer he possessed a skill and perspective that was otherwise often overlooked. He grappled with these same ideas of automatism and free will throughout his life. He therefore engaged in the debate in the best way that he knew, by constructing a device to understand automatism. The telautomaton was a way to understand his own automatism and produce a machine

> capable of acting as though it were part of a human being—no mere contrivance, comprising levers, screws, wheels, clutches, and nothing more, but a machine embodying a higher principle, which will enable it to perform its duties as though it had intelligence, experience, judgment, a mind![86]

The telautomaton then was never planned to be a finished product, but the first invention as part of Tesla's new "art of telautomatics." The telautomaton was the first invention in this new field, a way for Tesla to demonstrate the theories in human automatism, to test the limits of what could be understood and constructed. He envisioned that one day, it might act as an independent being. Although the first model, the telautomaton, merely acted as an extension of its human controller, later versions would not be so limited.

Fundamentally, Tesla's telautomaton suggested an alternative approach to understanding automatism. Instead of examining the physiological structures and studying those that were automatic as Huxley, Carpenter and Spencer sought to do, Tesla dreamed of one day being able to construct an automaton that would be able to act independently. He admitted in an 1907 article, that

> a machine of such inconceivable complexity as the body of an organized being, capable of an infinite variety of actions, with controlling organs super-sensitive, responsive to influence almost immaterial, cannot be manufactured by man.[87]

Yet Tesla attempted to construct a device that would "mechanically represent me" and one that would respond "to external influences."[88] To him, once again this was simply a limitation of the tools available to him. He explained, in an unpublished article likely from 1899, that much of

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[86] Tesla, "The Problem of Increasing Human Energy," 184.

[87] Tesla, "Tesla Tidal Wave to Make War Impossible."

[88] Tesla, "The Problem of Increasing Human Energy," 185..

technology was merely a matter of perspective and that "a savage, seeing [an automobile] for the first time, would be astonished and might possibly think that the engine is alive."[89] To him, the human automaton could be explained using precisely these principles. Tesla hoped to create a device that might one day be able to act independently. This device would respond to external influences in much the same way that Tesla believed humans responded to external influences. Extending the same description of an automobile, he continued:

> But suppose that on the ground where this machine is darting about there would be obstacles, as stumps of trees or rocks, and you would observe that the machine, running straight towards an obstacle, upon getting near it would go out of the way instead of running against it and destroying itself, and suppose that it would do this time and time again, then, the instant you would perceive this clearly, the thought would flash through your mind: this thing is alive! But why would you then consider it alive. Not because of its movements, however puzzling, but, evidently, because it had exhibited intelligence.

For Tesla, then, the limits in constructing an independent automaton would ultimately be overcome with new discoveries in technology. To Tesla, this gap in technology might potentially be overcome within his own lifetime through his own industrious study.

In each description of his telautomaton, Tesla mentioned the childhood visions that inspired his early conviction of his own automatism. These visions frequently appeared in his line of sight, obstructing his view of real objects. In his autobiography, published as a series of articles in 1919, he described his careful observation of the visions; he believed them to be the result of a reflex action from the brain that acted on the retina. Through coping with these visions he claimed that he was able to improve his observational abilities. Using these improved abilities and careful practice he was ultimately able to trace each of his visions to a particular external cause and this led to his conviction that not only his visions, but each of his actions

[89] Tesla, Nikola, " Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia. Although this is not labeled as the speech Tesla gave before the Commercial Club in Chicago in 1899, the details of the speech line up with a newspaper article outlining the major themes Tesla discussed.

could be explained by an external cause. This conviction is what he cited as inspiring his early idea of "planning a self-controlled automaton," in which self-controlled implied a lack of remote control, and he "believed that mechanisms can be produced which will act as if possessed of reason, to a limited degree."[90]

Tesla's description of the telautomaton emphasized organic language. He particularly offered explanations by using metaphors of various biological functions. In a 1900 article, promoting his telautomaton he explained that the internal circuitry of the telautomaton mimicked the "animated automaton, with its nerve-signal system."[91] He argued that "whether the automaton be of flesh and bone, or of wood and steel, it mattered little, provided it could perform all the duties required of it like an intelligent being." The device that he conceived would require "organs for locomotion, directive organs and one or more sensitive organs so adapted as to be excited by external stimuli."[92] The "organs for locomotion" were the propellers and motors and the "sensitive organs" used for the detection of external stimuli were carefully drawn and described as sensitive circuits for the detection of radio signals. The "propeller, driven by a motor, represented the locomotive organs" and the rudder "took the place of the directive organs."

The directive organs, or sense organs, should have replicated those in the human automaton, most importantly the eye. Surprisingly, given how crucial Tesla considered the eye, he explained that the sense organs designed in his telautomaton were engineered to mimic the ear. Although Tesla's understanding of electromagnetic theory was complicated as outlined in Chapter 3, he did understand that radio transmissions were electromagnetic waves, like light.

[90] Tesla, "My Inventions," 623.

[91] Tesla, "Tesla Tidal Wave to Make War Impossible."

[92] Tesla, "The Problem of Increasing Human Energy," 184.

This might have suggested that the sense device should correspond more closely to the eye, because of what it detected, electromagnetic waves like light. Why then did Tesla refer to the devices as an ear? It is more likely that the mechanical components used to construct the sensitive circuit were more reminiscent of an ear than an eye, as the circuit depended on detection and resonance. He described the telautomaton as dependent on "a number of sensitized receiving circuits each recognizable by its own free vibrations and all together by the character of their operative combination."[93] This device was able to "hear" transmissions that directed its movement. This description is far more reminiscent of a device attempting to mimic an ear than an eye. The transmitter emitted a wave of a composition exactly matching the "number and pitch of individual vibrations" which was detected by the telautomaton. Tesla's conceptualization of these vibrations and transmission mimicked sound waves more than light waves. Tesla, however, explained his decision not to include a device that would be "responsive to rays of light" like the human eye because the human eye posed too many difficulties to replicate with mechanical components. [94] The most promising mechanical equivalent he considered was a selenium cell, yet he dismissed the idea because "no thoroughly satisfactory control of the automaton could be effected by light, radiant heat, Hertzian radiations, or by rays in general, that is disturbances which pass thin straight lines through space."[95] Perhaps Tesla doubted his own ability to construct a device that complex and powerful. It is clear that his conceptual misunderstanding of Hertzian and light waves, discussed in greater detail in Chapter 3, contributed significantly to how he understood the detection circuits in the Telautomaton.

[93] Tesla, "Tesla Tidal Wave to Make War Impossible."

[94] Tesla, "The Problem of Increasing Human Energy," 186.

[95] The term "Hertzian radiations" was used to describe electromagnetic waves when electromagnetic theory was still gaining momentum.

Although Tesla had a strong practical understanding of how his devices functioned, he held onto a variety of theoretical misconceptions.

Although Tesla imbued the device with mechanical equivalents for locomotion and sensory information, he suggested that was not all that was required for life. The automaton still required "the capacity for growth, propagation, and, above all, the mind" and without these he noted the telautomaton would still not be complete. He listed these three attributes as the minimum required for life. Instead of attempting to construct mechanical equivalents for these properties, he explained that there was no need for growth as the machine was "manufactured full grown." His discussion of "propagation" concluded with his determination that ultimately it could be "left out of consideration for in the mechanical model it merely signified a process of manufacture." That Tesla considered reproduction and growth as capabilities that he might be able to construct in his automaton, even only long enough to dismiss them as unnecessary, indicated that he believed that what he had constructed would be a new form of life. With the uncertainty over the soul, and the Cartesian contention that animals were automata, it was a simple matter for Tesla to reach this conclusion. Combined with his usage of language that implied he was able to construct the mechanical equivalents of biological organs, the telautomaton, in Tesla's mind, had addressed all of the necessary requirements of an animal automaton.

Most notable in Tesla's 1900 article was his description of the mind of his telautomaton. He planned that the telautomaton might have "an element corresponding to the mind" that would control movements and operations as well as "cause it to act, in any unforeseen case that might present itself, with knowledge, reason, judgment, and experience."[96] He planned that future versions of the telautomaton might be perfected so that when "left to itself, [it] will behave as if

[96] Ibid., 185.

endowed with intelligence of its own;" it would truly be an independent being. Until the art of telautomatics was perfected, however, this type of a device would not be possible. Tesla did not predict when the perfection of telautomatics might be achieved, but he did fundamentally consider it to be a problem of technology. The mechanical construction of something that might act as a mind was beyond Tesla's abilities as an inventor, but he chose to use his own mind and have the machine embody the mind of a "distant operator." The telautomaton as constructed would behave as a "blindfolded person obeying directions received through the ear."[97]

Tesla pronounced that with the construction of the telautomaton he had founded the "telautomatic art." Although his critics considered that the construction of the telautomaton was no more than "merely an automobile torpedo," he believed that it represented a more impressive accomplishment.[98] Tesla's conviction that the telautomaton's construction was an art might explain his initial reluctance to develop the device with military funding. Perhaps he believed that potential investors failed to note the true potential of the device. But outside Tesla's organic metaphors to describe the internal functions of the device, why did he believe that he had invented something so wholly different from a mere automobile torpedo? He explained that

> The art that I have evolved does not contemplate merely the change of direction of a moving vessel; it affords a means of absolutely controlling, in every respect, all the innumerable translatory movements, as well as the operations of all the internal organs, no matter how many, of an individualized automaton.[99]

He believed that an autonomous torpedo was the least impressive application to warfare. The telautomaton might act as "an arm for attack as well as defense" and there was "virtually no restriction as to the amount of explosive it can carry." He also considered the potential

[97] Ibid., 187.

[98] Ibid., 188.

[99] Ibid.

application of his method to aerial as well as marine devices. Tesla believed that his telautomaton would revolutionize warfare and an investor who considered the device as anything less would have insulted his conviction.

The scientific dialogue on human automatism in the nineteenth century shaped Tesla's understanding of the telautomaton. His complicated understanding of consciousness and the soul framed his attempt to construct a device that might be developed to embody these same traits. In order to reach the pinnacle of the telautomatic art, it was essential to construct a device with the same qualities as were essential to the functioning of the human automaton, but it was unclear what traits were required. Tesla provided several accounts outlining the minimum of required traits that made the human automaton unique. His use of biological analogies to describe the mechanical parts in his inventions strengthens the connection between the telautomaton and the human machine. His descriptions of the human automaton were practically an inverse of his description of the telautomaton: in one case he used biological language to describe a mechanical device and in the other he used mechanical language to describe a biological device. Although these types of analogies were not uncommon, Tesla's reliance on mechanical language to understand the human automaton, helped develop what he considered distinctly human properties. Tesla was careful to consider precisely what functions were required so that the telautomaton would best mirror the traits of the human automaton. His understanding of these traits is often best understood through his attempts to embody them in his inventions.

Telautomaton meets Human Automaton

Many of Tesla's theories on human automatism filter into his descriptions of the telautomaton. Occasionally he outlined his theories of human automatism; in these writings he only used the telautomaton as a supplement to his description. As an inventor, Tesla reduced organic systems to their base mechanical equivalents, which helped him conceptualize the telautomaton. Although considering mechanical equivalents of human organs was not new, his emphasis on the consideration of mechanical analogues for biological systems was for the purpose of construction. These writings gain additional depth when examined alongside the systems of the telautomaton.

Tesla considered the problems he faced in constructing a device that would demonstrate the automatism of the man-machine. Most notably, in an article from 1907, he reduced the human machine to its most essential components:

> Disconnected from its higher embodiment, an organism, such as a human being, is a heat — or thermodynamic engine — comprising: — (1) a complete plant for receiving, transforming, and supplying energy; (2) apparatus for locomotion and other mechanical performance; (3) directive organs; and (4) sensitive instruments responsive to external influences, all these parts constituting a whole of marvelous perfection.[100]

These attributes were fundamental to animal life, and Tesla realized that these were the fundamental attributes required in the telautomaton. He explained, in an 1899 speech in Chicago, that in demonstrating the human automaton it was unnecessary to construct something that had "arms and legs and [would] walk about in an erect position" because these tasks had been accomplished and would "unnecessarily complicate and render difficult the task."[101] Instead he suggested that it would be more constructive to use a known mechanism for

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[100] Tesla, "Tesla Tidal Wave to Make War Impossible."

[101] Tesla, Nikola, "Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

locomotion, like a boat, balloon or carriage to accomplish the locomotion component of the telautomaton.

Tesla also considered human memory as a crucial component of the human automaton, and indeed this was a major component of the nineteenth-century discussions on automatism. On several occasions Tesla wrote about human memory, but the explanations were hazy until the reader considers the telautomaton. His telautomaton was not imbued with any memory in the conventional sense. Within the telautomaton there were constructed circuits that ideally behaved in a precise and predictable manner in response to external stimuli. The reaction of the telautomaton to the signals from the remote control performed a similar function to Tesla's earlier description of memory. In "How Cosmic Forces Shape Our Destinies," an article from 1915, he speculated that "there is no memory or retentive faculty based on lasting impression. What we designate as memory is but increased responsiveness to repeated stimuli." This description almost mirrors Carpenter's theory of the development of secondary automatism; that through repeated action, something could become automatic. He also emphasized that the "brain is not an accumulator. There is no permanent record in the brain, there is no stored knowledge."[102] In the telautomaton a signal would trigger a response in a circuit resulting in a predictable output, precisely as Tesla believed the human automaton reacted. In an unpublished draft of his autobiography, which was published in 1919, he gave another detailed example of memory using a tuning fork and a siren.

> Memory would then be nothing else but the facility of certain nerves to respond to impressions already received, easier than novel impressions. To be more explicit, suppose you take a dozen tuning forks, exactly alike in every particular. These tuning forks you place in a circle at the same distance from a siren, emitting a note of the same pitch as that of the forks. If you keep the forks gently vibrating, and all in the same manner, by some contrivance, you can then, by exciting the siren, excite them and make them vibrate energetically. Reduce now the intensity

[102] Tesla, "How Cosmic Forces Shape Our Destinies ('Did the War Cause the Italian Earthquake?')."

> of the sound emitted by the siren, until a point is reacted, at which none of the forks responds perceptibly. Now, pick out one of these forks and take all the others away to a distance, where the sound of the siren will not affect them, and then practice with the remaining fork for a long time, exciting it by the sound of the siren. […] Presently, take back the other eleven forks and put all the twelve again in their former places. You will now find that you have among these twelve forks one which exhibits memory. It is the fork that you have been experimenting with.[103]

The memory that Tesla suggests the tuning fork displays is a more vigorous response to the same stimulus than its fellow forks. The experiment described is flawed. The only way that a tuning fork would react in this way would be as a result of metal fatigue brought on by overuse. Understanding the brain and memory as a mechanical system or an electric circuit eliminated the need for a type of memory based on storage: idealized electric circuits follow a pattern and "memory" is the output of a circuit designed for a specific input. In many ways, Tesla's theories served to support the claims of his inventions. If memory could be understood in this way, then the difficulties that he faced in constructing such a device were not insurmountable.

Later Tesla accounted for differences in human reactions to the same stimulus, which gave the automaton the appearance of free will, by comparing the human automaton to an electrical circuit. He argued that what appeared to be free will or independent action was in fact no more than what you saw in two electrical systems which could react differently to the same input.[104] Tesla sought to reduce all of human functions to mechanical analogs that could be reproduced in the telautomaton, or in the case of human consciousness could not yet be replicated technologically. This simplified his goal of demonstrating that the human was an automaton. Fundamentally, this is what Tesla aimed to do: to construct and demonstrate an automaton that would act as though it were human. But he also considered what a deep

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[103] Tesla, Nikola, "Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia..

[104] Tesla, "How Cosmic Forces Shape Our Destinies ('Did the War Cause the Italian Earthquake?')," 507.

mechanical understanding could contribute to scientific understanding of the human automaton. Mechanical circuits did not just offer value in demonstration, but also provided potential explanation.

William Clifford and The Eye

Unfortunately, the telautomaton would never possess sense organs as powerful as the human automaton's. Tesla recognized that the eye presented far too many complications to replicate in his telautomaton. His descriptions of the telautomaton reflected this deficiency: it would behave as a "blindfolded person" and that the model would only be capable of embodying the "mind of a distant operator." But the eye was of tremendous importance to Tesla's understanding of human will and intelligent life. He believed that sight was a requirement for intelligent life and that vision was an evolutionary prerequisite for intelligent thought. It is unclear when Tesla developed this conviction, but the writings of William Clifford, a British physicist, mathematician and popular writer, on the eye provide some basis for comparison.

Tesla's conviction of the eye's supreme importance drew on physical theories, not theories from physiology. Tesla explained in an 1893 lecture that what made the eye a superior sense organ was what it sensed: light, electromagnetic waves vibrating in the ether. He suggested that "compared with it, all other organs are monstrously crude" as they were unable to detect oscillations in the ether, which "transmits all energy and sustains all motion." He argued that light, a manifestation of electric and electromagnetic energy, was a phenomenon of electrical science, and "electrical science has become the mother science of all and its study has become all important."[105] Tesla believed that information was transmitted to the eye directly by the ether,

[105] Nikola Tesla, "On Light and Other High Frequency Phenomena," in *The Nikola Tesla Treasury* (Radford, VA: Wilder Publications, 2007), 209.

that the eye was the "only sensory organ directly affected by the subtle medium."[106] As explored in Chapter, 3 the ether was a defining problem in physics in the nineteenth century. To Tesla the ether was the substance that all life was built upon and any organ that could detect waves in the ether was able to see the true likeness of things. He brought his argument concerning the superiority of the eye back to Descartes:

> What is the foundation of all philosophical systems of ancient and modern times, in *fact*, of all the philosophy of man? I *am I think; I think, therefore I am.* But how could I think and how would I know that I exist if I had not the eye? For knowledge involves consciousness; consciousness involves ideas, conceptions; conceptions involve pictures or images, and images the sense of vision, and therefore the organ of sight.[107]

This was a challenge to Descartes' "I think, therefore I am." Again, Tesla emphasizes that sight and intelligent thought, or consciousness, are inextricably linked to one another. Tesla considered himself qualified to revisit the original claims of Descartes, despite a fundamental misunderstanding of these claims, because of the developments in electromagnetism and his greater understanding of the ether. The advantage that the eye offered over other sense organs was apparent. The eye to Tesla was the organ through which all human knowledge was acquired, and without it the human automaton would not exist.

For Tesla the eye was the only reliable sense organ; other sense organs provide the brain with an inaccurate description. In his 1915 article "How Cosmic Forces Shape Our Destinies" he explained that:

> All knowledge or form conception is evoked through the medium of the eye, either in response to disturbances directly received on the retina or to their fainter secondary effects and reverberations. Other sense organs can only call forth feelings which have no reality of existence and of which no conception can be formed.[108]

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[106] Ibid., 206.

[107] Ibid.

[108] Tesla, "How Cosmic Forces Shape Our Destinies ('Did the War Cause the Italian Earthquake?')," 505.

Tesla implied with this statement that the eye was the sensory organ that was best able to transmit information as well as "form conception." What Tesla labeled as "form conception" was the true knowledge of an object that was transmitted to the human mind by vision particularly, but not by any of the other senses. This idea of the true knowledge of an object existed in Descartes's writings on the senses as well. To Tesla this knowledge was essential for thought: without true knowledge there could be no thought. He concluded that vision provided true knowledge because "knowledge of form [...] is dependent upon the positive fact that light propagates in straight lines, and, owing to this, the image formed by a lens is exactly similar to the object seen."[109] This indicated that the human automaton was governed by sight and the other sensory organs were not as powerful This was in direct contradiction to the Cartesian philosophy that all sense organs only provide the mind with impressions of objects and in direct contrast to visual theory of some of the most prominent scientists in the nineteenth century.[110] Helmholtz argued in an 1855 lecture that individuals learn much of visual spatial perception, and that visual images are representations of the true objects, or signs.[111] Tesla indicated in 1915 that the "eye transmits to it [the mind] the true and accurate likeness of external things."[112] If the eye was the only accurate sense organ, then the human automata could only be accurately guided by visual impressions.[113] His previous conviction that he was

[109] Tesla, "Tesla on Electricity."

[110] Ann Wilbur Mackenzie, "Descartes on Life and Sense," *Canadian Journal of Philosophy* 19, no. 2 (1989): 171.

[111] Timothy Lenoir, "The Eye as Mathematician: Clinical Practice, Instrumentation, and Helmholtz's Construction of an Empiricist Theory of Vision," in *Hermann von Helmholtz and the Foundations of Nineteenth-Century Science*, ed. David Cahan (Berkeley: University of California Press, 1993), 110.

[112] Tesla, "How Cosmic Forces Shape Our Destinies ('Did the War Cause the Italian Earthquake?')," 505.

[113] Philosophically, Tesla's ideas seem radical, but they appear to have largely been ignored. Tesla's essay "How Cosmic Forces Shape Our Destinies" initially appeared in the *New York American* but was later picked up by *The Washington Post*. It appeared on the front page of a Sunday magazine section and continued on page eight under the

governed completely by external causes suggested that the eye, in particular was responsible for controlling the human automaton. In an unpublished speech he explained that "with the innumerable and overwhelming evidences of external influence of suggestion through medium of the eye, which, as before stated, I am continuously obtaining and which unmistakably demonstrate to me, that not only my thoughts, but also my dreams are caused or evoked by visual impressions."[114]

Tesla noted, in 1893, that the blind presented a significant counter example to his assertion that there "is no way of acquiring knowledge except through the eye."[115] He suggested that because the blind are "descended from those who had seeing eyes" they possessed the ability to "form images and to think." He explained this in greater detail, arguing that

> It is not necessary that every individual, not even that every generation or many generations, should have the physical instrument of sight in order to be able to form images and to think, that is, form ideas or conceptions; but sometime or other, during the process of evolution, the *eye* certainly must have existed, else thought, as we understand it, would be impossible; else conceptions, like spirit, intellect, mind, call it as you may, could not exist.

When explaining how evolution might take place on other planets, he contended that vision, or a similar sense, would have to be developed at some point in evolution in order for there to be intelligent life. If this were the case, why then did Tesla give the telautomaton something that he explained as an ear? In addition to his complicated understanding of electromagnetic waves, Tesla believed that the "ear" allowed the device greater responsiveness to its controller. By controlling the device with the ear, he limited its capabilities to a device that would remain

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title "Italy's late earthquake disaster may have started in battlefields of France, is view of noted scientist." *The Washington Post,* which published a series of articles on the Italian earthquake, was more interested in the aspects of Tesla's article that might suggest a cause of the earthquake.

114 Tesla, Nikola, "Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

115 Tesla, "On Light and Other High Frequency Phenomena," 206.

obedient to its controller and incapable of intelligent thought. The eye was a requirement for thought and by limiting his telautomaton to a device analogous to an ear, Tesla limited the device's capabilities.

Tesla's devotion to the eye was reminiscent of William Kingdon Clifford's 1874 lecture, "Body and Mind" in which he expressed his belief that the eye was "the most perfect" sense organ. His discussion of the eye developed directly out of an analysis of Huxley's fourth proposition on senses and nerves. He used the example of the eye, the "most perfect" sense to explain Huxley's argument.[116] Clifford's interest in the eye and his efforts to combine new physical theories with physiological research provided a parallel scientific discourse to Tesla's telautomaton. Both Tesla and Clifford devoted significant attention to the eye, and Clifford's ideas, as a scientific naturalist, permeates much of Tesla's work. In Clifford's 1874 lecture, he explored the possibility of human automatism as an attempt to join the mental and the physical sciences by applying conservation of energy to the human mind.[117] Physicists were still determining the best methods for applying the doctrine of the conservation of energy in the 1870s, but Clifford believed it offered some insight into human automatism. Huxley's and Carpenter's discussions had relied heavily on discoveries in biology and physiology and Clifford explained that Huxley's lecture offered a potential bridge between the mechanical sciences and the biological sciences. This bridge suggested that the "science of organic bodies is only a complication of the science of inorganic bodies."[118] To Clifford, Huxley's speech signaled the progress made in physiology in its understanding of organic systems. One of the stones in this

[116] William Kingdon Clifford, *Lectures and Essays, Vol 2* (London: Macmillan and Co, 1879), 40.

[117] Daston, "The Theory of Will versus the Science of Mind," 201.

[118] William Kingdon Clifford, "Body and Mind," in *Lectures and Essay, by the Late William Kingdon Clifford, Vol. 2* (London: Macmillan and Co, 1886), 33.

bridge was the work of seventeenth-century British physician William Harvey on the circulation of blood. This was because Harvey showed that the movement of blood was "a mere question of Hydrodynamics."

Clifford aimed to uncover whether a similar bridge would be possible between the mental and physical sciences. In so doing, his explanation of human automatism primarily centered on the exploration of conservation of energy. He used the particular example of the eye to explore how information passed from the eye through the nerves and into the brain, something Carpenter also sought to do. Clifford, however, asked, "Is there any creation of energy anywhere? Is there any part of the physical progress which cannot be included within ordinary physical laws?"[119] In Clifford's estimation the creation of energy anywhere in this process would indicate the action of an outside force: free will, consciousness, the ego or the soul. Although Clifford concluded that "the will is not a material thing" and that it could not influence matter, he believed that it had to leave some evidence in the material world of its action.[120] Clifford, like Huxley, was left with the conviction that humans are automata, as no evidence of energy creation occurred. The process that Clifford used to reach this conclusion differed radically from Huxley's argument, but the conclusion was the same. When considering the possibility of a scientific explanation of telepathy, Tesla explored the possibility of energy within the human mind. He explained that the "energy necessary for performing the work of control or suggestion, might be, theoretically considered, infinitesimal. The energy used up in forming a thought is certainly a definite and possibly measurable quantity, but the energy required for suggesting a thought may be infinitely

[119] Ibid., 55.

[120] Ibid., 56.

small."[121] The possibility that suggesting a thought might be infinitely small was a concept exploited by physicists, specifically James Clerk Maxwell and William Thomson, who sought a solution to this same problem through the thought experiment of Maxwell's Demon.

With the telautomaton, Tesla demonstrated the defining principles in the nineteenth-century dialogue on human automatism. It is the demonstration by the construction of a physical device that offers a historical perspective. He believed that by demonstrating these principles he might contribute to the research of Huxley, Carpenter, Spencer and Clifford. His attempt to demonstrate these principles reflected how widespread and significant these theories were and furthermore offers the perspective of a prominent nineteenth-century inventor. In Tesla's estimation, the telautomaton represented the fundamental functions of the human automaton. That he could reproduce these functions so easily further confirmed his conviction that he was himself an automaton. But Tesla's consideration went beyond replicating what he considered to be the basic human functions. Tesla envisioned that the telautomaton would become ultimately become an independently acting device, capable of functioning in the same way as the human automaton. He believed that the greatest constraints for the construction of a device that acted independently was a technological problem, which to an inventor seemed a relatively small problem.

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[121] Tesla, Nikola, "Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

Chapter 3
Ghosts in the Machines:
The Ether and Making the Psychical, Physical

Nikola Tesla's research in the nineteenth and early twentieth centuries on wireless power, wireless communication and his telautomaton depended heavily on the new physical theories of electromagnetism, energy conservation and thermodynamics. As discussed in Chapter 2, the telautomaton was an experiment by Tesla that sought to address the major questions of nineteenth-century physiology pertaining to human automatism. Moreover he sought to explore the limits of his own automatism with the device. But Tesla's inventions, including the telautomaton, did not merely seek to demonstrate principles of automatism, but also physical principles. How did Tesla shape the telautomaton using the physical principals of the late nineteenth and early twentieth centuries? How was the telautomaton's function and form shaped by these theories? Physics was undergoing significant changes, spurred in part by the rise of energy physics, new developments in electricity and magnetism, and new apparent requirements of the ether. Tesla's inventions depended heavily upon the physical theories of British physicists and he was acutely aware of incorporating these theories into his work.[1]

The ether was the underlying concept on which energy physics, electromagnetism and Tesla's wireless research all depended. It was thought to be not only essential in the development of wireless communication but it would be the defining problem in physics in the nineteenth century. Scientists theorized that the ether was an invisible medium that permeated all space. Although it took on different attributes –gravitational, electrical, magnetic and some

[1] These advances in physics primarily took place in Germany and Great Britain. But the British and Continental theories deviated from one another significantly. Sometimes they were even in direct opposition of one another. M. Norton Wise, "German Concepts of Force, Energy, and the Electromagnetic Ether: 1845-1880," in *Conceptions of Ether*, ed. G.N. Cantor and M.J.S. Hodge (Cambridge: Cambridge University Press, 1981), 269–307.

very mysterious – the ether had never been detected. But physicists, particularly the British physicists who shaped Tesla's theories, still considered its existence a necessity, even in the absence of any evidence supporting its existence. Tesla explained simply that

> the ether- has resulted from the inability of otherwise explaining the interaction of bodies at a distance. The dictum of modern science is that no body can act upon another, unless there is some medium between them. So the Sun could not attract the Earth, if the space were not filled with some substance capable of transmitting the force or energy.[2]

Here, Tesla clearly defined a distinctly British understanding of the ether, which differed significantly from German understandings of the ether.[3] He drew from the theories of William Thomson, Oliver Lodge, J.J. Thomson and James Clerk Maxwell to develop his ether theory. But the theories of continental physicists like Hermann von Helmholtz and Heinrich Hertz differed significantly and focused less on developing a mechanical analog.[4] Additionally, Tesla's ether theory reflected the diverse and contested range of theories that arose in the nineteenth century.

This uncertainty over the nature of the ether caused widespread tensions in physics about exactly what properties the ether had. Tesla examined the possibilities of new research in thermodynamics and electromagnetism. As an inventor and an engineer, Tesla's work provides an alternative perspective to many interpretations of nineteenth-century physical theories. He observed the tremendous changes in physics and sought to construct inventions and devices that would most practically demonstrate these new concepts. How did the ether and the connection it formed between the various physical fields inform Tesla's understanding of his telautomaton

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[2] Tesla, "Chicago Speech."Tesla, Nikola, "Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[3] Wise, "German Concepts of Force, Energy, and the Electromagnetic Ether: 1845-1880," 301.

[4] Joseph F. Mulligan, "'The Aether and Heinrich Hertz's The Principles of Mechanics Presented in a New Form,'" *Physics in Perspective* 3, no. 2 (n.d.): 147.

and his wireless inventions? How did the uncertainty about the nature of the ether encourage Tesla to interject his own theory? Why was Tesla, unlike his contemporaries, so concerned with the demonstration of scientific principles?

Electromagnetism, thermodynamics and the new energy physics were also important to physicists who sought to understand God in the physical world. William Thomson and James Clerk Maxwell, two of the most important nineteenth-century physicists, used the ether to strengthen explanations about the role of God in physical theories. Other scientists vehemently denied the active role of God and used physics to argue for a deterministic universe. Some, like the physicists Balfour Stewart and Peter Guthrie Tait, suggested that the ether might offer a physical space for the possibility of life after death and a way to reconcile science and religion. A physical explanation for the afterlife led some physicists to pursue communication with the dead: psychical research. Tesla's research and inventions reflected not only the centrality of the ether but also the incorporation of its more mysterious attributes into physics. His writings suggest he was uncertain about the existence of a human soul or free will and this reflected the conflicted relationship between science and religion in the late nineteenth century. Despite his Serbian Orthodox upbringing, Tesla also incorporated Buddhist ideas into his understanding of physics and the ether. Calling the ether "Akasha" and explaining it was acted upon by the "Prana", both Buddhist terms.[5] Ultimately, Tesla's writings and inventions reflect his own uncertainty about the place of psychical and spiritual research in modern science.

[5] Nikola Tesla, "Man's Greatest Achievement," in *Columbia University Special Collections*, 1930.

Ether, Electricity and Magnetism and Energy

The perceived form and function of the ether changed radically from one century to the next and Tesla's writings and inventions reflected the state of the ether in the late nineteenth century. In 1873, the year that James Clerk Maxwell published his *Treatise on Electricity and Magnetism,* physicists considered the ether to possess very specific attributes. Although these attributes changed between Maxwell's *Treatise* and Tesla's own publications, most of the characteristics of the ether that Tesla's theory incorporated were established by 1873. Because of Tesla's fascination with Maxwell and his theories, it is useful to examine the theory of the ether as it was understood by physicists and engineers in 1873. In large part this is because Tesla attempted to incorporate many of these ideas into his theories on wireless and the ether. In an interview he explained that "the ether, which was structureless, of inconceivable tenuity and yet solid and possessed of rigidity incomparably greater than that of the hardest steel."[6] But this interest in electromagnetic theory never seemed to go beyond a conceptual level. Although Tesla was grappling with complicated concepts like the transmission of electromagnetic waves, it is clear that while he knew these ideas were important to his inventions, he did not fully comprehend the mathematical nuances. For example, in a lecture on his wireless lighting system he emphasizes that an understanding of the ether was necessary for understanding his new invention, yet he failed to integrate any explanation of these concepts into his description of the device. Physical theories played an important role in his general conceptual understanding of his work, but seemed to have very little impact on his calculations in the inventive process or on specific components or mechanisms.

[6] "'Nikola Tesla Tells of New Radio Theories,'" *New York Herald Tribune*, September 22, 1929, http://www.tfcbooks.com/tesla/1929-09-22.htm.

British physicists were certain that the ether must behave like an elastic solid instead of a fluid. This idea stemmed in part from the research of French physicist Augustin-Jean Fresnel and British scientist Thomas Young in 1819.[7] By shining light through a series of tiny slits, they provided strong evidence that light behaved as a wave, not a stream of particles. Both were independently able to detect an interference pattern by using a coherent light source shining through either a single slit or two parallel slits (Figure 12). If light consisted of a particles, they would not interfere in the manner observed. The only readily conceivable explanation was that light behaved as a wave. Fresnel's continued research on polarized light indicated that it must be a transverse wave, like waves on water, not a longitudinal wave like sound. Physicists realized that the speed of light depended on the rigidity of the medium through which it propagated. In order for a light wave to move at that speed, the ether had to behave as an incredibly rigid elastic solid.[8]

The discovery by Michael Faraday of the Faraday Effect in 1845 provided additional

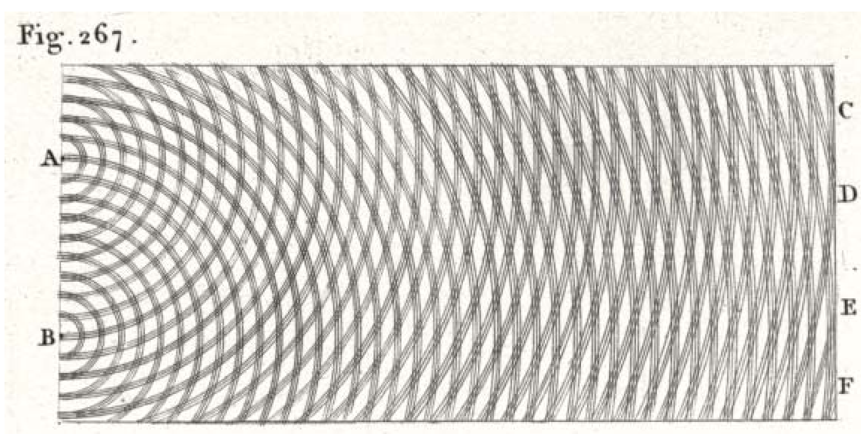

Figure 12 Young's sketch of the diffraction of water waves. (See Figure Note 12)

[7] Jed Z. Buchwald, *The Rise of the Wave Theory of Light: Optical Theory and Experiment in the Early Nineteenth Century* (Chicago: University of Chicago Press, 1989), 218.

[8] Jed Z. Buchwald, "Optics and the Theory of the Punctiform Ether," *Archive for History of Exact Sciences* 21, no. 3 (1980): 249.

information about the structure of the ether. Faraday was a British physicist best known for his work on field theory. Faraday was primarily searching for a way to find a relationship between electricity and light. Tesla may have sought to emulate Faraday, a scientist who possessed the same level of mathematical skill as Tesla and primarily gained his acclaim by uncovering physical principles through experimentation.[9] Faraday's strength was in his experimental work and it is quite possible that Tesla recognized similarities in many of the difficulties he faced. Faraday's previous work, which established a relationship between electricity and magnetism, left him convinced there was a similar relationship between light and electricity.[10] But understanding this relationship, along with attempts to determine the precise nature of electricity, plagued physicists throughout the nineteenth century. After failing to observe any interaction between light and electricity, Faraday changed tactics and examined the relationship between light and magnetism. He discovered that when he passed linearly polarized light through a piece of heavy glass in a direction parallel to a magnetic field, the plane of polarization rotated.[11] To Faraday the relationship between light and magnetism indicated that magnetic lines of force were more than a conceptual illustration, but physically existed in the space around a magnet.

To William Thomson these results suggested there had to be a rotation in the ether associated with magnetic lines of force and he wrote about the possibilities in an 1856 paper.[12] To Thomson, and later Maxwell, Faraday's results gave some indication of the small scale mechanics of the ether: if polarized light was rotated as a result of a magnetic field it indicated

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[9] Bruce J. Hunt, "Michael Faraday, Cable Telegraphy, and the Rise of Field Theory," *History of Technology* 13, no. 1 (1991).

[10] Friedrich Steinle, "Looking for a 'Simple Case': Faraday and Electromagnetic Rotation," *History of Science* 33, no. 100 (1995): 184.

[11] J. Brookes Spencer, "On the Varieties of Ninetenth-Century Magneto-Optical Discovery," *Isis* 61, no. 1 (1970): 35.

[12] Smith and Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, 407.

that magnetism set it into circular motion. Maxwell also embraced these possibilities, but not as quickly as Thomson. In 1861, Maxwell began to incorporate these ideas into his existing electromagnetic theory. His mechanical model, discussed later in this chapter, sought to incorporate the Faraday effect as rotation of the ether.[13] In his *Treatise on Electricity and Magnetism*, he summarized what was known and unknown about the structure of the ether.

> (1) Magnetic force is the effect of the centrifugal force of the vortices
> (2) Electromagnetic induction of currents is the effect of the forces called into play when the velocity of the vortices is changing
> (3) Electromotive force arises from the stress on the connecting mechanism [ether]
> (4) Electric displacement arises from the elastic yielding of the connecting mechanism [ether][14]

What Maxwell outlined above clearly emphasizes what physicists believed about the mechanical structure of the ether in the mid-nineteenth century. The *Treatise* emphasized the already important characteristic that electric and magnetic effects could be explained by strain, stress and rotation in the ether. Tesla grasped this same concept in his ether theory, suggesting that it "must be under some strain or in motion."[15] Although it is possible that Tesla possessed the mathematical ability to understand Maxwell's treatise, and he had a copy in his personal library gifted to him by Scottish chemist James Dewar, he more likely mainly had a conceptual understanding of Maxwell's theory.

Maxwell's *Treatise on Electricity and Magnetism* outlined far more than the relationship between electricity and magnetism and the ether; it also defined new properties of light. Prior to Maxwell's work, optics was a field completely separate from electricity and magnetism. Although Fresnel and Young determined that light was a transverse wave, it was still unclear

[13] Ole Knudsen, "The Faraday Effect and Physical Theory," *Archive for History of Exact Science* 15, no. 3 (1976): 253.

[14] James Clerk Maxwell, *A Treatise on Electricity and Magnetism, Volume 2* (Oxford: Clarendon Press, 1892), 470.

[15] Tesla, "Experiments with Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination."

why there was a relationship between the two. Maxwell's theory argued that light was an electromagnetic wave consisting of oscillating electric and magnetic fields. Tesla considered this the "fundamental teachings of Maxwell."[16] This discovery synthesized three fields, electricity, magnetism and optics, fields that Faraday previously had believed were connected. In 1888, German physicist Heinrich Hertz provided evidence of the existence of electromagnetic waves and what was considered proof of Maxwell's theory.[17] The waves that Hertz detected were of a longer wavelength than light, about 9 meters, but still displayed similar properties of diffraction and interference.[18] However, Hertz did not consider the existence of the luminiferous ether as essential and his work indicated that the concerns about the interaction between light and the ether were very much peripheral to him.[19]

In 1873, the ether also depended on recent developments in energy physics. Two very important aspects of energy physics arose from the work of British physicists. The first was field theory, proposed by Michael Faraday but later mathematized by William Thomson and Maxwell.[20] Field theory suggested that electric and magnetic effects established a field composed of lines of force. From Thomson's earliest work mathematizing the theory in a paper published in 1855, this idea was bound up in ideas of energy.[21] He sought to unite energy and field theory through the argument that the field was "constituted of mechanical effect," which

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[16] Nikola Tesla, "The True Wireless," *Electrical Experimenter*, May 1919.

[17] Hunt, *The Maxwellians*, 158.

[18] Ibid., 157.

[19] Buchwald, "Optics and the Theory of the Punctiform Ether," 328.

[20] Smith and Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, 275.

[21] Ibid., 263.

was distributed through a magnetic field when it was established.[22] Thus, when an object was moved within the field the work done would change the mechanical effect composing the field. The ether served as the substratum of these fields and different mechanical models offered potential explanations of how the underlying structure of the ether might function in order to produce fields. British physicists also used energy physics to further develop the field of thermodynamics. They posited that the ether was not just responsible for the transmission of light, magnetic and electric phenomena but proposed that it possessed thermodynamic properties. Although the laws of thermodynamics did not have any direct implications on the form of the ether, thermodynamics and the rise of energy physics were tangled up in physicists' understanding of the ether.

Inventors and the Ether

By 1891 Tesla had adopted the language of energy, ether, and electromagnetism that British physicists had developed. He seemed to revere the British physicists, closely following developments in physics and telegraphy in Great Britain and praising new advances. He credited "the work, principally, of English scientists" for the progress made on the ether theory. He explained that "enough knowledge [on electricity and magnetism] has been gained on the subject to enable us to treat simple cases which now present themselves in daily practice."[23] His esteem for the British physicists was demonstrated when William Thomson, perhaps the most admired physicist of the nineteenth century, visited the United States in 1897, Tesla commented that "if [Thomson] were a young man, we might express admiration for his achievements, but his age

[22] Ibid.

[23] Nikola Tesla, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination," *The Telegraphic Journal and Electrical Review*, August 7, 1891.

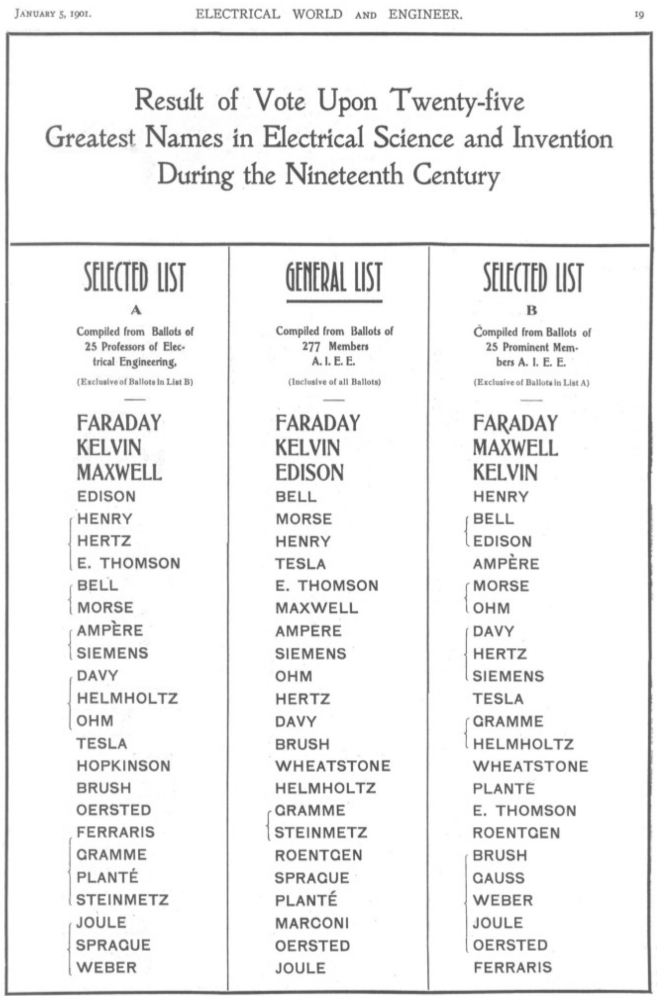
has almost given sanctity to the eminence of his position."[24] He even sent flowers to Thomson and his wife, and Thomson wrote to Tesla to thank him on behalf of his wife.[25] But Tesla lacked the theoretical education of many of those physicists. He had completed only one year of university. Instead, he developed his own understanding of physical theories as he did the theories of automatism: by attempting to demonstrate what he considered to be the major components of theory. To him, the demonstration of a theory with a practical working machine was the best way to understand, not through pages of written proofs. Moreover, these were the tools that were available to him to participate in scientific debate. Despite his comparative lack of education, he made a significant effort to exploit and utilize existing scientific theories. Although he developed his own interpretation of existing theories, which were often radically different than what the theory's developers intended, he did recognize that his understanding was limited and he hesitated to develop completely new theories. His ether theory and its reliance on other theories, in particular, demonstrates his hesitancy in developing his own theories.

Tesla's work on alternating current and the successful implementation of water turbines at Niagara Falls in 1886 established him as a celebrity in the nineteenth-century United States. Newspapers clamored for his opinion on the latest developments in science and engineering and Tesla happily provided his perspective. But exactly what perspective did he provide? The public referred to him as a scientist, a physicist, an electrician, an engineer, an experimenter, a scientist, an inventor, a magician and at times simply "Mr. Tesla." It seems that despite the diversity in his given titles, Tesla primarily considered himself to be an experimenter. Although he recognized that he did not have the same level of knowledge, or mathematical expertise, in

[24] "Lord Kelvin," *Electrical Review*, August 18, 1897.

[25] William Thomson to Nikola Tesla, October 10, 1897, Box 114, Folder 525-536, DOI 2726, Nikola Tesla Papers, Nikola Tesla Museum, Belgrade, Serbia.

physical science as Maxwell, Thomson and Oliver Lodge, also an accomplished British physicist, he still considered himself competent to comment on developments in physical theory. An article in *Electrical World* suggested that he was like Faraday, who knew "that the world would obtain most benefit from his genius if devoted to pure physical research, knowing that his discoveries would eventually have a practical fruition."[26] The parallel with Faraday is particularly relevant because of Faraday's and Tesla's comparative lack of education compared to Thomson and Maxwell. Tesla voiced his opinions on subjects ranging from the latest developments in the War of the Currents between alternating and direct current, to the power that electricity might offer to "cure the mental ills of children."[27]


January 5, 1901. ELECTRICAL WORLD AND ENGINEER. 19

Result of Vote Upon Twenty-five Greatest Names in Electrical Science and Invention During the Nineteenth Century

SELECTED LIST A Compiled from Ballots of 25 Professors of Electrical Engineering. (Exclusive of Ballots in List B)	GENERAL LIST Compiled from Ballots of 277 Members A. I. E. E. (Inclusive of all Ballots)	SELECTED LIST B Compiled from Ballots of 25 Prominent Members A. I. E. E. (Exclusive of Ballots in List A)
FARADAY	FARADAY	FARADAY
KELVIN	KELVIN	MAXWELL
MAXWELL	EDISON	KELVIN
EDISON	BELL	HENRY
HENRY	MORSE	BELL
HERTZ	HENRY	EDISON
E. THOMSON	TESLA	AMPÈRE
BELL	E. THOMSON	MORSE
MORSE	MAXWELL	OHM
AMPÈRE	AMPERE	DAVY
SIEMENS	SIEMENS	HERTZ
DAVY	OHM	SIEMENS
HELMHOLTZ	HERTZ	TESLA
OHM	DAVY	GRAMME
TESLA	BRUSH	HELMHOLTZ
HOPKINSON	WHEATSTONE	WHEATSTONE
BRUSH	HELMHOLTZ	PLANTE
OERSTED	GRAMME	E. THOMSON
FERRARIS	STEINMETZ	ROENTGEN
GRAMME	ROENTGEN	BRUSH
PLANTÉ	SPRAGUE	GAUSS
STEINMETZ	PLANTÉ	WEBER
JOULE	MARCONI	JOULE
SPRAGUE	OERSTED	OERSTED
WEBER	JOULE	FERRARIS

Figure 13 A list in *Electrical World and Engineer* of the most influential names in Electrical Science as voted by members of the American Institute of Electrical Engineers. (See Image Note 13)

A 1901 poll by the American Institute of Electrical Engineers (AIEE), of a prominent subset of its members and professors of engineering, ranked Tesla among his contemporaries (Figure 13). The list included the great physicists of the nineteenth century, Maxwell, Thomson (Kelvin), Faraday, Ampere and

[26] "Nikola Tesla," *The Electrical World* XXIII, no. 15 (1894).

[27] "Tesla Predicts More Wonders," *The New York Sun*, April 17, 1912.

Helmholtz. But it also included well known inventors and industrialists like Morse, Bell, and Elihu Thomson. It is particularly noteworthy that Faraday sits at the top of all three of these lists, perhaps indicating that Tesla's fellow electrical engineers shared his admiration for Faraday's methods and background. The poll of 277 members of the AIEE ranked Edison, Morse, Bell, Henry, Tesla and Elihu Thomson all above Maxwell while the professors of Electrical Engineering ranked Tesla the lowest of all three groups surveyed. It was the ambiguity of Tesla's position, demonstrated in part with this survey that allowed him the freedom to voice his interest in a many fields. Was Tesla an inventor? An engineer? A scientist? A popular lecturer? This same ambiguity combined with his confidence contributed to the popular press, never pausing to consider if he was qualified to voice opinions on the physical science and the ether.

Tesla was encouraged in this respect because early in his career, newspapers and electrical journals hailed him as a visionary. He garnered tremendous praise and publicity through his work on wireless technology and the application of his alternating current patents. An 1893 article in *The Electrical World* maintained that "there is no living scientist in whose life and work the general public takes a deeper interest, especially in this country."[28] Tesla's early success established his expertise to the public and the press. He used this publicity to promote some of his early ideas on the ether and his thoughts on the new developments in electricity and magnetism. In Tesla's later career, the opinions he offered to the popular press increasingly ventured further and further from the domain of mainstream science. Although many popular articles praised his work, some of his speculations pushed the limits of what electrical journals considered science. In response to an article written by Tesla in 1900, the *Mining and Scientific Press* warned its readers that "the recent published vagaries of Nikola Tesla are not to be given

[28] "Nikola Tesla and His Work," *The Electrical World* XXI, no. 17 (1893).

serious attention and are interesting only for their notable absurdity."[29] That sentence was the entirety of the article, which referred to the recent publication by Tesla, "On the Problem of Increasing Human Energy." This publication was the first of Tesla's foray into more speculative writings, which are discussed in greater detail in Chapter 4 and 5. These speculative articles from the twentieth century primarily speculated about the potential future of the telautomaton, the human race and technology.

Tesla began commenting on subjects outside of his generally considered area of expertise in 1891 with his electric light lecture. Here, he voiced his opinions on electricity and magnetism and energy. The reverence, however, with which he treated British physicists did not extend to all physicists. He described Maxwell's *Treatise* as "poetical conceptions" but ridiculed Hertz's work and declared that "he had ceased to look upon his results as being an experimental verification [of Maxwell's electromagnetic theories]."[30] Tesla claimed that Hertz had failed to provide a compelling demonstration, and emphasized his own superior expertise as a demonstrator of scientific theory. He believed that he had discovered a fatal flaw in Hertz's "old-fashioned" experimental apparatus and this made the results Hertz achieved impossible. He claimed that

> The consequence [of the old-fashioned apparatus] was that he failed to observe the important function which the air played in his experiments, and which I subsequently discovered. Repeating his experiments and reaching different results, I ventured to point out this oversight. The strength of the proofs brought forward by Hertz in support of Maxwell's theory resided in the correct estimate of the rates of vibration of the circuits he used. But I ascertained that he could not have obtained the rates he thought he was getting. The vibrations with identical apparatus he employed are, as a rule, much slower, this being due to the presence

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[29] "Concentrates," *Mining and Scientific Press*, January 12, 1901.

[30] Tesla, "The Problem of Increasing Human Energy," 201.

> of air, which produces a dampening effect upon a rapidly vibrating electric circuit of high pressure, as a fluid does upon a vibrating tuning-fork.[31]

He explained his reasoning once more in an article in *Electrical Experimenter* published in 1919. The editor introduced Tesla's piece explaining that "Dr. Nikola Tesla" wrote with the intention of proving that he was the "Father of Wireless." Tesla argued that true Hertz waves were "blotted out after they have traveled but a short distance." This might have been the result had Hertz had failed to account for resistance of the medium transmitting the waves. He spouted in a 1900 article:

> The Hertz wave theory of wireless transmission may be kept up for a while, but I do not hesitate to say that in a short time it will be recognized as one of the most remarkable and inexplicable aberrations of the scientific mind which has ever been recorded in history.[32]

Tesla's argument that Hertzian waves did not demonstrate what they purported to show rested principally in his argument that instead of detecting the transmission of electromagnetic waves, he instead "observed waves in the ether much of the nature of sound waves in the air."[33] But he fundamentally misunderstood the experiment because he believed the waves were longitudinal, when in fact they, and other electromagnetic waves, were transverse.[34]

Yet Tesla's arguments on the nature of light varied wildly throughout his lifetime. Despite his dismissal of the validity of Hertz's experiments in 1900 and again in 1919, in both articles Tesla readily accepted Maxwell's theory and believed that his own oscillatory system provided real proof of the theory. He believed his own experiments and his transmission of electromagnetic signals provided real proof of Maxwell's theories. Yet in direct contradiction to

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[31] Tesla, "The Problem of Increasing Human Energy."

[32] Tesla, "The True Wireless."

[33] "'Nikola Tesla Tells of New Radio Theories.'"

[34] Jed Z. Buchwald, *The Creation of Scientific Effects* (Chicago: University of Chicago Press, 1994), 322.

this belief, in a later article, published in 1932 in the *New York Times* he claimed to have obtained proof in an experiment from 1899 that the "sun and other heavenly bodies [...] emit rays of great energy which consist of inconceivably small particles."[35] But Bergen Davis, a professor of physics at Columbia University, responded explaining that Tesla's "theory" would "invalidate the universally accepted results of modern physics."[36] Overall Tesla's physical theories tended to be ignored and occasionally ridiculed as "vagaries," but never did they appear to be seriously considered by his contemporaries.

Tesla's interest in electricity also included field theory, which further reflected his devotion to British physicists. He argued that field theory, among other recent advances in physics, signaled new understanding; "the spark of an induction coil, the glow of an incandescent lamp, the manifestations of the mechanical forces and magnets are no longer beyond our grasp." To Tesla then the new theories in physics signaled a tremendous jump in physical knowledge. The ether above all was

> one of the most important results of modern scientific research. The mere abandoning of the idea of action at a distance, the assumption of a medium pervading all space and connecting all gross matter, has freed the minds of thinkers of an ever present doubt, and, by opening a new horizon—new and unforeseen possibilities—has given fresh interest to phenomena with which we are familiar of old. It has been a great step towards the understanding of the forces of nature and their multifold manifestations to our senses.[37]

In an interview in *The Sunday Star* in 1931, Tesla suggested "virtually all progress has been achieved by physicists, discoverers and inventors, in short, devotees of the science which

[35] Tesla, Nikola "The Cosmic Rays" *New York Times*, February 6, 1932, Proquest Database.

[36] Davis, Bergen "Letter to the Editor" *New York Times*, February 24, 1932, Proquest Database.

[37] Tesla, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination."

Newton and his disciples have been and are propounding."[38] Tesla considered the work of physicists to be of the greatest importance and with his inventions he hoped he might offer some insight into their research. As with much of his research, he integrated the concept of electrostatic fields into his inventions. In his talk on his wireless lighting system he explained that electrostatic and electromagnetic fields would offer many important applications beyond the application in wireless lighting that he demonstrated.

Tesla developed his inventions with the principles of energy physics in mind. In his 1891 speech before the American Institute of Electrical Engineers on his wireless lighting system he described the potential in an electric circuit containing an induction coil. The idea of "electric potential" in one of its earliest uses in 1864 was defined by Thomson, as "the potential, at any point in the neighborhood of or within an electrified body, is the quantity of work that would be required to bring a unit of positive electricity from an infinite distance to that point."[39] Only thirty years later Tesla had integrated the idea of electrical potential into his presentation of a wireless electric light. In other cases he described the storage of energy in capacitors and the loss of energy within circuits. Moreover, he described in his patents the conversion of mechanical energy into heat and energy within electrical systems.[40] There were many difficulties with early attempts to convert heat energy into electric energy and he sought to develop a "new method which would make it possible both to utilize more of the heat-energy of the medium."[41] To that end, he attempted to design a thermomagnetic motor and also conceived

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[38] Goldberg, "Great Scientific Discovery Impends."

[39] *Report of the Thirty-Third Meeting of the British Association for the Advancement of Science*, (London, John Murray, 1864), 154.

[40] Nikola Tesla, "Phenomena of Alternating Currents of Very High Frequency," *The Electrical World* XVII, no. 8 (1891).

[41] Tesla, "The Problem of Increasing Human Energy," 201.

of a thermopile.[42] Tesla pursued this side project after leaving Edison's laboratory but before he was able to find success with his alternating current motor. Although Tesla's thermomagnetic motor and thermopile ultimately were unsuccessful, he credited the work of William Thomson for his study of heat.

Why did Tesla devote so much time and energy to developing an understanding of physical theories? And why did he attempt to interject his own findings of physical theories? In an 1898 interview with the *New York Herald* Tesla explained that he invented by discovering the "natural laws governing the secret he is after" and only when "the laws controlling their appointed work in the universes have been once mastered, the making of the proper machine to act in harmony with the laws is comparatively an easy task."[43] In particular, here he was referring to his research on his "oscillator," the Tesla coil. Tesla's inventions were based on the physical theories, but it does not appear they included much beyond Ohm's law.[44] Although it is possible Tesla developed a mathematical understanding of Maxwell's equations and simply did not incorporate these ideas into his inventions, it seems more likely that he possessed a cursory conceptual understanding of these theories instead. He then incorporated these conceptual understandings into his inventions but made no use of the actual mathematics that supported these claims. Tesla, as a self-described experimenter, studied physical theories to develop his inventions.

Tesla frequently published announcements about his future plans or new inventions in trade magazines like *The Electrician, Electrical World*, *Electrical Review,* and others. Although

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[42] The thermomagnetic motor exploited the fact that magnets weakened when heated. The thermopile utilized the principle that a small potential difference was produced across a wire when there was a difference in temperature. Thermopiles are then able to produce an output voltage proportional to the temperature difference across the wire. This then was a method to convert heat energy into electrical energy

[43] "Around the World Without a Wire," *New York Herald*, November 13, 1898.

[44] Nikola Tesla and Aleksandar Marincic, *Colorado Springs Notes (1899-1900)* (Beograd: Nolit, 1999).

Marconi and Edison's inventions were sometimes discussed in these journals, neither wrote nor promoted their own inventions to the same degree as Tesla. In this respect, Tesla stood apart from his contemporaries; not only did he write accounts of his own inventions but he also attempted to insert himself into the scientific community in a way his fellow inventors avoided. Although Tesla did not attain the same level of commercial success as Marconi and Edison, he seemed to approach the process of invention far differently. He claimed he differed from the two other inventors because he instead sought an understanding of the physical laws governing his machines as well as a conceptual idea of how his inventions best fit into society.

In contrast, Guglielmo Marconi and Thomas Edison did not engage with the scientific community. Most of Marconi's interaction with the scientific community was through a scientific advisor, John Ambrose Fleming, a British physicist trained by Maxwell.[45] Overall, Marconi seemed uninterested in presenting his devices as demonstrations of physical theories in the same way Tesla strove for. Although he presented at the Royal Institution in 1900, he did not develop the same admiration for or relationship with the British scientists as Tesla. Instead, the relationship was more adversarial as many of the Maxwellian scientists felt frustrated that an Italian benefitted from the commercial application of a British scientist's discovery.[46] Thomas Edison did attempt at one point to work within the scientific community. In 1875, he announced the discovery of something that he labeled "etheric force." The force was discovered in the process of an experiment on the "acoustic telegraph," an attempt to send multiple telegraph messages along the same wire by varying the frequencies and using tuned receivers. But during a test of the device, sparks occurred at a point where no current should have been flowing. Edison announced his success to the popular press, boasting that this was a new force. But

[45] Hong, *Wireless: From Marconi's Black-Box to the Audion*, xi.

[46] Ibid., 44.

Edison's financial backers encouraged him to abandon the project.[47] Edison's assistant in this research was Charles Batchelor, who later supervised Tesla in Paris. Some of the backlash to Edison's announcement of "etheric force" may have come in part because of his tendency to go to the popular press instead of to a scientific forum. In this regard, Tesla was more cautious than Edison. In contrast, Tesla's discovery of a similar phenomenon, his wireless lighting system, appeared first in an 1891 lecture at Columbia College and then only surfaced much later in the popular press. Although the manner of the announcement of Edison's findings in the popular press might have contributed somewhat to his outsider status in science, the "etheric force" was the detection of high frequency electromagnetic waves and had already been detected by Joseph Henry, an American inventor and engineer, and predicted by James Clerk Maxwell.[48] Edison, instead of acknowledging their work in his announcement, mentioned the work of Karl Reichenbach, whose research comes later in this chapter in the context of psychical research. Reichenbach and his research were ridiculed by some scientists and Edison's recognition of him snubbed the research of far more relevant scientists. Two professors in the United States as well as a demonstration in London all attempted to show that Edison's discovery could be accounted for by known principles. British physicist Oliver Lodge recalled that "the time was not ripe; theoretical knowledge was not ready for it" and "he [Edison] called it 'etheric force' which rather set our teeth on edge."[49] Edison's brief foray into the scientific community ended poorly, and his own investors encouraged him to avoid drawing such attention to himself again.[50]

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[47] Ian Wills, "Edison and Science: A Curious Result," *Studies in History and Philosophy of Science Part A* 40, no. 2 (June 2009): 158, doi:10.1016/j.shpsa.2009.03.006.

[48] Matthew Josephson, *Edison: A Biography*, 1st ed. (New York: McGraw-Hill, 1959).

[49] Francis Jehl, *Menlo Park Reminiscences* (Dearborn, Michigan: Edison's Institute, 1936).

[50] Wills, "Edison and Science: A Curious Result."

But, for the public the practical success of Tesla, Edison and Marconi in wireless research seemed to qualify them as authorities in science.[51] While scientific authorities grappled with the underlying theories, Tesla, Edison and Marconi were all making tangible progress toward wireless telegraphy. The public and public newspapers discerned these concrete achievements and progress as evidence the authority of these individuals in science. Moreover, the failure of established scientists to make serious progress towards the transmission of wireless signals cast even greater doubt on their authority on these matters. Tesla took full advantage of this perceived authority, likely because he sought to demonstrate scientific theory with his inventions.

Ether Models

Tesla's writings and inventions regularly included details or concepts from new theories in energy, electromagnetism and the ether. His participation in physical theory, often through his explanations of his inventions, provides a utilitarian interpretation of nineteenth-century physical science. His display of wireless lights in 1891 at Columbia College, later repeated in similar lectures in 1892 in London and Paris, began with a sketch of a theory of the ether and the nature of electricity. Although compared to existing ether theories his theory was superficial, the content of the lecture was so tangential to the subject of the ether that he included far more detail than necessary. He combined several of the existing ether theories to form his own theory of the structure of the ether. He believed that this introduction was "necessary to a full understanding of the subject as it presents itself to my mind." Again Tesla emphasized the necessity in fully understanding the underlying physical theories as a part of his inventive process. For Tesla then,

[51] Hong, *Wireless: From Marconi's Black-Box to the Audion*, 39.

ether theory was essential to the mechanism of his wireless lights. Instead of attempting to introduce a completely new theory of the ether, Tesla assembled one from the existing theories. He then sought to demonstrate and exploit what he considered to be the essential principles with his wireless lights.

Tesla introduced his sketch of an ether theory before the American Institute of Electrical Engineers at Columbia College in 1891 when he presented his wireless lights for the first time. Tesla's theory is important for several reasons. First, it showed the breadth of his knowledge of British electromagnetic physics and indicated that his theory was developed with consideration of the work of William Thomson, James Clerk Maxwell, Oliver Lodge and J.J. Thomson. Tesla depended on the work of these British physicists, and key aspects of their ether theories appear in Tesla's theory. Additionally, Tesla's work as an inventor studying physics offers a contrasting perspective to the British physicists studying invention. His ether theory was motivated by his inventions and so his perspective on physical theories is far more utilitarian than the British physicists he admired. Maxwell, William Thomson, Oliver Heaviside, George F. Fitzgerald and Lodge were all involved in the creation of ether models. But they were all also involved in telegraphy.[52] The transatlantic telegraph project required the application of many concepts in electromagnetic physics. The engineers, like Tesla, that pursued the possibility of wireless telegraphy sought to expand on this work. Tesla believed these physical theories, particularly those related to electromagnetism and the ether, were integral to his work. His insistence on beginning his lecture on wireless lighting demonstrated this belief. But the ether was not integral in his development of these inventions; instead, the ether was crucial in his conceptual understanding of how his devices worked, whether or not these were the accurate conceptual understandings. His light, which he explained worked based on electrostatic effects functioned

[52] Hunt, *The Maxwellians*.

through the mechanism of "rapidly alternating high potentials" which were able to "disturb the ether carried by the molecules [...] causing them to vibrate and emit light."[53] Conversely, the way an engineer like Tesla understood these theories and attempted to engage with physicists further challenges assertions that there was a dearth of American science in the nineteenth century.[54]

The developments in electricity, magnetism and energy depended heavily on the underlying ether theory, yet the actual structure of the ether remained unknown to physicists. In an attempt to further develop their understanding, scientists proposed a wide range of mechanical models of the ether. In some cases, like for Maxwell, these mechanical models served solely as analogies which aimed to provide a mental framework of how such disparate theories of how the ether functioned might possible interact. The possibility of understanding the mechanical structures and interactions occurring within the ether offered significant potential for further advancement. Even analogical structures, like the theories explored below, offered some explanatory power to develop a deeper understanding of the ether. Since scientists could neither detect nor observe the ether directly, models of how it might be constituted offered an important mechanical framework that might provide answers to questions

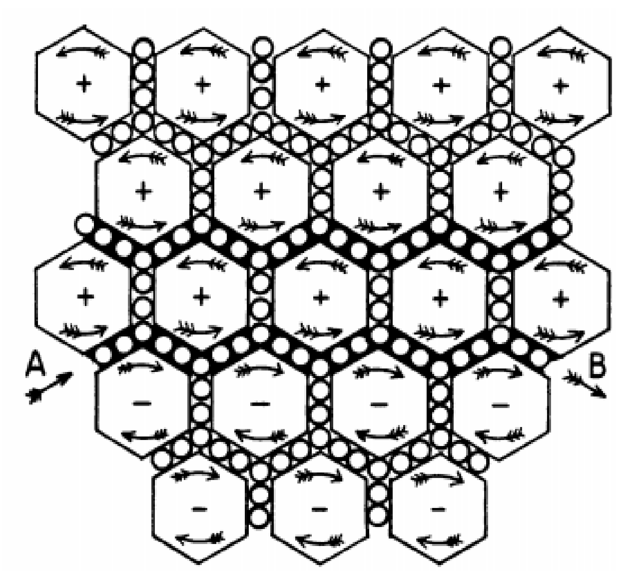

Figure 14 Maxwell's ether model, corrected. (See Image Note 14)

[53] Tesla, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination."

[54] Paul Lucier, "The Professional and the Scientist in Nineteenth-Century America," *Isis* 100, no. 4 (2009).

such as: what electricity might be, and how light was transmitted. Tesla drew on the mechanical models of Maxwell, William Thomson, J.J. Thomson and Oliver Lodge in his ether theory.[55] This approach, that of imagining mechanical models for the ether, was a distinctly British approach to ether theory. Whereas the French and German theories of the ether depended far more on abstract ideas "formulated in the clear and precise language of geometry and algebra, and connected with one another by the rules of strict logic."[56] These were only a few of the analogical models of the ether presented in the nineteenth century, and as Tesla explained, "to understand [the ether's] functions it would be necessary to have an exact idea of the physical construction […] which, of course, we can only form a mental picture."[57] Tesla, like the British physicists he so admired, believed that developing a logical mechanical model would provide valuable insight into the nature of the ether.

As outlined previously, Maxwell suggested many of the requirements of the ether on which later theories depended. He also proposed one of the earliest analogies of how the ether might be constructed.[58] Maxwell posited that the ether could be modeled after spinning vortices (hexagons) separated by smaller particles acting as idle wheels (Figure 14). The idle wheels would allow neighboring vortices to spin in the same direction. However if there were an electric current travelling from A to B, the idle wheels would move in that direction. This would cause the vortices on each side of the current to spin in opposite directions. Maxwell's model

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[55] For Maxwell, Fitzgerald and Lodge's ether models see Hunt, "Lines of Force, Swirls of Ether," 103. and M. Norton Wise, "The Mutual Embrace of Electricity and Magnetism," *Science* 203, no. 4387 (1979): 1311.. For Thomson's discussion of mechanical models, see Smith and Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, 464.

[56] Pierre Duhem, *The Aim and Structure of Physical Theory* (Princeton, New Jersey: Princeton University Press, 1954), 70.

[57] Tesla, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination," 71.

[58] Daniel M. Siegel, *Innovation in Maxwell's Electromagnetic Theory* (Cambridge: Cambridge University Press, 1991), 31.

explained, using the ether, why an electric current might cause a magnetic field that encircled around a wire. The model also took into account electrostatics: when the idle wheels were displaced from their equilibrium position, this would result in a distortion of the hexagonal cells; when the force displacing the idle wheels was removed then they would return to their equilibrium position. To Maxwell this offered a possible analogy for the underlying mechanics in the ether.

Physicists were not only positing that vortices might make up magnetic field lines but also that they might offer explanatory powers for atoms. The vortex motion of the ether, a theory developed from the work of William Thomson, was a consistent feature in Tesla's writings. In 1867, Thomson proposed that atoms and matter were constituted by vortex motion of the ether.[59] He suggested that vortices formed from ether could form different knots; the composition of these knots would explain different elements (Figure 15). In a demonstration, Peter Guthrie Tait demonstrated that smoke rings exhibited the same basic properties as the vortex rings. Thomson described the demonstration:

> A large rectangular box open at one side, has a circular hole of six or eight inches diameter cut in the opposite side… The open side of the box is closed by a stout towel or piece of cloth, or by a sheet of India-rubber stretched across it. A blow on this flexible side causes a circular vortex to shoot out from the hole on the other side. The vortex rings thus generated are visible if the box is filled with smoke.[60]

Thomson had considered vortex motion as a possible connection between matter and ether but it was not until his introduction to a paper by Hermann von Helmholtz, originally published in 1858 but not introduced to Thomson until 1862 by Tait, that he had a mathematical framework

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[59] Smith and Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, 410.

[60] Cargill Gilston Knott, *Life and Scientific Work of Peter Guthrie Tait, Supplementing the Two Volumes of Scientific Papers Published in 1898 and 1900* (Cambridge: Cambridge University Press, 1911), 68.

for his theory. Helmholtz's paper suggested that vortex rings were stable, something Thomson had been unable to establish. The vortex atom theory quickly gained supporters, including Maxwell. Maxwell promoted Thomson's theory in the "atom" article in the *Encyclopaedia Britannica* (1878) in which he enthusiastically explained the advantages of vortex atom theory despite the theory only being published in 1867. Although he admitted that there still remained flaws in the theory, he claimed that it "satisfies more of the conditions than any atom [theory] hitherto imagined."[61] Tesla, in one of his unpublished addresses, interpreted the theory differently. He described "every ponderable atom" as "filling all space merely by spinning motion, as a whirl of water in a calm lake."[62] He embraced Thomson's theory of atoms being formed by vortices in the ether and hypothesized that it might one day be possible to control these whirls. He imagined that man's powers would then be "unlimited and supernatural" and that "he could fix, solidify and preserve the ethereal shapes of his imagining."[63]

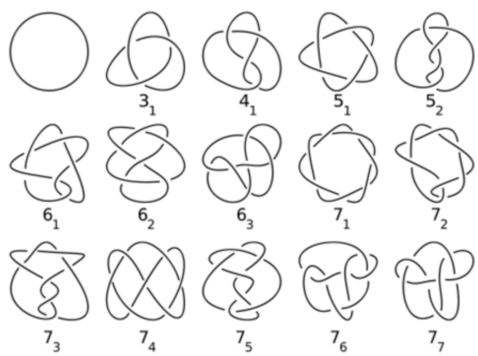

Figure 15 Knots in vortex atoms. (See Image Note 15)

J.J. Thomson, a British physicist best remembered for his work on the electron, was particularly interested in William Thomson's vortex atoms and their implications in chemistry. J.J. Thomson embraced vortex atoms and explored how they might interact in chemical reactions. In 1882, he published a paper "A general investigation of the action upon each other of two closed vortices in a perfect incompressible fluid" that suggested the vortex model provided a superior explanation not only for thermodynamic phenomena, but also atomic and

[61] James Clerk Maxwell, "Atom," *Encyclopaedia Britannica*, 1875.

[62] "Mr. Tesla's Vision," *The New York Times*, April 21, 1908.

[63] Tesla, "Man's Greatest Achievement."

molecular structure. Critical of chemists who sought only a macroscopic explanation of interactions, Thomson provided a detailed explanation of how vortex atoms might interact and combine with one another. His interest, however, gradually shifted away from chemical reactions, and focused instead on "Faraday Tubes." These tubes were physical threads, not analogical structures, embedded in the ether and were "tubes of electrostatic force connecting the atoms."[64] These tubes of force connected opposite electrical charges; each unit of positive electricity represented one end of a Faraday tube and a negative unit represented the other. Tesla described something similar in his own ether theory, explaining

> We can conceive of lines or tubes of force which physically exist, being formed of rows of directed moving molecules; we can see that these lines must be closed, that they must tend to shorten and expand, etc.[65]

Thomson theorized that the vortex motion forming the tubes bound a volume of ether within them—thus associating the mass of the ether bound by a Faraday tube with the unit charge of a Faraday tube (Figure 16). Thomson had not entirely abandoned vortices in his new theory. The vortices remained in his ether but instead of forming the atoms, they explained how the mass of the ether was bound up in each Faraday tube. In William Thomson's theory, each atom was a vortex but J.J. Thomson's theory suggested that an atom was a collection of Faraday tubes connecting positive and negative

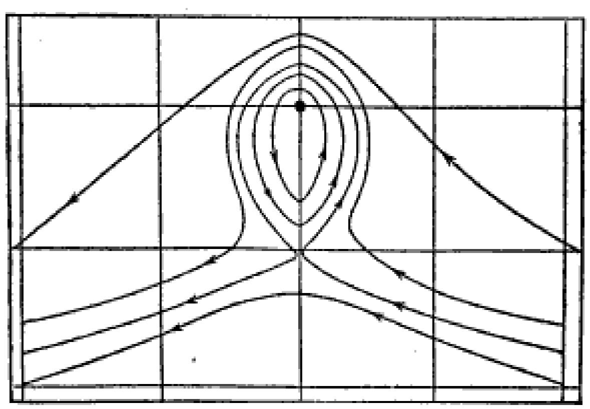

Figure 16 Cross-section of a Faraday Tube showing how the ether would be bound within the tube. (See Image Note 16)

[64] Thomson quoted in S.B. Sinclair, "J.J. Thomson and the Chemical Atom: From Ether Vortex to Atomic Decay" 34, no. July (1987).

[65] Tesla, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination."

charges and each tube binding some mass of the ether within it by a vortex. These tubes of force connected opposite charges; "since electrolysis defines a 'natural unit of charge, there should also exist a natural unit of electric force."[66] Thomson drew a general conclusion using the Faraday tubes as a beginning; he summarized that "all mass is mass of the ether, all momentum, momentum of the ether, and all kinetic energy, kinetic energy of the ether."[67] Thomson's association of electrostatic charge with atoms and tubes imbedded within the ether were concepts that Nikola Tesla drew upon for his own ether theory.

In 1889, Oliver Lodge offered another possible analogical model for the ether. Lodge differed from J.J. Thomson and William Thomson significantly; he subscribed to the "two fluids" theory, which proposed that electricity was composed of two kinds of electrical fluid, positive and negative. J.J. Thomson had discarded the two-fluid theory of electricity, calling it "indefinite" and complaining that if there were two fluids, then when combined they would neutralize one another. Lodge, however, suggested in *Modern Views of Electricity*, that electricity could best be explained by the two-fluid theory. He proposed an ethereal structure that was highly mechanical. The magnetic field was treated as a field of tiny cog wheels, geared together, that would crank into motion with the passage of an electric current (Figure 17).[68] Although the diagram here represents a magnetized field, the two-fluid theory was particularly useful in explaining why some parallel cogs would rotate in opposite directions. In order for current to pass, cogwheels rotating in one direction were positive electrical fluid while those rotating in the opposite direction would be negative electrical fluid. The apparent requirement of

[66] Russell Mccormmach, "J.J. Thomson and the Structure of Light," *The British Journal for the History of Science* 3, no. 4 (1967): 365.

[67] J.J. Thomson, *Electricity and Matter* (London: Constable & Co., 1909).

[68] Hunt, "Lines of Force, Swirls of Ether."

magnetic rotation dictated by the Faraday Effect also appeared here. Lodge maintained the idea of magnetic rotation as motion in the ether. His electrical and ether theory proposed something very different from William Thomson or J.J. Thomson. He believed that positive and negative electricity together made up the ether and that it "may be sheared by electromotive forces into what would become positive and negative electricity." Lodge concluded speculatively by mentioning several relationships between atoms and the ether: that the cogwheels might be atoms, that the atom is something "superposed upon, not substituted for, the ether." Ultimately, Lodge declined to discuss further how doubly-constituted ether might interact with matter.[69]

Figure 17 Lodge's ether composed of tiny cogwheels (+ and -) set into motion with the passage of an electrical current. (See Image Note 17)

Tesla's ether theory synthesized aspects of the ether theories of Maxwell, William Thomson, Lodge and J.J. Thomson. But, fundamentally for Tesla, the ether was an incompressible medium under some tension or strain. Like William Thomson, J.J. Thomson, Maxwell and Lodge, he concluded that electrostatic force was the effect of this ether under strain and electric current and electromagnetism were the ether in motion. These attributes, although contested, were established in Maxwell's *Treatise* in 1873.[70] In his 1891 theory Tesla bluntly stated that it

[69] Oliver Lodge, *Modern Views of Electricity* (London: Macmillan and Co., 1889), 410.

[70] Knudsen, "The Faraday Effect and Physical Theory," 253.

“cannot differ in density, ether being incompressible.”[71] He wholeheartedly rejected the two fluids electricity theory promoted by Lodge, making an argument similar to J.J. Thomson’s that the two fluids would neutralize each other. As reflected in William Thomson’s theory, an important aspect of many ether theories was how the ether interacted with matter. Tesla and J.J. Thomson both suggested that the interaction of matter and ether resulted in electricity. Unlike Lodge, who argued that the two electricities combined to form the ether, Tesla maintained, like J.J. Thomson, that electricity was “bound ether.” If electricity was bound ether, the spinning of molecules and atoms in the ether caused the motion and strain required for electrostatic force and magnetism. In summary, “the spinning of the molecules and their ether sets up the ether tensions or electrostatic strains; the equalization of ether tensions sets up ether motions or electric currents, and the orbital movements produce the effects of electro and permanent magnetism."[72] He regarded “all electrostatic current and magnetic phenomena as being due to electrostatic molecular forces,” and described these as being “tubes of force which physically exist.” Furthermore, tubes of force could explain permanent magnetism, because they “must be closed” and would “tend to shorten and expand.”[73]

Tesla’s contribution to the existing ether theories did not go unnoticed. An editorial, published in *Industries* magazine in 1891 critiqued the inclusion of such scientific speculations into Tesla’s talk. The reviewer suggested that Tesla had “an extraordinary habit of advancing theories or explanations of phenomena, what are either rational theories rendered unintelligible

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[71] Tesla, “Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination.”

[72] Ibid.

[73] Nikola Tesla, “What Is Electricity?,” *The Literary Digest* 3, no. 12 (1891): 11.

by being oddly expressed, or mere strings of words without clear-cut definite meaning."[74] The article complained that Tesla did not possess enough knowledge of the existing ether theories to offer any coherent contribution. Instead it rudely announced that he should "keep phantom ideas about the electromagnetic theory of light and Hertz and Dr. Lodge out of his work." As a mere "electrician," he should refrain from meddling in theories beyond his ken. In contrast William Crookes, a respected physicist who attended the talk and would later develop a friendship with Tesla, wrote an article supporting Tesla treated the suggestion of bound ether as seriously as Lodge's proposal that electricity was a form of ether. Crookes explained further that very little was known about electricity and its relationship to the ether. It is unlikely that Tesla intended to offer any new insight into the ether with his theory. Instead he considered the information as a necessity for understanding the underlying physical theories on which his inventions depended on. He relied on this conceptual understanding of the ether to explain conceptually what the physical properties of his inventions were. The physical theories were essential, just like the diagrams outlining the arrangement of internal circuitry. Particularly with the diversity of ether theories circulating within the scientific community, he believed a clear explanation of his own understanding was essential.

For Tesla, the inclusion of his ether theory was not only necessary background for his 1892 lecture but also the logical continuation of his research on alternating current. His wireless research rose directly from his interest in transmitting alternating current power around the earth. In the patent application for his wireless lights Tesla noted that "generally accepted theories of scientists" agreed that "molecular bombardment, condenser action, and electric or etheric disturbances were the cause of the phenomenon [of wireless lighting]." The wireless lighting system served as the first instance in which he was able to transmit power wirelessly and this

[74] "Mr. Tesla's High Frequency Experiments," *Industries*, July 24, 1891.

became the goal of many of his future inventions. He believed that the underlying principle behind wireless power transmission was "etheric vibrations" and that these vibrations created a sympathetic resonance within the circuits. As explained previously, Tesla conceived of these vibrations as sound waves or longitudinal waves in the ether. High frequency alternating current was able to induce this vibration in the ether. He explained that in this way "he obtained energy in another conductor without any metallic connection whatever."[75]

The ether was not the only problem of physics on which Tesla offered his views. Shortly after Wilhelm Roentgen's 1895 announcement of his discovery of "Roentgen shadows," later called x-rays, Tesla published an article in *Electrical Review* featuring several of his own x-rays. There he attempted to explain the phenomenon. In fact he had used a method similar to the one Roentgen had used prior to the discovery. In attempting a photographic experiment using a Crookes tubes as a light source, Tesla believed that the photographic plate had been ruined. The tube, however, had produced x-rays as well as visible light and instead of producing the image expected, it produced an image of the screw in the camera. The tube had ruined the photographic plate even before it exposure to visible light.[76] But Tesla never made the connection and so missed his chance to discover x-rays. In the article, he suggested that the "effects on the sensitive plate are due to projected particles, or else to vibrations far beyond any frequency which we are able to obtain by means of condenser discharges."[77] The idea that x-

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[75] "Nikola Tesla and His Wonderful Discoveries," *The Electrical World* XXI, no. 17 (1893).

[76] Carlson, *Tesla: Inventor of the Electrical Age*, 222.

[77] Nikola Tesla, "Tesla's Startling Results in Radiography at Great Distances through Considerable Thickness of Substance," *Electrical Review*, March 11, 1896

rays were projected particles, was drawn from the British physicists and the suggestion that x-rays were high frequency vibrations was the other major competing theory.[78]

What Tesla did reveal with the ether theory he promoted in 1892 and his criticisms of his scientific contemporaries was how essential he believed physical theory was to his inventive process. His reliance on physical theory for his own invention meant that his invention was colored by those theories. In the case of the ether, Tesla's invention and his understanding of theory reflected the uncertainty in British physics about the precise form and function of the ether. Tesla's writings also reflected the difficulty scientists faced in understanding the relationship between God and the new discoveries in physics. In one article, Tesla explained that the "luminiferous ether" was the Akasa, a term for the ether used in Buddhism.[79] Although he never expanded on this, it reflected his uncertainty about whether the ether was simply a physical phenomenon or if it had some metaphysical attributes, an uncertainty reflected by other nineteenth-century scientists. His inclination to attempt to understand physical science using spiritual ideas was something Crookes, Thomson, Maxwell and many other scientists grappled with in the late nineteenth century. Energy physics and the ether had significant implications on debates about human free will. As new laws of physics arose, some implied that the natural laws dictated that there was no possibility of an active creator. Others sought to further incorporate the role of the creator into physical theories. They proposed that the ether might possess additional properties that might explain life after death.

[78] Bruce R. Wheaton, *The Tiger and the Shark: Empirical Roots of Wave-Particle Dualism* (Cambridge: Cambridge University Press, 1983), 20.

[79] Tesla, "Man's Greatest Achievement."

Physics, Religion and Free Will

An important aspect of the development of nineteenth-century physics was the role of a divine creator. Tesla had a very conflicted relationship with religion, perhaps because he was brought up as the son of a clergyman, yet he was deeply involved in the scientific world. He explained in an article from 1935 that he was "not a believer in the orthodox sense" but that he did

> commend religion, first because every individual should have some ideal—religious, artistic, scientific, or humanitarian—to give significance to his life. Second, because all the great religions contain wise prescriptions relating to the conduct of life, which hold good now as they did when they were promulgated.[80]

The inconsistencies in his personal views on religion were also reflected in the work of his idols, the British physicists. For some, like William Thomson and James Clerk Maxwell, the creator's role remained essential in scientific discoveries. They believed in an omnipotent God who had created the universe and established the laws of nature. These laws, the laws of conservation of energy and mass, could only be altered by the divine creator, for they were absolute. But physics faced the same difficulty as the physiologists discussed in the previous chapter: what role did free will have in relation to the new theories? A creator imbued the body with a soul, but how could physicists observe the action of that soul? How could the soul exert a force? Energy? Maxwell suggested that if the soul exerted a direct force, ultimately "it would only last till it had done a certain amount of work, like the spring of a watch" at which point it would run out.[81]

Tesla had a complicated understanding of free will, framed by his work on the telautomaton. He came to an understanding of the human soul like he did for many physical

[80] Tesla, "A Machine to End War."

[81] James Clerk Maxwell to Lewis Campbell, April 21 1862, in Lewis Campbell and William Garnett, *The Life of James Clerk Maxwell with a selection from his correspondence and occasional writings,* (London: Macmillan and Co, 1882), 335.

theories, by attempting to develop an experimental understanding. Previously, his understanding of the ether developed as a result of his work attempting to transmit electrical power wirelessly using the ether. The telautomaton offered Tesla a way to understand the limits of automatism: how human could an automaton be made and how automatic was a human? This was not only an attempt to construct an automaton, but also to determine the limits of technology in creating an automaton: could he imbue it with free will? Intelligence? The telautomaton as constructed was a device that "mechanically represented" him and had a "borrowed mind." But he believed the "art of telautomatics" might one day develop an automaton "which will have its 'own mind," and would be able to react to external influences and perform "independent of any operator." [82] To him the telautomaton was the first creation in a new field and future automata would be more capable of acting independently.

Tesla frequently mentioned his own "free will" as a matter of fact in his writings throughout his adult life. In his autobiography he claimed that he was able to exert the force of his will, but in the same text he explained that he discovered he was an "automaton, devoid of free will."[83] In other texts he suggested that the soul showed itself in the eye. But whether he actually believed in the soul remains unclear. In 1931, when asked if there was a soul or a spirit he said "there is no soul or spirit. These are merely expressions of the functions of the body. These life functions cease with death and so do soul and spirit."[84] Yet in other interviews he seemed to take the existence of the human soul as a matter of fact. When interviewed about a medical team's claim to have "weighed the soul" in 1907, Tesla first ridiculed the attempt, saying it was "altogether too absurd for discussion" that "an aggregation of impressions thoughts

[82] Tesla, "The Problem of Increasing Human Energy."

[83] Tesla, "My Inventions," 665.

[84] "Tesla Seeks to Send Power to Planets."

and feelings have no materiality." Nevertheless, he went on to criticize the method the team utilized. He argued that the scale used would not be a "fit instrument" for weighing the human soul.[85] Still, several of his other writings suggest the existence of the soul. He compared energy to the soul that "animates the inert universe."[86] In another case, when discussing the growth of a human child, he suggested that "the artist, the inventor and the man of science give expression to the longing of the soul."[87] Tesla observed other scientific studies like these doctors and considered this carefully in his own work, analyzing any experimental error that might offer explanation. He attempted to develop an experimental understanding of free will through observation of other experiments and the development of his own automaton.

While Tesla searched for an experimental understanding of free will, his British contemporaries attempted to understand free will and the human soul on a more theoretical level. Maxwell sought to understand how human free will could be made compatible with the conservation of energy. Although Maxwell was not the first to consider this issue, his work influenced other physicists in the nineteenth century. In a thought experiment, first proposed in 1879 and later called "Maxwell's 'demon,'" he developed and exploited a theory that free will required no work, preventing the problem of the human automaton winding down like a watch. William Thomson coined the term demon and was quite enthusiastic about the thought experiment.[88] Maxwell's "demon," imagined a situation in which the second law of thermodynamics could be violated and it presented a powerful example of the limits of human

[85] "Scientists Doubt the Human Soul Was Weighed."

[86] Tesla, "What Is Electricity?"

[87] Tesla, "Nikola Tesla Shows How Men of the Future May Become as Gods."

[88] Smith and Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, 622.

knowledge.[89] The second law of thermodynamics states that heat will never flow from a cold object to a hot object but it will always seek a state of equilibrium.

Maxwell's thought experiment, however, proposed that in a pair of isolated objects, the flow of heat between the two gases at equilibrium is restricted to a small gateway. A small demon would open and close the gateway, but it would only do so to allow faster than average molecules to pass through the doorway. By allowing only the faster than average molecules to pass, one of the objects would become warmer. In this thought experiment, the second law of thermodynamics could be violated: a system's entropy would decrease (be made more ordered) without any energy expended because the only "force" in the system was the free will of the demon. The demon, a finite being with the same capabilities as man, was able to violate the second law of thermodynamics.

> the notion of dissipated energy could not occur to a being who could not turn any of the energies of nature to his own account, or to one who could trace the motion of every molecule and seize it at the right moment. It is only to a being in the intermediate stage, who can lay hold of some forms of energy while others elude his grasp, that energy appears to be passing inevitably from the available to the dissipated state.[90]

Humans were limited because they could neither control molecular motions nor could they precisely observe them.[91] Maxwell's demon served as a counterexample to the arguments of some scientists that the second law of thermodynamics and energy physics indicated a deterministic world view. Unlike Tyndall and Huxley who suggested that new discoveries in statistics and atomism strengthened and clarified the scientific world, Maxwell's demon

[89] Wise, "The Maxwell Literature and British Dynamical Theory," 199.

[90] James Clerk Maxwell, "Diffusion," in *The Scientific Papers of James Clerk Maxwell* (Cambridge: Cambridge University Press, 1890), 646.

[91] Matthew Stanley, "Maxwell's Demon, Victorian Free Will, and the Boundaries of Science," *Journal of the History of Ideas* 69, no. 3 (2008): 489.

presented an example of where the connection between statistics, atomism and thermodynamics failed to provide a coherent explanation. [92] The demon served to illustrate the limitations of the human mind, which was limited to a statistical understanding.

Maxwell's and Thomson's promotion of the "demon" arose in part because of their objections to the lectures of John Tyndall. Tyndall, a British physicist and public lecturer who strongly supported Thomas Huxley's and Charles Darwin's work, interpreted the problem that free will presented very differently. In an article titled "Physics and Metaphysics," which he published anonymously in 1860, he declared that, "every thought and every feeling has its definite mechanical correlative."[93] For Tyndall, feelings and thoughts could be reduced to a purely mechanical explanation, eliminating two traits typically attributed to the soul. Maxwell's demon provided a mathematical solution to free will, but he argued that the problem remained that there was no mechanical correlative. No physical structure in the brain or observed system behaved in a manner suggesting the soul exerted any influence. Tyndall lamented that his contemporaries refused to acknowledge this and expected that further research should reduce "the visible phenomena of life to mechanical attraction and repulsions." Although Tyndall speculated that physics ultimately might be limited in its explanation of the human mind, he did not believe that scientists had reached that point.

In 1860, Tyndall also suggested that the term "vital force" should be discarded.[94] "Vital force" and "animal spirits" were used in medicine and physiology to explain internal forces and internal energy and were often linked with the soul. To Tyndall this term was far too vague to be

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[92] Theodore M. Porter, "A Statistical Survey of Gases: Maxwell's Social Physics," *Historical Studies in the Physical Sciences* 12, no. 1 (1981): 103.

[93] John Tyndall, *Essays on the Use and Limit of the Imagination in Science* (London: Longmane, Green, and Co., 1870), 70.

[94] Ibid., 72.

included in a scientific discussion. Tesla likewise recommended that vital principle should be discarded. He further explained that "the realistic aspect of the perceptible universe as a clockwork wound up and running down […] need not be in discord with our religious and artistic aspirations."[95] Tesla, likely unknowingly yet using the same metaphor, directly contradicted Maxwell's suggestion that human free will could not direct the moving force of the body because "it would only last till it had done a certain amount of work, like the spring of a watch."[96]

Maxwell and Tyndall were central in the conflict between those who believed that there was a divine creator and those who believed there was insufficient evidence to support the existence of one. This conflict played out in many forums, but most publicly in a series of addresses before the British Association for the Advancement of Science given by William Thomson, James Clerk Maxwell and John Tyndall. William Thomson concluded his 1871 presidential address by stating that the

> overpoweringly strong proofs of intelligent and benevolent design lie all round us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature the influence of a free will, and teaching us that all living things depend on one ever-acting Creator and Ruler.[97]

For Thomson and Maxwell, God and free will were fundamental assumptions. As was clear from Thomson's response to energy conservation and to Maxwell's demon, Thomson profoundly believed that the creator continued to act in nature. Maxwell's 1873 address echoed these beliefs. In a talk on molecules Maxwell argued that each molecule has "the essential character of a manufactured article." He, like Thomson, suggested that some findings lay outside of the

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[95] Tesla, "How Cosmic Forces Shape Our Destinies ('Did the War Cause the Italian Earthquake?')."

[96] James Clerk Maxwell, "Letter from Maxwell to Lewis Campbell, April 21, 1862," in *Maxwell on Molecules and Gases* (Boston, MA: MIT Press, 1986), 337–338.

[97] William Thomson, *Popular Lectures and Addresses, Vol II* (London: Macmillan and Co, 1894), 205.

realm of scientific understanding and that "science is incompetent to reason upon the creation of matter itself out of nothing." [98] Scientists did not have the kind of authority to determine either positively or negatively existence of the soul.

Tyndall's address before the British Association in 1874 drew significant criticism and stood in stark contrast to Maxwell and Thomson's arguments. Newspapers and fellow scientists interpreted the talk as an attack on religion and a promotion of determinism and materialism. Unlike Thomson and Maxwell, Tyndall ruled out the possibility that there existed phenomena outside the realm of scientific understanding. He argued that "all religious theories […] must submit to the control of science, and relinquish all thought of controlling it" instead of Thomson and Maxwell's work on the demon which suggested that some phenomena may defy scientific explanation. In the address he primarily promoted Darwin's theory of evolution but his speech also included some discussion of the doctrine of the Conservation of Energy. He promoted the theory, arguing that it bound "nature fast in fate" and brought "vital and physical phenomena under the dominion of that law of causal connexion which […] asserts itself everywhere in nature."[99] For Tyndall then, the Conservation of Energy provided more evidence of the connection between cause and effect.

Like Tyndall, William Clifford, who previously had entered into the debates on human automata, believed that science offered significant explanatory power and that religion had no place in science. Clifford, a physicist who had voiced his opinions on the mind-body debate, directly attacked Maxwell's argument that atoms seemed to be manufactured articles. He considered Maxwell's argument briefly, but in an 1874 lecture asked "whether the evidence we

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[98] James Clerk Maxwell, "Molecules," *Nature*, September 1873.

[99] John Tyndall, *Address Delivered Before the British Association Assembled at Belfast* (London: Longmane, Green, and Co., 1874).

have to prove that these molecules are exactly alike is sufficient to make it impossible that they can have been produced by a process of evolution."[100] He argued further that Maxwell provided no clear evidence and argued from a position that was completely impossible to disprove. Instead, he suggested that Maxwell's argument rested only on "his great authority." The accomplishments of Thomson and Maxwell placed them in a position of significant scientific authority in large part because of their role in the development of energy physics.

In an 1877 essay published in the *Fortnightly Review*, Clifford attacked religion directly. He instructed believers to "bring your doctrines, your priesthoods, your precepts, yea, even the inner devotion of your soul, before the tribunal of conscience; she is no man's and no God's vicar, but the supreme judge of men and Gods." Clifford's written style suggested the tone of a sermon; he called forth the believers. He also deliberately selected a wide variety of religions to analyze: Egyptian, Greek, Roman as well as Christian. He asked the reader: is it right to worship a god who commits immoral acts? He used the example of Zeus and his marital transgressions, but quickly transitioned to a discussion of original sin. He argued that "if God holds all mankind guilty for the sin of Adam […] then it is wrong to worship him."[101] But Clifford's argument was largely theological and logical and he introduced no scientific argument against religion.

Tyndall and Clifford seized upon the difficulty that rose out of the new advances in science in the nineteenth century. They considered religion and science to be incompatible and said that the two could not coexist. In contrast, Tesla believed that religion offered a valuable service to mankind and he believed that the two could coexist. But instead of emphasizing the role of the creator he examined religion as an institution. This is a significant difference from the approach of others who either believed or rejected religion. Although Maxwell, Thomson, and

[100]William Kingdon Clifford, *Lectures and Essays, Vol 1* (London: Macmillan and Co., 1879), 203.

[101] Clifford, *Lectures and Essays, Vol 2*, 373.

Joule were aware of the difficulties that these new advances posed to religion, they still attributed some agency to a divine creator. They did not believe the two were incompatible, yet they did realize that there were significant difficulties in reconciling religion and science. For them, these difficulties came from incomplete scientific knowledge.

The Unseen Universe

Some scientists concluded that religion and science were now incompatible, but others still sought to reconcile the two. British physicists, Balfour Stewart and Peter Guthrie Tait attempted to do just this in *The Unseen Universe*, published in 1875. Their book sought this reconciliation in the same way as Tesla: to develop a physical understanding of the psychical. Although the first few editions of *The Unseen Universe* were unsigned, the authors' identities were not a complete mystery because of the theories that they employed in their argument. They relied heavily on William Thomson's vortex atom theory, thermodynamics, and the conservation of energy. The aim of the book, as stated in the preface to the first edition, was to "show that the presumed incompatibility of Science and Religion does not exist." [102] Ultimately, Stewart and Tait concluded "by strict reasoning on purely scientific grounds" that "a life *for* the unseen, *through* the unseen, is to be regarded as the only perfect life."[103]

Stewart and Tait's argument relied heavily on the Principle of Continuity: that scientific progress goes from the "less to the more perfect."[104] From this principle they argued that a

[102] Balfour Stewart and Peter Guthrie Tait, *The Unseen Universe or Physical Speculations on a Future State*, 2nd ed. (London: Macmillan and Co, 1875), xi.

[103] Ibid.

[104] Ibid., 85.

"supreme Governor of the universe" would not "put us to permanent confusion."[105] What they meant became clearer as they worked to incorporate more scientific theories. They began by describing the theory of conservation of energy and the interconvertibility of work and heat. They then transitioned to an explanation of the origin of the second law of thermodynamics and, using a different method, reached the same conclusion as William Thomson. The second law of thermodynamics dictated that ultimately the universe was progressing toward a state of complete disorder. This disorder would be the heat death of the universe.[106] By using the principle of continuity in concert with the second law of thermodynamics, Stewart and Tait reiterated the argument of Thomson that the visible universe would "arrive at such a state as to be totally unfit for the habitation of living beings."[107] This conclusion of the laws of thermodynamics intimidated many scientists in the late nineteenth century. In Stewart and Tait's brief outline of the history of thermodynamics and energy the authors suggested that heat energy presented the greatest "problem:" "at each transformation of heat-energy into work a large portion is degraded, while only a small portion is transformed into work."[108] Fundamentally, they supported the conclusion that the visible universe would come to an end.[109] But, they maintained that the Principle of Continuity dictated that there must be something beyond the visible and both theologians and scientists had overlooked this possibility. To them the proof of the unseen universe rested in the reality that the visible universe came to an end. The energy lost by man could be used by the invisible in an afterlife and energy physics was the key to not only

[105] Ibid., 60.

[106] Smith and Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, 501.

[107] Stewart and Tait, *The Unseen Universe or Physical Speculations on a Future State*, 63.

[108] Ibid., 90.

[109] P.M. Heimann, "The ' Unseen Universe ': Physics and the Philosophy of Nature in Victorian Britain," *The British Journal for the History of Science* 6, no. 1 (1972): 77.

understanding visible life but also the afterlife.[110] By introducing the unseen universe as the logical continuation of the progress of physics and the progress of the universe, they attempted to gain some legitimacy.

Tesla's work also offered the possibility of interaction between the unseen and the human body, and like Stewart and Tait he attempted to incorporate physical theory into his reasoning. He argued that when "ether waves impinge upon the human body they produce the sensations of warmth or cold, pleasure or pain, or perhaps other sensations of which we are not aware."[111] Stewart and Tait relied on the "unseen" to explain these sensations. They credited spiritualists with the introduction of the invisible or the "unseen universe." Spiritualism was a belief system that gained significant popularity in the nineteenth century and proposed, despite the arguments of scientists like Clifford and Tyndall, that there was life after death. The invisible world was not "absolutely distinct from the visible universe" and it shared "some bond of union with the present."[112] Stewart and Tait defined the unseen universe as "an invisible order of things intimately connected with the present, and capable of acting energetically upon it."[113] Although they sought to reconcile science and religion, they never directly tackled the problem of free will or the human soul. They referred to free will repeatedly and seemed, like Thomson and Maxwell, to take its existence as a fundamental assumption. *The Unseen Universe* did not question the existence of the human soul; instead it attempted to understand the soul's interaction

[110] Graeme Gooday, "Sunspots, Weather, and the Unseen Universe," in *Science Serialized: Representations of the Sciences in Nineteenth-Century Periodicals*, ed. Geoffrey Cantor and Sally Shuttleworth (Cambridge, Massachusetts: The MIT Press, 2004), 133.

[111] Tesla, "On Light and Other High Frequency Phenomena," 205.

[112] Stewart and Tait, *The Unseen Universe or Physical Speculations on a Future State*, 43.

[113] Ibid., 158.

with the seen and unseen universes. The authors suggested nature "works by unseen bodies" like smell, heat and cold and so the suggestion of an unseen universe was not outrageous.[114]

The ether in particular provided a way for Stewart and Tait and Tesla to incorporate metaphysical concepts into the physical. Although very different from their work, Tesla's description of the luminiferous ether as the "Akasa […] which is acted upon by the life-giving Prana, or creative force" certainly attempted to incorporate aspects of the physical and the metaphysical.[115] Akasa or ākāsa translates from Sanskrit as "ether" and an "all-pervading, infinite, indivisible, permanent and unperceivable substratum."[116] Similarly, Tait and Stewart suggested that through the ether "the scientific mind is led from the visible and tangible to the invisible and intangible" as "the properties of the ether are of a much higher order in the arcana of nature than those of tangible matter."[117] For Stewart and Tait and Tesla, the ether, a perfect fluid that filled all space, was the primary material that composed the invisible universe, and the connection between the two universes was Thomson's vortex atoms. Tait and Stewart emphasized that these atoms, although they were composed of the invisible, were a part of the visible universe. Similarly, Tesla suggested that the "primary substance, thrown into infinitesimal whirls of prodigious velocity, becomes gross matter."[118]

The Unseen Universe elicited a wide range of responses from both theological and secular sources, but one of the most critical responses came from William Clifford. Clifford's review, published in 1875 in the *Fortnightly Review*, offered a very critical response to the

[114] Ibid., 90.

[115] Tesla, "Man's Greatest Achievement."

[116] A Pablo Iannone, *Dictionary of World Philosophy* (New York: Routledge, 2001), 30.

[117] Stewart and Tait, *The Unseen Universe or Physical Speculations on a Future State*, 116.

[118] Tesla, "Man's Greatest Achievement."

theories promoted by Stewart and Tait. Clifford began his review with a critical response to Stewart and Tait's use of Thomson's vortex atoms. Although he appeared to find Thomson's vortex atom theory useful and brilliant, he objected to its use in *The Unseen Universe* because the argument depended on describing "phenomena in terms of phenomena." Thomson's work was still so theoretical that describing other theories depending on vortex atoms was problematic. Vortex atoms were only "still more complex mental images" or overly complicated conceptual explanations.[119] He also took issue with the implication that when the human body and consciousness ended in this universe, a "spiritual body" would be formed in the second ether. He explained the complexity of the human mind and consciousness and concluded that "if there is any similar connection with a spiritual body, it only follows that the spiritual body must die at the same time with the natural one." But it was Stewart and Tait's assumption that "the existence of a Deity who is the Creator of all things" that Clifford attacked most vehemently:

> Let us contemplate the reposeful picture of the universal divan, where these intelligent beings whiled away the tedium of eternity by blowing smoke-rings from sixty-three different kinds of mouths. We may suppose, if we like, that the intelligent beings were all alike, and each had sixty three mouths; or that each was so constituted in his physical or moral nature that he could or would pull only sixty-three faces.[120]

When Clifford wrote this passage in 1875 there were only sixty-three elements in existence, hence the sixty-three mouths. To Clifford it was unscientific to assume the existence of a deity when no evidence existed to support the conclusion. This was problematic because this assumption, like the existence of a human soul, was a major premise in the book. Clifford's scathing response to *The Unseen Universe* highlighted the continued division in science and physics over the role of the ether.

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[119] Clifford, *Lectures and Essays, Vol I*, 243.

[120] Ibid., 250.

Tesla sought to develop physical theory and to participate in discussions on those theories in a way that other inventors from in the nineteenth century avoided. The theories that he discussed most were some of the most important to nineteenth-century physics, but also some of the most disputed. So not only does Tesla provide a detailed description of how nineteenth-century engineers might have understood physical theory, but his participation was framed by his inventions, particularly the telautomaton and the wireless system. Although Tesla's theories were far from revolutionary, he was able to participate in these discussions through the fame and perceived expertise he acquired through his work on alternating current. Moreover, he was able to explore many of these ideas in a way that nineteenth-century scientists only imagined. While Lodge, Maxwell and Thomson theoretically considered ways that the ether might be analogically constructed, Tesla created devices that were meant to demonstrate these theories.

Chapter 4:
Society for Humanity
The Social Body, Health, Mesmerism and Psychical Research

The boundaries of science and what could be considered scientific prompted serious discussion in the nineteenth century. Psychical research, mesmerism, electrotherapeutics and electrobiology all struggled to find a niche and gain scientific legitimacy. Some of this research, like electrotherapy, found widespread acceptance within the medical fields in both theory and practice. Other research, like that performed by members of the Society for Psychical Research, never gained legitimacy. The telautomaton sat, once again, squarely in the middle of these discussions. I argue that Tesla's involvement in electrotherapy and psychical research were deeply connected with his philosophical consideration of the remote controlled automaton. Tesla's inventions and research aimed, above all, to improve the health of the social body using whatever means necessary, including psychical research. How did the telautomaton and the wireless system integrate ideas on the fringes of science? How did this serve to connect to respected nineteenth-century physical and physiological theories? Although Tesla did aim with the telautomaton to demonstrate important principles in physics and physiology, the device also fit into a particular social vision. Fundamentally, the ambiguity concerning the role of the telautomaton allowed Tesla to consider it for a wide range of purposes. This same ambiguity was reflected in the nature of the ether. Because scientists lacked certainty about the form and function of the ether, it served as a possible medium for the transmission of psychical energy in addition to the transmission of electrical energy.

Interest in the scientific study of unexplained phenomena like those described in the *Unseen Universe* took several different forms in the late nineteenth century. In some cases it was promoted by scientists, but other times this research took place by those outside of science by public exhibitionists who sought to emulate it. The introduction of the ether as a possible medium for the transmission of these psychical phenomena, and the uncertainty about the nature of the ether presented the opportunity for many to become involved in what they claimed were scientific demonstrations. Franz Mesmer, an eighteenth-century researcher, and Baron Charles von Reichenbach in the nineteenth century, investigated similar phenomena but proposed radically different explanations for these phenomena.[1] Fundamentally, both sought to manipulate individuals' magnetic energies in an effort to heal them of assorted maladies. Although Mesmer's research took place in the eighteenth century, his methods gained such popularity that they were still widely practiced in the middle of the nineteenth century and the ether provided a potential new focus for these speculations. By the nineteenth century, mesmerism gained significant empirical support through scientific research and repeated public demonstrations.[2] Mesmerists also incorporated their own explanations of physical theories on light and electricity.[3] Reichenbach proposed his own theory of animal magnetism and apparently conscious of new theories in the ether as he described the "odic fluid" that transmitted sensations. Both of these investigators sought to establish scientific legitimacy of their research through the language they used and the appearance of scientific research.

The study of animal magnetism and mesmerism often intersected with research and demonstrations of electrobiology. Although sometimes used to describe a specific practice, in this paper electrobiology will refer to a wide range of researches that attempted to discern the

[1] Winter, *Mesmerized: Powers of the Mind in Victorian Britain*.

[2] Arthur Wrobel, "Introduction," in *Pseudo-Science and Society in Nineteenth Century America*, ed. Arthur Wrobel (Lexington, Kentucky: The University Press of Kentucky, 1987), 5.

[3] Robert Darnton, *Mesmerism and the End of the Enlightenment in France* (Cambridge, Massachusetts: Harvard University Press, 1968), 128.

connection between electricity and life, a definition outlined briefly by Edward Bulwer Lytton in 1886 and later in detail in the 1918 edition of the *Encyclopedia Americana*. The studies that I consider as part of the field of electrobiology often failed to gain scientific or medical support, with the exception of research in electrotherapy. Electrotherapy stands apart from much of the other research explored in this chapter because the research took place in a medical clinic and its study was far more regimented than that of animal magnetism. Those scientists and doctors pursuing electrotherapy, however, had to be particularly cautious of claims of charlatanism.[4] There existed at least two professional organizations, including the "American Electro-Therapeutic Association," and electrotherapy was taught in many first-rate medical schools.[5] Practitioners published articles in medical journals evaluating the efficacy of electrical treatment of patients.[6]

Investigations into mesmerism and animal magnetism captured the imagination of the nineteenth-century public. Mesmeric knowledge spread primarily through traveling lecturers who introduced the subject and dazzled the spectators with their demonstrations.[7] It was precisely the spread of mesmerism through these travelling lecturers, who often traveled with their own "patients" in case an appropriately sensitive subject was not in the audience that blurred the line between science and charlatanism. Fields dealing with the physiological effects of electricity and magnetism were particularly difficult to distinguish from these new demonstrations of mesmerism and the possibilities that mesmerism suggested about science was particularly seductive. Nineteenth-century mesmeric and spiritualistic demonstrations claimed

[4] Iwan Rhys Morus, "Batteries, Bodies, and Belts: Making Careers in Victorian Medical Electricity," in *Electric Bodies: Episodes in the History of Medical Electricity*, ed. Paola Bertucci and Giuliano Pancaldi, 2001, 212.

[5] Lawrence D. Longo, "Electrotherapy in Gynecology: The American Experience," *Buelletin of the History of Medicine* no. Fall (1986): 350.

[6] George M. Beard, "Suggestive Cases Treated By Electricity," *The American Practioner* 9, no. April (1874).
[7] Winter, *Mesmerized: Powers of the Mind in Victorian Britain*, 114.

to be able to manipulate the volition of the subjects of the demonstrations.[8] This possibility of a connection between volition, physiology and electricity and magnetism represented incredible possibilities. Some scientists condemned this research; however, a small group of interested scientists sought to uncover what connections might exist between psychical phenomena, mesmeric phenomena, the ether, and electricity and magnetism. The telautomaton and the wireless system sit squarely, once more, in the middle of this wide range of research. The possibility of constructing an automaton capable of acting with volition mostly clearly demonstrates the connection between these ideas of ether, energy and volition.

Figure 18 An advertisement for a public demonstration of mesmerism. (See Image note 18)

The scientists who pursued research on these topics were members of the Society for Psychical Research, which had active chapters in the United States and Great Britain. The Society sought to determine the legitimacy of mediums, mind readers and others that claimed psychical abilities or connections. Moreover, they investigated the claims of mesmerism, Reichenbach's Odylism and mysteries like telepathy. Many believed that the basis for these connections could be found in the connection between an individual and the ether. Some of their peers, like Michael Faraday and William Thomson,

[8] In Winter's *Mesmerized* she particularly uses the example of the demonstrations of H.E. Lewis would "would suspend an individual's will while leaving him or her conscious and fully cognizant of all that transpired," 281.

rejected the research of these scientists. Although Tesla never joined the ranks of the Society for Psychical Research, he maintained a friendship with William Crookes, the President of the British Society for Psychical Research and also a respected researcher of electromagnetic phenomena. Crookes's influence on Tesla's consideration of these topics was strong, and the telautomaton in particular pushed Tesla to seriously consider a connection between life and electricity. Because of his profound conviction that the telautomaton would one day be able to function as an independent being, he explored, however briefly, the possibility of the psychical.

Realizing that the division between recognized scientific study of electrobiology and mesmerism was frequently unclear, Tesla attempted to distance himself from the outrageous claims of Odylism and Mesmerism when he pursued his own research in electrobiology and electrotherapy. Because of his expertise in electricity, he communicated frequently with researchers in electrotherapeutics. The Tesla coil provided a significant opportunity for progress in electrotherapeutics because of its portability and the high voltage and high frequency discharge that it could provide. Despite the significant advantages of his devices, he was careful with the invention, demonstration, and testing of medically associated devices. He emphasized the importance of the consultation of medical professionals and backtracked quickly when others made improbable claims about the abilities of his inventions. Despite his care in this regard, much of his work paralleled some of the more questionable claims of those researching electrobiology. The clearest case was the second and final time he presented the telautomaton, for the Chicago Commercial Club in 1899. In this demonstration, he detailed some of these ideas that he believed might push the boundaries of what could be considered psychical science, a field he flatly rejected, and what could be considered physical science. He claimed that by using electricity and magnetism he believed he could demonstrate to the audience that inanimate objects could be understood as "dead" or "alive." Although this view seems an extreme example, it underlines how convinced Tesla was that the idea of life and death were closely connected to electricity and magnetism. While this perspective seems an idea that could be easily explained away as one of Tesla's eccentricities, the connection between life and electromagnetism was prominent in nineteenth-century thought.[9]

At its core, the connection between the wireless system and electrobiology, mesmerism and electrotherapy, and many other scientifically ambiguous theories from the nineteenth century, was the idea of communication. All of the researchers in these fields sought to improve communication. Tesla's wireless system attempted this through global communication while mesmerists and electrobiologists sought to improve communication within the human body. Some scientists in the late nineteenth century, like William Crookes and his colleagues in the Society for Psychical Research, desperately wanted to believe that some form of communication was possible directly between people using the medium of the ether. Researchers made use of any connection that might be available, even connections that lacked significant scientific support.

Electrobiology

The possibility of communication between mind and body through the ether offered an exciting new direction to some scientists. If the mind communicated with the body using the ether, the medium for the transmission of electromagnetic waves, then those waves might be able to affect mind and body communication. This possibility is precisely what the authors of the

[9] Baron Karl Von Reichenbach and John Ashburner, *Physico-Physiological Researches on the Dynamics of Magnetism, Electricity, Heat, Light, Crystallization, and Chemism in Their Relation to Vital Force* (New York: J.S. Redfield, 1851); Beard, "Suggestive Cases Treated By Electricity"; Charles Radclyffe Hall, "On the Rise, Progress, and Mysteries of Mesmerism," *The Lancet*, February 1, 1845; Winter, *Mesmerized: Powers of the Mind in Victorian Britain*.

Unseen Universe sought to understand in the late nineteenth century. They used the ambiguity of the form and function of the ether to suggest a connection between the soul and the body through the ether. The study of the possible connection between electromagnetism, the ether and mind-body communication renewed interest in electrobiology, a subject of research that had existed on the fringes of science since the work of Franz Mesmer in the late eighteenth century.

Mesmer was best known for his research attempting to study the effects of magnets on nervous disorders. He believed that these magnets would manipulate the fluid of animal magnetism within the subject; this could then improve communication within the body and bring relief to the disorder. Mesmer suggested that most nervous disorders were caused by improper flow of the "fluid of animal magnetism." Despite his best efforts, the Berlin Academy, the Royal Society of Medicine and the French Academy of Sciences all refused to acknowledge the authenticity of his results. A French Royal Commission issued a report in 1784 arguing that "the fluid of animal magnetism cannot be perceived by any of the senses and that it has no effect either upon themselves nor upon the patients submitted to them."[10] Despite the refusal of scientific bodies to recognize Mesmer's research, he gained many followers who were convinced that his methods were successful. Often, the reluctance and sometimes outspoken opposition of medical and scientific authorities only served to encourage these supporters. Mesmerism and the manipulation of animal magnetism spread rapidly and increased in popularity throughout Europe. Mesmer and his investors founded the "Society of Harmony," in the late eighteenth century, a group that sought to train others in mesmerism. As members founded more of chapters, the "Society for Harmony" increased their scope to include any who wished to adopt Mesmer's teachings. In particular they opened the group to those seeking to improve the health of the social body, not just those seeking the manipulation of the magnetic fluid. The

[10] Frank Pattie, *Mesmer and Animal Magnetism* (Hamilton, New York: Edmonston Publishing, Inc., 1994), 151.

improvement of individual health through the manipulation of their magnetic energies improved the state of public health and thus improved the overall health of the social body.[11]

Mesmerists grasped at connections to scientific research that might strengthen the claims of their demonstrations. Moreover, some scientific theories capitalized on the ubiquity of mesmeric demonstrations that spread knowledge of unconscious movement. In particular, Hall's 1832 paper on the reflex arc and Carpenter's 1852 paper on ideo-motor reflex played critical roles. The emerging theory of mental reflexes capitalized on the mesmeric demonstrations that highlighted individuals acting automatically based on external events. This theory explained clearly a phenomenon previously considered to be mysterious. Some outside of science also sought to grasp these connections. Walter Bagehot, a nineteenth-century British writer, wrote *Physics and Politics* in which he provided an evolutionary history of civilization and the close connection between the nervous system and the progress of mankind.[12] He explained that without a sound understanding of the "transmitted nerve element [it would be impossible to] ever understand 'the connective tissue' of civilisation."[13] For Bagehot evolution was most apparent in the "nerves of men, and age after age, making nicer music from finer chords."[14] He suggested that as the system of man's nerves evolved then society and government moved towards the present system. Mesmerism in the nineteenth century sought to capitalize on some of these ideas: improved communication within the individual could improve communications between individuals and improve social communication in much the same way.

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[11] Winter, *Mesmerized: Powers of the Mind in Victorian Britain*, 307.

[12] Ibid., 333.

[13] Walter Bugehot, *Physics and Politics* (New York: Appleton and Co., 1893), 9.

[14] Ibid.

Baron Karl Von Reichenbach published research resembling Mesmer's in an article on "Odic" force that appeared in 1839. He observed that in certain patients the exposure to a strong magnet would cause "sensations of drawing, pricking, or creeping."[15] Tesla reported a similar sensation in his description of the sensations produced when ether waves "impinge upon the human body" causing any number of sensations "of which we are not aware."[16] Although Reichenbach recognized a connection to electromagnetism, he believed what he encountered was an entirely new force. He struggled to name the force that he described, which "had the greatest variety of names applied to it, almost all of which have been derived from certain resemblances or complications of magnetism" and so he called the force "od" or "odic force."[17] This force was perceptible only to a few "sensitive persons" who were able to detect "odic emanations." Reichenbach's claims, sometimes called odylism, offered yet another potential connection between electromagnetic and psychic phenomena. "Sensitives" were able to detect visible emanations from "odic" forces. He offered photographic examples of the odic emanations as well as demonstrations of sensitive persons (Figure 19). In his 1851 paper, *Researches on Magnetism, electricity, heat, light, crystallization, and chemical attraction* he provided a list of over fifty sensitive persons. He explained that they were confirmed sensitives and were willing to respond to any questions about their abilities. This careful documentation was because Reichenbach, like Mesmer, sought scientific recognition for his work. In the early 1860s he performed a series of experiments for physicists in Berlin in an attempt to gain scientific acknowledgment of his research. They were unconvinced by his demonstration and he never

[15] Von Reichenbach and Ashburner, *Physico-Physiological Researches on the Dynamics of Magnetism, Electricity, Heat, Light, Crystallization, and Chemism in Their Relation to Vital Force*, 18.

[16] Tesla, "On Light and Other High Frequency Phenomena," 205.

[17] Von Reichenbach and Ashburner, *Physico-Physiological Researches on the Dynamics of Magnetism, Electricity, Heat, Light, Crystallization, and Chemism in Their Relation to Vital Force*, 176.

received any scientific acknowledgment of his work.[18] Gustav Fechner, a physicist who gave the greatest credence to Reichenbach's claims, was involved in the evaluation of other psychical claims in Germany.[19] The entanglement of electromagnetism, the ether and psychical phenomena was not only unique to Great Britain (examined later in this chapter). The physicists evaluating Reichenbach and other psychical claims in Germany were also involved in the development of German ether theories.[20]

In Great Britain and the United States, other researchers sought to develop a potential connection between human health and the ether. As already indicated by the work of Tait and

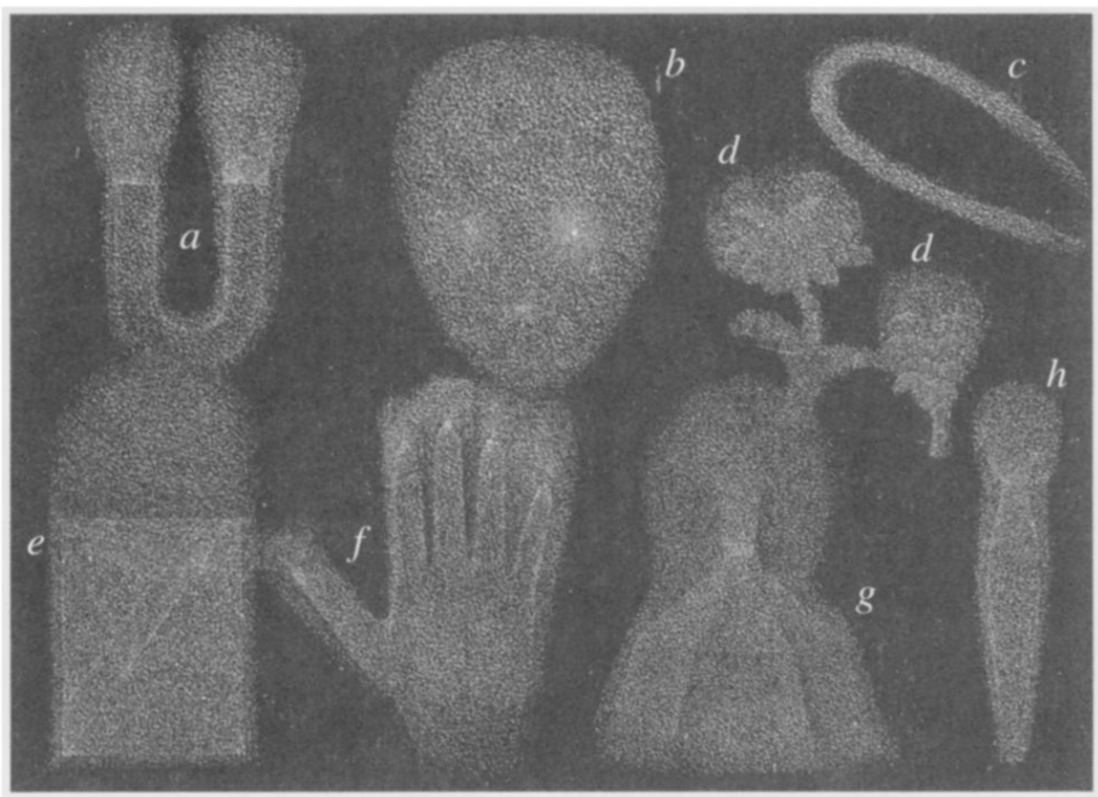

Figure 19 Photographic plate of odic emanations. (See Image Note 19)

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[18] Gustav Theodor Fechhner, *Erinnerungen an die letzten Tage der Odlehre und ihres Urhebers* (Leipzig: Breitkopf und Härtel, 1876) retrieved from http://gutenberg.spiegel.de/buch/1097/1 January 30, 2014.

[19] Heather Wolffram, "The Stpechildren of Science: Psychical Research and Parapsychology in German, C. 1870-1939," *Rodopi* 88 (2009): 41.

[20] Wise, "German Concepts of Force, Energy, and the Electromagnetic Ether: 1845-1880," 283.

Stewart on *The Unseen Universe,* the possibility of a connection between light, electromagnetism and the human soul was attractive to many. This included Edward Bulwer Lytton, the novelist responsible for the fictional account of the telautomaton. In *The Coming Race,* published in 1886, Bulwer Lytton provided a definition of "electrobiology" as well as the description of the telautomaton. Although the novel was fiction, the principles of electrobiology that he described developed from research similar to Reichenbach's and Mesmer's. Electrobiology as Bulwer-Lytton described it was the force used to control the automata: "that by other operations, akin to those ascribed to mesmerism, electro-biology, odic force, &c., but applied scientifically through vril conductors, they can exercise influence over mind, and bodies animal and vegetable, to an extent not surpassed in the romances of our mystics."[21] Bulwer Lytton's definition of electrobiology relied on the fictional force of "vril," yet he included in the description odic force and mesmerism. He explained that vril was a force very similar to electricity, except much more universal and incorporating other forces of nature. One of the earliest users of the term "electro-biology" was Alfred Smeet, a British surgeon. In 1849, he published *Elements of Electrobiology* in which he described his research on electricity and animals and suggested that all animal life could be considered as an electrical circuit.[22] Electro-biology began to appear more widely and a late definition that incorporated much of the historical ideas of the subject, appeared in *The Encyclopedia Americana*, in 1918:

> The term electro-biology was coined about 1850 to describe the relationship between electricity and life. We do not know what electricity is, and we do not know what life is; we have to judge of both by their manifestations. We know little of the nature and nothing of the origin of either, although some scientific men and some theologians are apt to be dogmatic in asserting that this or that must be or cannot be possible. But we do *know* that through *some medium* the

[21] Bulwer-Lytton, *The Coming Race*, 54.

[22] Alfred Smee, *Elements of Electro-Biology* (London: Longman, Brown, Green, and Longmans, 1849), 5.

> will controls man's sensory organism and physical functions and we choose to call this thing "animal magnetism" as Mesmer called it, and to consider it of the nature of electricity. Reasoning analogously, that as the wireless telegraph conveys a certain vibration which may be picked up by an instrument hundreds of miles away through etheric vibrations, caught by a coherer or detector, so we conclude that the will also originates vibrations, which many call thought-vibrations, and sends them through the etheric magnetism that imbues all men and animals, and perhaps all nature.[23]

Uncertainty about the exact nature of electricity and an incomplete understanding of human volition allowed a space in which those on the periphery of science pushed for a reconsideration of science. These experiments rarely took place in a laboratory and primarily were performed in public demonstrations.

In the nineteenth century, scientists, doctors, and the public discussed the potential of mesmerism and animal magnetism. These claims about the healing properties of electricity and the potential applications of Mesmerism were so widespread that it is difficult to believe Tesla was unaware of them. Moreover, the research in the early nineteenth century firmly established electrotherapy as a field of study that a "respectable" inventor might make an active contribution to. This was not the case with Mesmerism however. In a series of articles published in 1845 in *The Lancet* examined the claims, history and even outlined a detailed explanation of a particular demonstration of mesmerism. The article explained, "the public now expects the medical profession to investigate mesmerism and, as if any stimulus beyond this most reasonable expectation were needed, we were informed that in Paris every fourth medical man is already a mesmerist."[24] Nevertheless, after careful examination the author concluded that while some of the claims of mesmerism might be possible, overall "common sense will best refute the

[23] "Electro-Biology," *The Encyclopedia Americana: A Library of Universal Knowledge* (The Encyclopedia Americana Corporation, 1918), 184.

[24] Hall, "On the Rise, Progress, and Mysteries of Mesmerism," February 1, 1845, 112.

mesmerism of the mesmerists."[25] Yet, in a reprint of an 1843 address at an Ohio medical convention, published in *The Western Lancet* Dr. Robert Thompson provided rules that would allow the clearest approach to studying animal magnetism. He urged his colleagues to approach the study of mesmerism carefully and that "no person should be operated upon, who is not entirely willing to submit to mesmeric influences."[26] Although the general tone of these magazines directed at mesmerism was generally one of skepticism, many suggested that there was an element of truth to the claims made. *The Examiner*, a weekly British paper, offered in 1841 a detailed description of a mesmeric demonstration; they concluded that "however the phenomenon may be explained, or attempted to be denied, there is one fact of which there can be no doubt– the power of the somnambulist" to resist electrical impulses.[27] When a member of the audience exposed himself to the same electric current as the somnambulist, he was "so stunned by the blow that he actually pulled the machine off the table."

One of those involved in public demonstrations of the connection between the human nervous system and electricity and magnetism was Charles Wheatstone, a key inventor in the development of telegraphy. He collaborated with Bulwer Lytton and Dionysus Lardner in 1838, a writer of popular science, on a series of experiments relating electricity and mesmerism.[28] The goal of the experiments was to assess the "manifest connection of the phenomena of animal magnetism with the nervous system" and to determine "how far the operation of electricity upon that system would be modified by it."[29] In particular, Lardner believed that certain "magnetic

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[25] Charles Radclyffe Hall, "On the Rise, Progress, and Mysteries of Mesmerism," *The Lancet*, May 3, 1845, 495.

[26] Robert Thompson, "On Mesmerism," *The Western Lancet* 2, no. 4 (1843): 165.

[27] "Animal Magnetism," *The Examiner*, July 24, 1841, 473.

[28] Winter, *Mesmerized: Powers of the Mind in Victorian Britain*, 54.

[29] Dionysius Lardner and Edward Bulwer-Lytton, "Animal Magnetism," *Monthly Chronicle* 2 (1838): 26.

subjects" responded differently to electrical shocks. Wheatstone developed a variety of galvanic and electrical apparatuses that were then used to induce electrical currents and shocks in the patients. As with many demonstrations, the electrical apparatus was first tested on members of the audience, and "in each case produced a very severe effect." In the experiments,

> When administered, however, to the two patients, no visible effect whatever was produced: they held the ends of the wire steadily and apparently without any sensation or consciousness of any particular effect. It was observed, however, that a contraction of the muscles of the hands was apparent and the patients were not able to disengage their hands from the extremities of the wire.[30]

Wheatstone, Lardner and Bulwer Lytton's experiment is a clear example of the type of public demonstrations and research that took place in the mid and late nineteenth century under the auspices of scientific research.

Many of these demonstrations gave the impression of scientific research and studied phenomena that experimental science sometimes failed to explain. In particular, the connection between animal magnetism and theories in electricity and magnetism lent these studies significant legitimacy. The late nineteenth century marked a rise in "public" science, with increased scientific demonstrations, popular lecturers and increased public education in science.[31] Huxley's public lectures, and Tesla's demonstrations at the Electrical Exhibition in 1898 both served as examples of the public's increased access to science or to public lectures that claimed scientific authority. Despite the objections of some scientific researchers, there was frequently a perception of these demonstrators as performing scientific research. Efforts to discredit this type of research as unscientific confused the public, as electrotherapy, promoted by

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[30] Ibid.

[31] Theodore M. Porter, "How Science Became Technical," *Isis* 100, no. 2 (2009): 292–309.

doctors and using electricity and magnetism did offer some new treatment possibilities in medicine, particularly in the treatment of nervous disorders.

Tesla and Electrotherapy

In addition to his research on wireless power, Tesla also performed direct experiments on the effects of electricity on the human body. His research suggested that “the higher the frequency the greater the amount of electrical energy that may be passed through the body without serious discomfort” and he theorized that electrical currents might offer some potential medical benefits.[32] Tesla initially based this research on his observations from accidental exposure to electrical currents, and recording the results and the potential benefits quickly drew attention. It is important to note that this research occurred in the field of electrotherapeutics, not electrobiology or the associated fields of Odylism and Mesmerism. Although both fields sought to treat nervous disorders by using electrical current, electrotherapy attained a level of legitimacy never reached by Mesmerism. Electrotherapy sought to treat nervous disorders by using electrical currents. Sometimes these treatments took the form of a simple direct application of current to the affected body part and at other times patients were immersed in a bath through which an electric current was then passed.[33] In contrast, Mesmerism attempted to manipulate an individual’s magnetic fluid, a fluid whose existence many scientific researchers doubted. Electrotherapy made no such claims about the manipulation of an invisible fluid. Instead, practitioners published articles in medical journals like *The American Practitioner* in which they provided detailed case analyses and outcomes of patients treated with different electrical

[32] Nikola Tesla, “The Physiological and Other Effects of High Frequency Currents,” *The Electrical Engineer* XV, no. 248 (1893).

[33] Morus, “Batteries, Bodies, and Belts: Making Careers in Victorian Medical Electricity,” 214.

treatments. These patients presented with a wide variety of symptoms including facial spasms and neuralgic pain.[34] In the late nineteenth century, electrotherapy gained wide popularity as a treatment in gynecology as an alternative to surgical treatment.[35] Electricity was also a popular treatment for women's hysteria, often under the supervision of a gynecologist.

Early experimenters and researchers in electrotherapy found quickly that alternating current was far more practical for medical applications than direct current.[36] At the voltage required to cause muscle contractions, one of the desired effects of electrotherapy, direct current would cause blisters and burns on the skin. Although it is unclear when this transition in electrotherapy took place, it would have been a difference immediately apparent to practitioners. With alternating current, therapists could use far higher voltages without risking any secondary burns to the patient. It was then possible to use far more powerful and prolonged muscle contractions than could be achieved with direct current. Tesla, as the promoter of alternating current in the United States, communicated with physicians as early as 1897 about how best to implement his inventions in a medical setting. His Tesla coil, developed as part of his wireless lighting system in 1891, produced the greatest changes to electrotherapy because it allowed the consistent discharge of high frequency alternating current. He explained that "if every one who uses my machine in electro-therapy alone would give me a quarter I would be a very wealthy man."[37] Although the *Transactions of the American Electro-Therapeutic Association* indicate

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[34] Beard, "Suggestive Cases Treated By Electricity," 201.

[35] Longo, "Electrotherapy in Gynecology: The American Experience," 343.

[36] ""Electric Energy and Living Matter," *The Electric Journal* 1, no. 15 (1896): 308.

[37] "Tesla and the Roentgen Rays," *The New York Herald*, February 23, 1896.

that the Tesla coil was in use, the device was not as widespread as Tesla suggested.[38] In an undated draft of an article, presumably from the late nineteenth or early twentieth century, he asserted that: "electrotherapy is another great field in which there are unlimited possibilities of electrical applications." He also hoped that "the time will come when this form of electrical energy will be available in every private residence."[39]

In 1891, Tesla first speculated on the possibility of physiological applications of high frequency currents, possibly because of his accidental exposure to these currents in his own research.[40] He explained that he had noticed some potentially beneficial effects after exposure to the currents in the course of his work. In 1892, a letter from William Crookes suggested that he used Tesla's 'Tesla Coil' for creating electrical currents in the human body. Crookes described the "phosphorescence through his body" and an experimental set up utilizing Leyden jars. The experimental set up described by Crookes resembles an experiment described by Tesla in 1893, when a "heavily-charged battery of Leyden jars is discharged through a bent wire," and this meant that "a great amount of energy may be passed into the body of a person without causing discomfort."[41] Although Tesla explained to Crookes about how to construct a working Tesla coil, Crookes never shared any details on the content and goals of the experiments he performed. Crookes's description of the "phosphorescence" in his body is far more reminiscent of a mesmeric demonstration and Tesla explained the experimental setup as one of "Dr. Lodge's," another physicist turned psychical researcher. Tesla was intent on exploring all of the

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[38] *Transactions of the American Electro-Therapeutic Association* (New York: A.L. Chatterton & Co., 1906).The transaction discusses the use of the coil in treatment of Tuberculosis (107) and as a static spark generator with a variety of applications (288).

[39] Tesla, Nikola, "What Will we do with Electricity?" Box 18, DOI 437-7, Activity - Articles – Miscellaneous, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[40] Tesla, "Experiments with Alternating Currents of High Frequency."

[41] Tesla, "The Physiological and Other Effects of High Frequency Currents."

possibilities that his inventions might offer, and the potential benefit that electricity might have in medicine could not be ignored.

Despite all of Tesla's care to prevent wild claims about his devices, an 1896 article in the *Detroit Free Press* promoting "electrical healing," heavily featured Tesla. The piece never described the actual device in any in detail, but the article boasted that Tesla's invention would "cure consumption" and that "nobody need die except as a result of old age or accident." The device worked by passing tiny powerful electric shocks "at a rate of 100 per second."[42] Tesla responded to the article, distancing himself from the bold claims, but emphasizing that there were positive physiological responses to the passage of electricity through the human body. This is the clearest example of Tesla's efforts to maintain an important distance between the invention and application of his devices in medicine. In an 1898 presentation at the American Electro-Therapeutic Association, he detailed the different methods that could be used to apply a current to a patient, specifically for the purpose of electrotherapy. These devices ranged from a simple direct connection between the generator and the patient to devices making use of a secondary coil to achieve higher frequency currents (See Figure 20).[43] The devices described each offered different advantages to the physician depending on the amount of current desired. Despite the detailed possible configurations that he offered for his new device, he was careful to admit that "it remained for the physician to investigate the specific actions on the organism and indicate proper methods of treatment, [but] the various ways of applying these currents to the body of a patient suggested themselves readily to the electrician."[44] Although he did not exercise

[42] "Tesla's Health-Giver," *Detroit Free Press*, January 18, 1896.

[43] Nikola Tesla, "High Frequency Oscillators for Electro-Therapeutic and Other Purposes," *The Electrical Engineer* XXVI, no. 550 (1898): 338.

[44] "Tesla on Animal Training by Electricity," *New York Journal*, February 6, 1898.

this level of caution about all of his scientific claims, he chose to avoid making strong claims about the effectiveness of his treatment methods.

There is only one recorded instance of Tesla attempting to administer an electrical cure came as part of a public demonstration. By this point, his fame was well established, thanks to his research on alternating current. In 1896, *The New York Record* reported that the "blind merchant" Charles Rouss would be administered an electrical shock to attempt to restore his sight. Tesla was reported to administer the shock to the patient. The article questioned if the treatment had the "subtle fluid power" to restore sight.[45] *Western Electrician* called it a "pathetic incident" that showed the "extent of Tesla's fame."[46] It was unsuccessful and Tesla never commented on the incident. The attitude displayed by the *Western Electrician* did not differ significantly from the treatment of electrobiology by many scientists throughout the nineteenth century. This incident highlighted the major difference between Mesmerism and

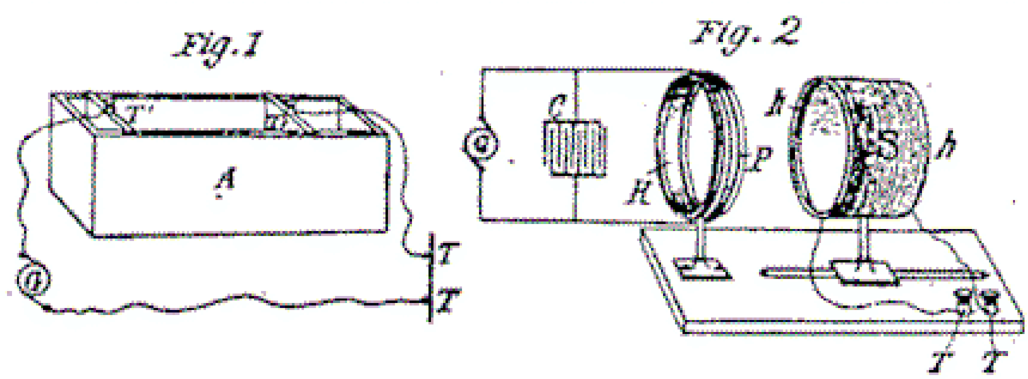

Figure 20 Two of the devices that Tesla proposed for electrotherapeutic usage. (See Image Note 20)

electrotherapy: Mesmerism depended on the contentious theory of animal magnetism and administration of the "cure" by the inventor and an appropriately receptive subject, while electrotherapy used existing theories physical theories and devices and was administered by

[45] "Tesla Will Try to Cure Rouss," *The New York Record*, April 3, 1896.

[46] "New York Notes," *Western Electrician*, April 18, 1896, 190.

therapists and doctors in a medical setting. Electrotherapy in the late nineteenth century was evolving into an established medical discipline that enjoyed approval and respect whereas mesmerism primarily faced skepticism and ridicule.

Tesla was communicated with doctors and members of societies on electrobiology and offered demonstrations in his laboratory on of the use of his Tesla coils in medicine. Margaret Cleaves, a pioneer in electrotherapy, corresponded with Tesla briefly starting in 1897 and requested a demonstration of the coil and instruction on its practical workings. Cleaves was an instructor in electrotherapeutics at the New York Post-Graduate Medical School and the founder of the New York Electrotherapeutic Clinic. She also published on the use of electricity and radioactivity in the treatment of disease.[47] Tesla responded, explaining she would "be welcome any afternoon […] where I will show you my new coil in action."[48] He also communicated with Charles R. Dickson of the American Electro-Therapeutic Association, beginning in 1898, about the application of his work. Although Tesla was modest about the extent of his contributions to electrotherapy, Dickson emphasized that the "demonstrations to us on that occasion […] were simply invaluable in giving us new ideas as to the action of electricity."[49] Tesla wrote that he planned to present a paper at the Electrotherapeutic exhibition on "an improved instrument designed by me as a 'High Frequency Oscillator for Electrotherapeutic Purposes.'"[50] Tesla was referring here to a variation on his Tesla coil. Ultimately, he withdrew his paper from the

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[47] John William Leonard, ed., *Woman Who's Who of America* (New York: The American Commonwealth Company, 1914).

[48] Tesla, Nikola, *Nikola Tesla to Margaret Cleaves, September 27, 1897,* Letter. From Nikola Tesla Museum, Belgrade, Folder 2.

[49] Dickson, Charles R, *Charles R. Dickson to Nikola Tesla, February 2, 1898*, Letter. From Nikola Tesla Museum, Belgrade, Folder 4.

[50] Tesla, Nikola, *Nikola Tesla to Charles R. Dickson, February 6, 1898*, Letter. From Nikola Tesla Museum, Belgrade, Folder 4.

meeting but promised that "in a very short time I expect to put into the hands of physicians improved apparatus which will serve as evidence that I have not been idle all this time."[51] He did provide a detailed presentation of a variety of different electrical devices that could be used in electrotherapeutics in an 1898 presentation for the Association (See Figure 20).

Tesla was also interested in the application of Roentgen rays that allowed doctors to see the underlying bone structure. Tesla had performed an experiment resembling Roentgen's prior to Roentgen's 1895 announcement of the discovery but Tesla never developed the photographic plate of the image. After Roentgen's announcement, Tesla wrote extensively about the possibilities of the rays and published several of his own photographs. Newspapers featured many of Tesla's theories on the dangers and benefits the rays might present. An 1896 article in the *New York Herald* implied that Tesla's work on Roentgen rays was pivotal to their application and suggested that although Roentgen was the first to publish, many other scientists had unknowingly worked with the rays before his discovery.[52] That same year, Tesla wrote an article in the *Electrical Review* that attempted to analyze precisely how the waves worked. Ultimately, he "confirmed" Roentgen's findings on the x-rays. He suggested that the images were produced either by "projected particles" or by "vibrations far beyond any frequency which we are able to obtain by means of condenser discharges."[53] As discussed in the previous chapter, these were the two major competing theories that attempted to explain Roentgen Rays.[54] His concern went beyond the physical theory surrounding the new discovery. He also conducted his own

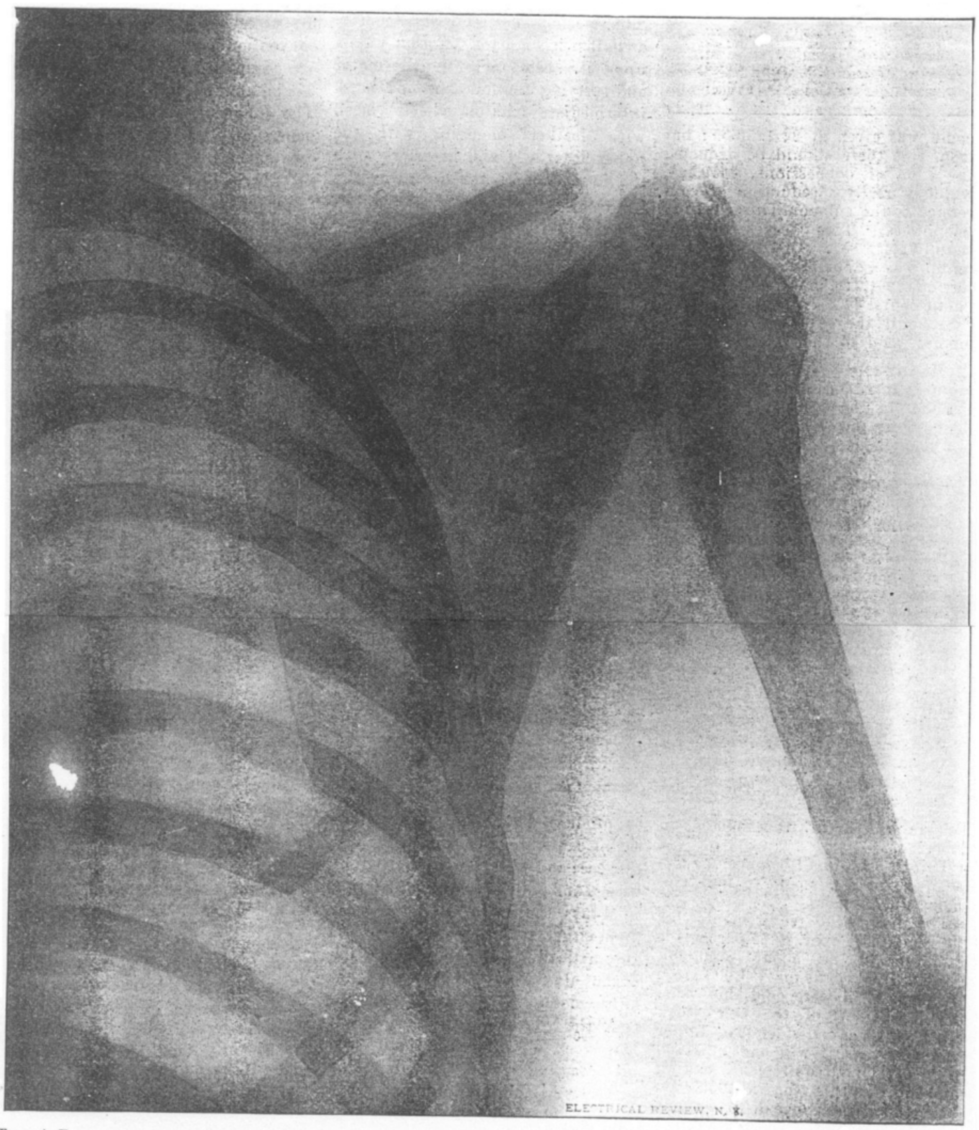
[51] Tesla, Nikola, *Nikola Tesla to Robert Newman, September 21, 1897,* Letter. From Nikola Tesla Museum, Belgrade, Folder 17.

[52] "Tesla and the Roentgen Rays."

[53] Tesla, "Tesla's Startling Results in Radiography at Great Distances through Considerable Thickness of Substance."

[54] Wheaton, *The Tiger and the Shark: Empirical Roots of Wave-Particle Dualism*.

experiments to demonstrate the value of Roentgen's discovery and published a variety of radiographs that showed the results of different exposure lengths and distances from the cathode tube. He primarily sought to demonstrate to the public that this method was completely safe. By making such images commonplace, he helped to normalize the images and familiarize the public with their appearance.[55]



TESLA'S RADIOGRAPH OF A MAN'S SHOULDER AND RIBS THROUGH CLOTHING BY MEANS OF A REFLECTOR.—EXPOSURE FORTY MINUTES, DISTANCE FOUR FEET.—IMPRESSION PRODUCED WITHOUT A PHOSPHORESCENT INTENSIFIER. (SHIRT BUTTON ON TOP OF SHOULDER PLAINLY SHOWN.)

Figure 21 One of Tesla's radiographs published in *The Electrical Review*. (See Image Note 21)

[55] M. Norton Wise, "Making Visible," *Isis* 97, no. 1 (2006): 78.

Tesla was certain that electricity in every home could offer benefits far beyond what was available in the late nineteenth and early twentieth centuries. In addition to the benefits that he believed would be possible in electro-therapy, he suggested that electricity offered serious potential in the realm of hygiene. He explained in a 1935 article that one day it would be possible to "do away with the customary bath." Instead, high potential electricity could be used and would "result in the throwing off of dust or any small particles adhering to the skin."[56] Hygiene was a serious concern of Tesla's and he suggested that by the year 2100, once his imagined utopia was achieved, "hygiene, physical culture will be recognized branches of education and government."[57] The secretaries of these departments would be more important than any others. Stimulants would be avoided because "it [would] simply no longer be fashionable to poison the system with harmful ingredients." This concern with the health of the individual was also a major concern in mesmerism, which sought to use animal magnetism to improve health.

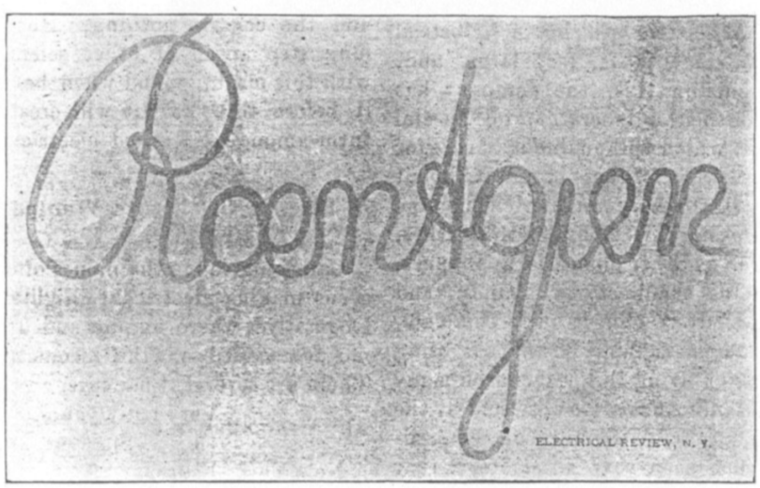


FIG. 2.—TESLA'S RESPECTS TO PROF. ROENTGEN—A RADIOGRAPH OF A WIRE SIGN TAKEN THROUGH A WOODEN COVER AT THE REMARKABLE DISTANCE OF ELEVEN FEET, WITH ONE-HALF HOUR'S EXPOSURE.

Figure 22 "A radiograph of a wire sign taken through a wooden cover at the remarkable distance of eleven feet, with one-half hour's exposure." (See Image Note 22)

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[56] " Tesla, Nikola, "What Will we do with Electricity?" Box 18, DOI 437-7, Activity - Articles – Miscellaneous, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[57] Tesla, "A Machine to End War."

Tesla's work in electrotherapy also served to redirect some of the negative press from the suggestion that alternating current was the most efficient means for executing criminals. As part of the War of the Currents, Thomas Edison encouraged the public to consider alternating current as the most practical manner for execution. This served to promote Edison's claim that alternating current was more lethal than direct current. Tesla sought to discourage this type of thinking and performed experiments to "stop the movement in favor of this mode of execution."[58] The use of alternating current in the practice of electrotherapy while direct current often resulted in electrical burns lent further credence to Tesla's assurances that alternating current was the safer of the two systems.

Tesla's involvement in electrotherapy is unsurprising given his expertise in alternating current and its superiority in medical applications over direct current. Unlike many of his inventions, he refrained from adopting an aggressive promotion strategy of the application. He deferred to the expertise of medical personnel. Although he frequently allowed dramatic exaggerations of his inventions to go unchecked, with his work in electrotherapy he did attempt to reign in some of the extraordinary claims. Tesla's interest in the application of Roentgen rays closely paralleled his own work as he had actively experimented with the same types of rays. Tesla, however, was interested in a much more comprehensive application of electrical ideas to improve human health. The health of the individual was a high priority in his imagined future utopia and he believed that electricity could be used to improve the health of the individual as well as the wellbeing of society. It was only through the improvement of the health of the social body that his utopian vision could be attained.

[58] Tesla, Nikola, "Letter to D.L. Danot" Box 2, DOI 456-7, Activity - Miscellaneous - Physiology and Biology - Physiological Effects of Electrical Currents, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia..

The Telautomaton and The Chicago Speech

Although Tesla struggled to ensure that most of his research could be squarely situated as legitimate scientific work, some of his writings and speeches paralleled the research in electrobiology. The fundamental ideas of electrobiology suggested a connection between life and electromagnetism, something that Tesla desperately sought. The telautomaton explored this concept in part, but the device also presented intriguing potential applications in his wider research. In an unpublished speech given to the Chicago Commercial Club in 1899, on his way to perform research in Colorado Springs, Tesla articulated his theories on these concepts in detail that was not equaled again in his career. Most importantly, in the speech, Tesla focused on outlining the physical causes of what he explained and the speech demonstrated his commitment to that line of research. The ether served well as a medium that offered an explanation for these types of physical explanations of psychical phenomena. The possibilities of a medium the permeated everything, yet also still not fully understood, offered a scientific explanation.

In 1893, Tesla documented prickling sensations that resembled Reichenbach's: when "ether waves" affected the human body they "produce the sensations of warmth or cold, pleasure or pain, or perhaps other sensations of which we are not aware."[59] When lecturing on his telautomaton in Chicago in 1899, he considered the definition of "alive" and "dead" and used the example of two metal rings.

> One is just a ring of iron wound with wire-nothing more: inactive, inert, dead. The other is gifted with wonderful qualities, it is the seat of a living force, it is endowed with life! When I approach this delicately pivoted metal disk to the former, the disk is unaffected, it does not even stir; but when I bring it near to this other, the animated ring, it is set rapidly spinning and continues to rotate, when held anywhere in its neighborhood.[60]

[59] Tesla, "On Light and Other High Frequency Phenomena," 206.

[60] Tesla, Nikola, "Chicago Speech" Box 59, DOI 333-2, Activity - Telemechanics - Physical Life as Teleautomatics, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

Although it is unclear what exactly Tesla demonstrated with these two iron rings, evidently he displayed some type of magnetic or electrical properties that he believed served as an analogy for life and death. He explained that

> a crystal, though incapable of movement, is considered a living being by scientific men, and so a piece of iron, endowed with power of movement, may, and perhaps more appropriately, be classed among the animated objects, in contra-distinction to another piece of the same metal devoid of this power, or dead.[61]

Even if Tesla only sought to provide analogous example, the movement of the ring, spurred by the connection with electricity and magnetism demonstrated how inextricably connected these ideas were in his mind. One of the rings responded to electrical and magnetic stimulus while the other did not; thus one ring was alive and the other dead. What Tesla demonstrated was that magnetic and electrical phenomena signaled that an inanimate object, like an iron ring or a telautomaton, which might otherwise be considered dead, could be made to be "alive." This argument strayed close to the demonstrations and claims in electrobiology, a field that Tesla sought to distance him from.

Tesla sought to do much the same as the scientists he admired, those like William Crookes, who were members of the British Society for Psychical Research. He sought to ensure that all of his research possessed some scientific basis and theory. As demonstrated with his work on electrical healing, he often sought to develop a physical explanation for what appeared to be psychical phenomena. As with his inventions he believed that everything could be reduced to a physical explanation. At one point, a group of engineers at Ford Motor Company invited Tesla to join a psychical research group. He apparently rejected the offer, and commented that

[61] Ibid.

"those engineers never knew how near they came to being fired out of my office."[62] Despite his disdain for the psychical when directly labeled as such, Tesla sought, as his contemporaries did, to ground mysterious phenomena in physical theories.

In addition to discussing the definition of life and demonstrating these principles with the iron rings, he also discussed the possibilities of psychical research. Tesla was careful to articulate the difference between psychical research, what his colleagues like William Crookes pursued, and pursuing scientific research that might uncover a physical explanation of a psychical phenomenon, something he pursued in his own work. Although Tesla did not contribute directly to psychical research, he believed that through proper research and experimentation an answer to these unexplained phenomena could be uncovered. It was simply a matter of uncovering the best technological or scientific demonstration. He believed that our inability to read thoughts was most likely a limitation of the present technology and that at some point it would be possible. He explained that

> I believed then, and do now, even more so, that by proper instruments, still to be invented, enabling us to analyze the changes of the retina, we shall be able to read or to interpret thoughts. I am absolutely convinced, that this is a rational problem which will be successfully solved in the near future, and I cannot think of a more interesting subject of scientific investigation, nor of one which would be in certain respects of greater importance and farther reaching consequences for mankind than this.[63]

What he described here was something very different from telepathy or thought transmission. Instead, he suggested that a scientific device could be developed that would be able to use the retina to, quite literally, peer into the soul. But once again the eye was at the center of Tesla's theory. Thoughts and ideas caused changes in the retina and with proper technology thoughts could be "read" on the retina.

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[62] Ibid.

[63] Ibid.

Alternatively, Tesla explained he could not "side" with those who promoted the reality of telepathy or thought transmission. Nevertheless, he was careful to explain that he did not wish to express contempt for their research. Instead, he considered "that researches in these directions should not be disdained by those who are engaged in the study of exact science, for even if they should not lead to tangible facts and evidences, they would still be commendable." Research such as that performed by William Crookes could "stimulate thought and elevate mind, and contribute to the interest and enjoyment of life."[64] But he still considered most psychical phenomena to be little more than coincidence. He offered the example of an experience from his childhood of striking a fish that was leaping out of the water with a rock. Just as with what were considered to be psychical phenomena, he believed that "examined in the light of physical facts and divested of all that which appeared inexplicable at first, such occurrences generally turn out to be of a ridiculously common character."[65]

Yet Tesla hesitated to definitively state that all of the subjects that psychical researchers studied were merely matters of coincidence. Once again, he suggested that there might be a physical explanation for something described as a psychical event. He attempted specifically to address the situation of two "distant individuals" linked by "subtle ties" that "under certain exceptional conditions, may assume a dominating influence and become the means of intercommunication." He explained that this was not so improbable

> first, that two human beings separated by a distance, however great, or, generally speaking, not in contact with their known senses, do actually transmit upon each other energy, of known form quite certainly [such as heat energy], and very probably also of a form still unknown [such as psychical energy], second, that the amount of energy which is actually transmitted, in known form is, to all theoretical and experimental evidence, many times greater, very likely several millions of times, than the energy required for starting a thought or, popularly

[64] Ibid.

[65] Ibid.

> stated, for effecting the releases of the mechanism involved in the formation of a thought, and, third, that one of the organs possessed by a human being- the eye- is sensibly excited by an amount of energy smaller by far than that which, in the form of known radiations alone, a person may or does transmit to another one situated at the greatest possible distance at the diametrically opposite point of the terrestrial globe.[66]

Although Tesla emphasized the necessity of experimental evidence, his theories here were far more speculative than his other work. To him it seemed impossible that the eye could detect light from something as far away as the sun and that "cosmic pain" or some sort of human connection could not be detected on the other side of such a small planet. His friend William Crookes and a handful of other British physicists certainly believed that this type of communication might be possible. Tesla devoted far more content in his Chicago speech to the idea that there were possible physical explanations of psychical occurrences than this type of speculation. Although he suggested that some physical explanations might be the result of coincidences, he seemed more convinced that what appeared to be a coincidence was in fact, a scientist's failure to fully understand the phenomena presented. He believed that a discovery could occur "which may suddenly disclose the hidden mechanism involved in these complex phenomena of the mind and turn into obvious facts seeming psychical mysteries."[67]

The connection between electrical and magnetic phenomena and human physiology was one of Tesla's motivations in constructing his telautomaton. In his autobiography, published in 1919, Tesla detailed these motivations. If the human automaton were working properly, then it would respond appropriately to external stimuli like sound, light, touch and smell. Tesla indicated that there was an additional "vital quality" that endowed the human automaton with a "transcending mechanical sense, enabling him to evade perils too subtle to be directly

[66] Ibid.

[67] Ibid.

perceived." Tesla was describing something beyond the physical sense. He emphasized his conviction that humans were automata, "controlled by the forces of the medium" so this sense must be based on the transmission of information through the ether. He also suggested that all humans were connected by "invisible links." It was through these invisible links that sensations were transmitted, sensations he described as "cosmic" pain. These were typically experienced "whenever either myself or a person to whom I was attached, or a cause to which I was devoted, was hurt by others in a particular way."[68] He argued that this was not telepathy; instead it was the marker of a "very sensitive and observant being." Although he did not claim to have the ability to detect "cosmic pain," as discussed previously he did repeatedly remark on his superior skills of observation and sense.

The Chicago Speech in 1899 was the only occasion when Tesla addressed psychical research in detail. Although he mentioned psychical research in passing on other occasions, his most detailed discussion was in this unpublished speech. This speech reveals that he believed that in most cases in which psychical phenomena were observed, it was merely a matter of coincidence or of a scientist's incomplete understanding of the human automaton. To Tesla then, the psychical was nothing more than the "yet-to-be-explained," phenomena that were beyond the present understanding of science. Tesla did not doubt the validity of the observations of scientists like Crookes and Lodge; he simply doubted their explanations. He believed that in time, experiments and scientific study would yield physical explanations for these phenomena. This was precisely what the Society for Psychical Research sought to do: perform scientific study of psychical phenomena in an attempt to determine their validity.

[68] Tesla, "My Inventions."

The Society for Psychical Research

During the nineteenth century, an increasing number of scientists expressed interest in exploring the possibilities of psychical research. The Society for Psychical Research in Great Britain, founded in 1882, sought "to investigate that large body of debatable phenomena designated by such terms as mesmeric, psychical and 'spiritualistic,' and to do so 'in the same spirit of exact and unimpassioned enquiry which has enabled Science to solve so many problems.'"[69] The Society for Psychical Research (SPR) drew many respected scientists into its membership. The first president was Henry Sidgwick and members included J.J. Thomson, William Crookes, Lord Rayleigh, and Alfred Russell Wallace.[70] For some, like Wallace, psychical research and a belief in spiritualism offered a new moral guide and their interest in the subject lay between science and religion.[71] Although the stated aim of the SPR was to investigate psychical and spiritualist phenomena, the validity of spiritualism sparked controversy even within the SPR.[72] Crookes, who became a close friend of Tesla's, and other psychical researchers recognized that spiritualism was "a subject which, perhaps more than any other, lends itself to trickery and deception."[73] Many, including Crookes, sought some explanation of spiritualistic phenomena, like mediums, and proceeded to investigate the phenomena with significant skepticism. These types of signals could potentially be transmitted through a medium like the ether. Since scientists lacked a detailed understanding of the precise nature of

[69] Allan Gauld, *The Founders of Psychical Research* (London: Routledge & Kegan Paul, 1968), 138.

[70] Oppenheim, *The Other World: Spiritualism and Psychical Research in England, 1850-1914*, 329.

[71] Turner, *Between Science and Religion*, 83.

[72] Jenny Hazelgrove, *Spiritualism and British Society between the Wars* (Manchester: Manchester University Press, 2000), 197.

[73] William Crookes, "Spiritualism Viewed by the Light of Modern Science," *The Quarterly Journal of Science*, July 1870, 317.

the ether, it was entirely possible that it possessed these psychical attributes. But, as suggested by the range of views on spiritualism even within the SPR, the distinction between science and pseudo-science was not clear cut in the late nineteenth century.

Spiritualism, which gained significant popularity in Great Britain in the middle and late nineteenth century, was the belief that spirits of the dead communicated with the living world. There were a variety of ways in which these spirits were able to communicate. Mediums were those said to be able to communicate, sometimes directly, with the spiritual world. One of the aims of the SPR was the investigation of the authenticity of mediums. Mediums used several different methods to communicate with the dead. In table-turning or table-rapping, the spirit would communicate by turning the top of a table or a series of knocks or raps would occur. Tesla's display of the telautomaton almost seemed to mimic this experience: the device blinked the lights in response to questions from the audience. The connection is particularly evident because Tesla made no effort to explain the controlling unit and even made an effort to conceal that component of the device. Frequently this would take place in a séance, during which a group of laypeople, led by a medium, attempted to communicate with the spirits. Some mediums entered trances that allowed them to communicate with the dead. In particular, William Crookes investigated the full materialization of a spirit, "Katie," in the presence of the medium Florence Cook. Later testimony indicated that these séances were fake, that Crookes was aware of the charade, and that he used his research to cover up a relationship with Cook. [74] It seems most likely that in 1873 Cook, who had recently lost a spiritualist patron, set out deliberately to seduce Crookes, who later became complicit in the fraudulent materializations of "Katie." The SPR

[74] Trevor H Hall, *The Medium and the Scientist: The Story of Florence Cook and William Crookes* (Buffalo, New York: Prometheus Books, 1984), 107.

uncovered many mediums believed to be frauds, though some members of the organization believed some of the mediums studied were authentic.

The rise of spiritualism in Great Britain reflected a resurgence of interest in mesmerism, in part because of the recent discoveries in electromagnetism. Reichenbach's odic fluid offered one connection between the three phenomena or electromagnetism, mesmerism and psychical research. It also served as a potential explanatory concept by connecting the psychic and odic forces. Because of these connections Reichenbach's research prompted one of the earliest investigations by the SPR in 1883, less than a year after it was founded. The Reichenbach committee only issued one report in which it explained that "the Committee inclines to the opinion that, among other unknown phenomena associated with magnetism, there is a prima facie case for the existence [...] of a peculiar and unexplained luminosity."[75] This luminosity referred to the "odic emanations" from certain items with a strong odic connection. But the committee offered no judgment on the existence of any odic force or fluid that might be connected more widely to psychical phenomena.

William Thomson, Michael Faraday and William Carpenter all objected to the work of electrobiologists and mesmerists. Carpenter delivered two talks in 1876 at the London Institution, later published separately. He explained that "the extravagant pretensions of Mesmerism and Odylism have been disproved by scientific investigation."[76] Carpenter attacked mesmerism, odylism and electrobiology because there was an absence of any prolonged rigorous scientific study of the subjects.[77] He instead offered physiological, physical or practical explanations of the results that researchers might have witnessed. Carpenter's approach left the

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[75] *Proceedings of the Society for Psychical Research* (London: Trubner and Co., 1883), 236.

[76] William Benjamin Carpenter, *Mesmerism, Spirtualism, &c* (New York: D. Appleton and Company, 1877).

[77] Winter, *Mesmerized: Powers of the Mind in Victorian Britain*, 287.

possibility open that the researchers observing these phenomena were not complicit in the fraud that was occurring. Instead, he suggested what occurred was an ideo motor or reflex response. William Thomson did not offer as detailed a rebuttal as Carpenter. He called the study of the subjects "wretched superstition" and argued that there was "no such thing."[78] Thomson deferred to the research of Michael Faraday on a phenomenon called "table turning." Faraday constructed an experimental apparatus that demonstrated that table turning was caused by nothing more than unconscious muscle movements. Like Carpenter, he left open the possibility that the researchers were not consciously attempting to defraud the observers of the experiment. Yet a letter of Faraday's from 1857 indicates that he was interested in the possibility of animal magnetism and he wanted to establish if there was any connection to terrestrial magnetism.[79] The criticism by Faraday, Thomson and Carpenter of psychical phenomena predated Tesla's study of electrobiology and the telautomaton. But like those in the Society for Psychical Research, Tesla's research aimed to establish a physical basis for psychical phenomena. He learned from the unsuccessful promotion of mesmerism and was particularly careful about his promotion of his research on devices used for medical treatments by trained doctors. He was careful to distance himself from the methods used by mesmerists and electrobiologists in their demonstrations and instead he deferred the application and demonstration of his devices to medical personnel.

Members of the Society for Psychical Research were not the only investigators of psychical phenomena. Because of the strong associations between electromagnetism,

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[78] Silvanus Phillips Thompson, *The Life of William Thomson, Baron Kelvin of Largs, Vol II* (London: Macmillan and Co., 1910), 1105.

[79] Frank A J L James, ed., *The Correspondence of Michael Faraday, Volume 3, 1841-1848* (London: The Insitution of Engineering and Technology, 1996), 494. In a letter to Benjamin Dann he recounted some mesmeric experiments and offered that "if [I] can throw any light upon the subject […] I shall be most happy to do so."

mesmerism and spiritualism, there were requests for Faraday to investigate the validity of table turning. Faraday, a critic of psychical researchers, designed a device in 1853 to prove that the results of table turning were in fact unconscious muscular movement of the medium. Faraday's evidence allowed opponents of spiritualism a method of "discrediting people without casting doubt on their honor."[80] Others, however, were not as careful about their criticism. Carpenter wrote a second article on mesmerism that offered particularly scathing criticism of psychical researchers in 1871. In it, he criticized Crookes's research in particular as unscientific. He accused psychical researchers of not employing "the tests which men of science had a right to demand before giving credence to the genuineness of those phenomena."[81] Crookes responded, claiming that Carpenter's review was "so full of perverse, prejudiced, or unwarranted mis-statements, that it is impossible to take note of them all."[82] Crookes disputed Carpenter's arguments line by line, emphasizing his commitment to a rational and scientific approach to his investigations.

The Society for Psychical Research continued to draw many respected scientists into its membership despite the disdain of many of their contemporaries. These scientists were drawn to psychical research for a wide variety of reasons. For some, like Lord Rayleigh and J.J. Thomson, the interest was largely spurred by curiosity and by a wish to reconcile Christianity with new physical discoveries.[83] For others like Oliver Lodge and William Crookes the interest

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[80] Winter, *Mesmerized: Powers of the Mind in Victorian Britain*, 292.

[81] "Spiritualism and Its Recent Converts," *The Quarterly Review*, October 1871, 308.In Oppenheim, *The Other World: Spiritualism and Psychical Research in England, 1850-1914.*. the article is credited to William Carpenter.

[82] William Crookes, *Researches in the Phenomena of Spiritualism* (London: J Burns, 1874), 53.

[83] Oppenheim, *The Other World: Spiritualism and Psychical Research in England, 1850-1914*, 330.

was spurred by the loss of loved ones.[84] The possibility of being able to contact loved ones after their death was extremely seductive, particularly in the face of Victorian materialism. William Crookes was particularly outspoken about his belief that psychical research was a valuable pursuit for scientists. Crookes was a British chemist and physicist best known for his work on vacuum tubes and cathode rays. In 1870 Crookes, already a fellow of the Royal Society, announced his intention to pursue the scientific study of psychical phenomena. He explained his own reservations on the subject:

> at first, like other men who thought little of the matter and saw little, I believed that the whole affair was a superstition, or at least an unexplained trick. Even at this moment I meet with cases which I cannot prove to be anything else; and in some cases I am sure that it is a delusion of the senses.[85]

Figure 23 The Source of Spring by Arnold Böcklin. Likely the painting that Tesla saw before the death of his mother. (See Image Note 23)

Balfour Stewart, co-author of *The Unseen Universe*, wrote an 1871 article in *Nature* in support of Crookes' goals.[86] Stewart was skeptical of Crookes' attempts to communicate with the dead, yet he alluded to his support of research in clairvoyance and telepathy. Stewart admitted to his own difficulty in accepting some psychical phenomena, but he emphasized his intention of keeping an open mind.

[84] Ibid., 343.

[85] Crookes, "Spiritualism Viewed by the Light of Modern Science."

[86] Balfour Stewart, "Mr. Crookes on the 'Psychic' Force," *Nature* 4, no. 91 (1871): 237.

After his visit to London in 1892, Tesla began a correspondence with Crookes that continued sporadically until 1897. Tesla had a complicated relationship with mesmerism, spiritualism and psychical research and his perspective seemed to change several times throughout his life. The most pivotal moment in his interest was immediately after his mother died during Tesla's tour of the European continent in 1892. He later explained that Crookes's influence led him to consider that a psychical experience might have occurred following his mother's death. During her illness, he fell asleep and experienced a vivid dream. When he woke, his mother was dead. During the dream he

> saw a cloud carrying angelic figures of marvelous beauty, one of whom gazed upon me lovingly and gradually assumed the features of my mother. The appearance slowly floated across the room and vanished, and I was awakened by an indescribably sweet song of many voices. In that instant of certitude, which no words can express, came upon me that my mother had just died.[87]

Ultimately he concluded that his vision was the combination of the image from a work of art he had seen while traveling and that the "sweet song" was from the choir in the church nearby. Once more he was able to trace all of his internal thoughts to external impressions. He explained in more detail in his unpublished account:

> Through long concentration on a special subject certain fibers in my brain for lack of blood supply and exercise were benumbed and could no longer react properly to the influences from the outside. With the diversion of my thoughts they were gradually vivified, and restored to their normal condition. The intense desire to see my mother was due to my examination of some artistic fabrics woven by herself which she had given me on my departure from home many years before and which had awakened in me tender memories shortly before I began to concentrate. I heard the song because my mother died on the morning of Easter when there was an early mass and a choir was singing in a church not far from me. But to locate the external impression on which caused the apparition I had much difficulty until I remembered that on one of my returns from Europe I passed through Munich, Bavaria and saw there a painting of Arnold Boecalin, the celebrated German artist, representing one of the seasons, and showing a group of allegorical figures on a cloud. So wonderfully skilled was the painter in this

[87] Tesla, "My Inventions," 662.

creation, the cloud with the figures seemed positively to float in the air as if supported by some invisible means. This made a deep impression on me and explains the phenomenon.[88]

Tesla traces each component of the vision he received of his mother to a particular event, item or experience. This instance was the only one when Tesla believed he had a psychical experience, but his description suggests a far closer relationship between the observed phenomena and the unconscious. As with every research experience, he was determined that there must exist a physical explanation for what he saw.

It is particularly notable that Tesla, in the unpublished article and undated, explained that he went to his mother's death bed in 1892, attempting to test if he could have a psychical experience. He sought to observe Crookes' claim that upon death there might be a disturbance in the ether. As mentioned earlier, his mother died in the middle of his lecture tour of Great Britain and Europe and he had just begun exchanging letters with William Crookes.

> When I was alone in my bed I meditated on what would happen if my mother were to die. Would there be a disturbance in the ether? If so could I detect it? At that time my senses were keen to an incredible degree. I would hear the ticking of a watch at a distance of fifty feet. A fly alighting on a table in the center of the room produced in my ear a thud like that of a pile driver and I could plainly hear the clatter of his feet as he scurried over the table. I was a trained scientific observer well qualified to make an undistorted record of what I perceived. My mother was a woman of genius and rare courage who was meeting her fate with perfect composure and I was sure that she would think of me to her last breath. If her death produced a disturbance in the medium the very best condition for its detection at a distance existed.[89]

Again Tesla claimed incredible powers of perception and observation; not only was he a "trained scientific observer" capable of detecting disturbances in the ether, but he was also able to hear the footsteps of a fly. Tesla's account of his mother's death suggests that during his time in

[88] Tesla, Nikola, "A Strange Experience" Box 18, DOI 433-1, Activity - Articles – Physical Phenomena, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[89] Ibid.

London he had spoken with Crookes at length about the possibility of psychical communication. He wrote to Crookes about his mother's death and about the vision he witnessed. In a later letter, Crookes enclosed a copy of his presidential address for the SPR. The address emphasized Crookes's pursuit of careful experimental and scientific investigation of psychical phenomena. As explained in his Chicago lecture, Tesla did not consider Crookes's research with the Society for Psychical Research outside scientific study. Although Thomson, Faraday and Carpenter considered these subjects non-scientific, Crookes and the SPR approached the subject as they might any other research. Although Tesla was hesitant to engage personally in psychical research, he admired and supported the research performed by Crookes. Moreover, Tesla considered himself particularly qualified to potentially observe or detect changes in the ether. Frequently in his writings Tesla boasted of his superior observation skills, in one case claiming to have "an ear thirteen times more sensitive" than his assistants.[90]

Spiritualism and mesmerism tended to encourage the strongest rebuttals from scientists, but telepathy was a slightly less controversial focus of research than spiritualism. Telepaths made no claims to be able to communicate with the dead. In fact, as noted in the Chicago lecture, Tesla considered telepathy a possibility that might one day be given an explanation using science and technology. The ether in particular offered a possible medium through which telepathic information could be communicated and did not require researchers to believe in the existence of life after death or a spirit realm. For Tesla, the eye was key to the possibility of mind reading. As discussed in the previous chapter he believed the eye was the only sense organ capable of making an accurate impression of external phenomena. This was because the eye was the sense organ associated with ether waves. In an article published in 1893 in *The Literary Digest*, as well as in the 1899 Chicago lecture, Tesla suggested that by developing a device to

[90] Tesla, "My Inventions."

"analyze the condition of the retina" it might be possible to read "one's thoughts with precision, like the characters of an open book."[91] Mind reading was possible because the retina, the window to the soul, could potentially be analyzed by a technological creation. But this still depended on the ether. When interviewed in 1894, Tesla clearly stated that he did not believe in the existence of telepathy and that it could be explained by "mere coincidence."[92] In 1893, however, he described the sensation of a "cosmic" pain, experienced "whenever either myself or a person to whom I was attached, or a cause to which I was devoted, was hurt by others in a particular way, which might be best popularly characterized as the most unfair imaginable."[93] To him this was not telepathy; instead it was the marker of a "very sensitive and observant being." Again, Tesla believed that he was uniquely "sensitive" to vibrations in the ether. Although Tesla would likely object to Reichenbach's claims about the properties of odic fluid, he clearly considered some individuals to possess greater sensitivity than others. In an article in 1898, shortly after his presentation of the telautomaton he was asked about his method for controlling the device. The telautomaton could be controlled

> By an effort of will […] I can stand two metres away from that instrument and by a mere stiffening of my muscles cause it to send a signal. It is so delicate in its adjustment that the disturbance of the electrical equilibrium caused by my muscular action affects it.[94]

Tesla exaggerated the capabilities of the telautomaton here, confounding his hopes for the future of the device, being able to be controlled by will alone, with the reality of the present, requiring a controller in close proximity. But the way in which Tesla exaggerated these claims lends further

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[91] Nikola Tesla, "Mind-Reading," *The Literary Digest*, June 10, 1893.

[92] Arthur Brisbane, "Our Foremost Electrician," *The World*, July 22, 1894.

[93] Tesla, "My Inventions," 665.

[94] H.W. Phillips, "Tesla Talks and Confirms His Astounding Story," *The Criterion*, November 19, 1898.

credence to his claim that he believed that the telautomaton was an extension of himself, that he was able to project his mind into the device. He continued by briefly discussing some of Crookes's research. He suggested that Crookes would "not hesitate to state openly his belief in telepathy" as a possible method for controlling the device.

Oliver Lodge, whose theories on the ether were discussed in Chapter 3, went beyond the mechanical model that he proposed in *Modern Views of Electricity* in 1889. Lodge outlined his telepathic theories in a paper presented in 1892. At the time Lodge's views on the connection between the ether and telepathy remained unclear. In the midst of outlining physical examples of mechanisms similar to telepathic communication, Lodge emphatically stated that "the real medium of communication […] is still the ether."[95] Yet he explained that the real medium, the ether, was also responsible for telepathic communication, or "sympathy at a distance." In *Ether and Reality,* published in 1925, Lodge attempted to connect psychical phenomena to the ether. In the final chapter he discussed the connection between life, mind and the ether. Lodge explained that life and the conscious mind came into contact with the ether through "protoplasmic material," which he described as the "vehicle for life."[96] Lodge continued, describing the action on matter exerted by mind, consciousness, memory and affection. Thoughts could be transmitted by vibrating matter in the ether. Lodge confessed he was not completely certain of the method of telepathic transmission, but he was convinced that the origin of telepathic communication was in the mind. He described the signal and noted "in some mysterious way it liberates energy from the brain-cell, which then travels along a nerve, stimulates a muscle to contract; and then either the hand writes, or the larynx vibrates, or the

[95] Oliver Lodge, "Thought Transference: An Application of Modern Thought to Ancient Supertisions (1892)," in *Spiritualism, Mesmerism and the Occult, 1800-1920, Vol 4.*, ed. Shawn McCorristine (London: Pickering and Chatto, 2012), 107.

[96] Ibid., 159.

fingers press a telegraph key."[97] This energy was transmitted to the receiving mind. Lodge concluded his description of the ether explaining "it is the primary instrument of the Mind, the vehicle of Soul, the habitation of Spirit."[98] To Lodge then, the ether was the place where human spirit lived. Despite this, he maintained that the ether was also a physical thing with physical properties, not only a psychical entity.

Lodge's theory on thought transference and telepathic communication reflected a wider and longer-standing interest by members of the Society for Psychical Research in telepathic communication. Balfour Stewart, co-author of the *Unseen Universe* published in 1875, performed experiments on thought transference and presented some of his results in the first meeting of the Society for Psychical Research. He began the presentation of his research by describing phenomena that, even with reports from trustworthy observers, were rejected because theories could not account for them. After a changes in theory the phenomena were accepted: "without overthrowing entirely our received views on electricity, [it] has certainly enabled people to accept evidence that they would not have accepted before."[99] Stewart implied that telepathy was in a similar position scientifically and presented detailed results of telepathic tests on a group of children. William Barrett, a founder of the Society for Psychical Research and fellow of the Royal Society, Edmund Gurney, a psychologist, and Frederic Myers, another founder of the SPR, also regularly presented their research on thought-transference.

British physicists were not the only investigators of psychic phenomena. Thomas Edison was interested in the possibility of communication with the dead. In a 1920 article he explained

[97] Ibid., 167.

[98] Ibid., 179.

[99] Balfour Stewart, "Note on Thought Reading (1882-3)," in *Spiritualism, Mesmerism and the Occult, 1800-1920, Vol 4.*, ed. Shawn McCorristine (London: Pickering and Chatto, 2012), 31.

that an "instrument so delicate as to be affected, or moved, or manipulated […] by our personality as it survives the next life" might be able to record communication.[100] Despite this, he ridiculed the work of others that attempted to communicate with the dead. Edison believed that there had not been a proper scientific instrument developed for communicating with the dead. His theory rested primarily on his belief that humans were made of thousands of "life units," a theory he first suggested in an interview with *Scientific American* in 1920. Edison also explained in the article that he hoped to make some progress on communicating soon as he had "a collaborator in this work [that] died only the other day."[101] Edison's approach was far more direct than any research that Tesla ever conducted and he was much less concerned with connecting his ideas to physical theory. But, the existence of Edison's work indicates that participants in psychical research ranged from Tesla's idols, the British physicists, to his contemporaries and competitors.

Tesla's telautomaton and his work on wireless communication and wireless power opened several avenues of research that might otherwise have been outside the purview of an inventor in the nineteenth century. His relationship with British physicists started because of his presentations on wireless power. As explored in Chapter 3, these physicists shaped Tesla's understanding of the ether, energy physics and electromagnetism. But his association with these physicists ultimately opened him to some interest in psychical research. Using the telautomaton he developed this interest and explored research that took place on the periphery of science. If the telautomaton was capable of demonstrating definitively an elusive concept like free will, then Tesla was convinced that technology could demonstrate all manner of scientific mysteries.

[100] B.C. Forbes, "Edison Working on How to Communicate With the Next World," *The American Magazine*, October 1920.

[101] Austin Lescarbours, "Edison's Views on Life and Death," *Scientific American* 123, no. 15 (1920): 446.

Although he was ultimately ridiculed for his claims that the telautomaton might one day function independently, his understanding of the development of psychical research supported this belief. The defining principle he set forth in his Chicago speech was that any theories had to be supported by careful research. He believed that in time, some of the phenomena that scientists viewed as psychical, would easily be explained by advances in science.

Chapter 5:
Of Mars and Men:
Warfare and communication

"The solution to our problems does not lie in destroying, but in mastering the machine."

"A Machine to End War" Liberty, February 1937

Until now, I have primarily focused on how Tesla's wireless system demonstrated the major principles of nineteenth and early twentieth-century science. This chapter explores some of Tesla's more problematic inventions and some of his least studied published and unpublished documents. Tesla's later career, particular in the twentieth century, is problematic for historians seeking to understand his work.[1] In part, this is because his proposed inventions, writings and theories become increasingly radical and speculative. He suggests complete changes to human society, ranging from simple hygiene to clear breeding guidelines to improve the human population. It is easy to suggest that these changes are part of some mental deterioration or that Tesla's career and ingenuity simply declined in the twentieth century. His work in the early twentieth century sought to exploit the same scientific principles he developed in his most successful inventions. Electrical science continued to factor heavily into all Tesla's work. This focus largely represented to Tesla the pinnacle of scientific achievement and he believed that through the wireless system's application, the situation of humanity could be tremendously improved. Of great interest is how Tesla used these more speculative inventions to shape his ultimate vision for the application of his wireless system. What role did the telautomaton and the wireless system play in shaping Tesla's views about a possible future? How was this wireless

[1] Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*; Carlson, *Tesla: Inventor of the Electrical Age*.

future a synthesis of nineteenth-century scientific study? Tesla had a clear vision of how his concepts and inventions could be best utilized to improve the situation of humanity and the telautomaton was the cornerstone of this system. Instead of discarding Tesla's later work, it is more valuable to treat his writings in the early twentieth century as a period with far greater transparency in his ambitions.

In some ways, Tesla was "stuck" on the wireless system. Unlike the alternating current system, Tesla failed to effectively market and sell his wireless system to investors. Without the system's successful implementation, he never moved on to researching and developing a new invention or another system. Instead, he continued to promote the wireless system in newspapers, popular journals, speeches and interviews. All of these writings were aimed at the public, not at the scientific community.[2] These attempts to promote his work became more and more eccentric, with promises increasingly far-fetched. Although he still maintained contact with other scientists, his increasingly wild claims only served to alienate him from these circles. Yet, these far-fetched promises offered some of his most interesting analysis of his inventions. Free from the limits of practicality and financial considerations, Tesla had hopes for these devices that are easier to discern. These writings showed that Tesla developed an entire vision for on how to successfully implement his work and exactly how this would radically change the world.

Initially, Tesla's hopes for the implementation for his wireless system appeared to be realized on the planet Mars. At the turn of the century, new maps of the Martian surface indicated to some astronomers that there might be straight lines, possibly canals, on the surface of the planet. Many people, including astronomers, scientists and the public, considered that

[2] Most of Tesla's publications were from newspapers and popular journals. Particularly in his later career his publications in trade journals markedly decreased.

these canals might indicate that intelligent life existed on Mars and some inventors and scientists launched into research that sought to communicate with the planet.[3] Tesla was one of these scientists. To him, life on Mars presented an even greater opportunity.[4] In an undated article he explained that, to him, Mars was an older planet and likely to have inhabitants far more technologically advanced than people on earth. He imagined that on the more technologically evolved planet, a system similar to his wireless system might be in use. Although he did not devote significant research to Martian communication, he weighed in on possible theories in newspapers and even believed that he had once detected a signal from Mars.

When Martian communication failed to develop any promising results, with the exception of a signal Tesla received in 1900, he imagined the future of earth. Although Mars had offered a happy possibility of the application of his devices, he still hoped to radically change the human condition for the better. In particular, he considered what effects the application of his inventions, both real and imagined, might have on the future of warfare. To him, the greatest potential change that his inventions could effect would be on the conduct of warfare. To this end, he proposed not only the way they might help to change warfare, but also how they might help to establish peace. He profoundly believed that warfare was the single greatest waste of human energy and that through its elimination the human condition would improve dramatically. In part, this was reflected in a series of interviews on his reactions to World War One, but even beyond these interviews he continually expressed his conviction that warfare must cease.

Tesla envisioned applications of his concepts and inventions far beyond just the abolition of warfare. He also considered the possibilities of the future application of the telautomaton for

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[3] Steven J. Dick, *The Biological Universe, The Twentieth-Century Extraterrestrial Life Debate and the Limits of Science* (Cambridge: Cambridge University Press, 1996), 62.

[4] Tesla, Nikola, "I Expect to Talk to Mars" Box 9, DOI 202-10, Activity - High Frequency Engineering - Interplanetary Communication, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

agricultural, industrial and medical applications. Although some of these ideas seem to have generated earlier in his career, most developed because of his later speculations. As more time passed without any interest or attempts to implement Tesla's wireless system, he wrote more and more detailed accounts of the possibilities that the system might offer for the future. What Tesla described in these writings was a possible utopian future. Hunger, warfare and disease would be either abolished or would rapidly disappear. Individuals would take measures to improve their own health by eschewing stimulants, drugs and anything that might potentially shorten their life span. Tesla's designed his wireless system as the ultimate triumph of electrical science. The changes that this system would be able to effect on humanity, if only an investor could recognize its potential, would be significant.

Tesla and the Human Race

Tesla carefully framed his consideration on the best way to improve the health of the social body around how best electrical devices could improve humanity. He believed that the best way to establish his utopia was to improve human health with the ultimate goal of lengthening human life, a very similar goal to that of Mesmerism, explored in the previous chapter. Tesla shared his plans for the improvement of the "human condition" in the simplest terms he could conceive, using the language of physics. In an article published in 1900, titled "The Problem of Increasing Human Energy," he presented the condition of the human race in the terms of conservation of energy. Conservation of energy was not the only theory that offered a potential social application. New scientific theories provided a new potential structure for understanding the social problems that presented themselves. Most popular of these theories in the early twentieth century were the ideas of eugenics and Social Darwinism, but other scientists such as Balfour Stewart and Norman Lockyer used the language of physics to describe the energy of man and how that contributed to society.

Balfour Stewart, a co-author of *The Unseen Universe*, published in 1875, attempted to use the principles of kinetic energy and potential energy to describe the social realm. In an article he co-wrote with Norman Lockyer published in 1868 in *MacMillan Magazine,* he explained that energy in the social world was “the power which [a man] possesses of overcoming obstacles.”[5] The language and perspective presented by Lockyer and Stewart bear incredible similarity to a later article by Tesla in which he attempts to draw a similar parallel. The article primarily sought to explain the new science of the conservation of energy in simple and accessible terms to the magazine’s audience. Therefore, the power to overcome social obstacles was described as analogous to energy. A man’s social status could be translated into the physical concept of height. So that social status would be the equivalent height, where potential energy is equal to mass × gravity × height. Stewart and Lockyer separated energy into two types, just as it was divided in the physical world. In physics this energy was kinetic and potential while in the social realm, they argued, it was personal energy and energy derived from social position or status. Stewart explained that if two men had equal energy the one in the “highest social positon has the best chance of succeeding.”

Similarly, in his 1900 article, Tesla explained how he could model human society after the same principles used in the conservation of energy. He suggested that the principles of energy could be used to predict and ultimately improve society. He believed that it would be possible to “assume that human energy is measured by half the product of man’s mass with the

[5] Balfour Stewart, “The Place of Life in a Universe of Energy,” in *Contributions to Solar Physics* (London: Macmillan and Co., 1874), 89.

square of a certain hypothetical velocity."[6] The definition of human energy that Tesla proposed is the same as the calculation of the kinetic energy of a body in physics: $\frac{1}{2} mv^2$. Although Tesla's equations are identical to those used in conservation of energy, the terms used in those equations, of necessity, deviated significantly. In Tesla's equation "m", instead of representing the mass of a body, represented the human mass: the sum of the human population "v" represented human mental velocity, or the level of enlightenment and intelligence in the human population.

In order to increase human energy, Tesla thought it was therefore necessary to discover the best way to increase the human mass and human velocity. The simplest way to improve the human mass was preventing loss of life during war, which was precisely the goal of the telautomaton. Yet, Tesla believed that the human mass, or human population, could also be increased by "careful attention to health" and "the observance of all the many precepts and laws of religion and hygiene." He explained that by observing these principles, it would be possible to extend life, and thereby increase the total human population. He specifically detailed that "whisky, wine, tea, coffee, tobacco, and other such stimulants" were factors that served to decrease the human mass, in part by causing a shorter life span. Tesla's explanation of the human velocity was more abstract. He argued that the human velocity could be increased by attaining a higher degree of enlightenment in the newly added mass; this could best be done by educating children. Unlike with mass, Tesla did not describe any scenario in which the velocity could be increased in the existing population. Fundamentally, it seems that "human energy" was a method of measuring the number of healthy, enlightened humans and Tesla believed that increasing human energy would improve the human condition.

[6] Tesla, "The Problem of Increasing Human Energy."

To this point, Tesla's theory outlined in 1900 did not deviate significantly from the example set in 1868 Lockyer and Stewart on how to understand social settings using the new theory of energy. Tesla took the theory further however and considered how energy might be lost in the social system. In Tesla's estimation there were existing forces, ignorance in particular, that were slowing human velocity and preventing an increase in human energy. Organized warfare in particular was the most deplorable form of ignorance.

> the immense sums of money daily required for the maintenance of armies and war apparatus, representing ever so much of human energy, all the effort uselessly spent in the production of arms and implements of destruction, the loss of life and the fostering of a barbarous spirit, we are appalled at the inestimable loss to mankind which the existence of these deplorable conditions must involve.[7]

And even though a universal peace was a "beautiful dream" he explained that it was not attainable, that war "is a negative force, and cannot be turned in a positive direction without passing through the intermediate phases." What then could be done to turn warfare in this positive direction? Tesla proposed that his telautomaton would eliminate the tragic loss of human life in warfare. Warfare could continue, but without any loss of human life, or any decrease of the human mass. He concluded grandly, stating that

> When all darkness shall be dissipated by the light of science, when all nations shall be merged into one, and patriotism shall be identical with religion, when there shall be one language, one country, one end, then the dream [universal peace] will have become reality.

Another important aspect of Tesla's plans that he outlined in the 1900 article "The Problem of Increasing Human Energy" was the utilization of the sun's energy. He considered the wasteful usage of the sun's energy one of the primary impediments to increasing human energy. He contended that all motive power was drawn from the sun, and "to increase the force

[7] Ibid.

accelerating human movements means to turn to the uses of man more of the sun's energy."[8] Tesla was not the only one concerned with the energy transmitted to earth by the sun. Balfour Stewart, co-author of the *Unseen Universe* investigated the frequency of sunspots. He suggested that sunspots increased as Venus approached the sun and that this indicated that heavenly bodies affected the sun's luminosity. Although this presented the possibility that the sun's energy might not dissipate, Stewart emphasized the second law of thermodynamics and that all forces tended toward dissipation.[9] Tesla's system for wireless power transmission, as well as his earlier work on alternating current both aimed to promote economic usage of electrical power. Tesla proposed that manufacturing and energy production could be improved significantly. He predicted that aluminum would revolutionize future construction and that a windmill or a solar engine would be the most practical ways to derive power.

One of the more notable social theories that developed out of nineteenth-century science was Social Darwinism. Social Darwinism, eugenics and the application of the theory of evolution to human society produced a startling range of theories about how best to improve the human race. But precisely who was and was not a social Darwinist was complicated by the incorporation of a wide variety of theories into individual's theories.[10] In the late nineteenth and early twentieth centuries Herbert Spencer, Francis Galton and others suggested that society should seek to improve the human genetic pool by allowing the strong to multiply and preventing the weak. The designation of the strong and the weak for reproduction differed, sometimes targeting class, race or intelligence differences. Field work and observational study

[8] Ibid.

[9] Gooday, "Sunspots, Weather, and the Unseen Universe," 116.

[10] Diane B. Paul, "Darwin, Social Darwinism, and Eugenics," in *The Cambridge Companion to Darwin*, ed. Jonathon Hodge and Gregory Radick (Cambridge: Cambridge University Press, 2003), 228.

were important in establishing which groups might offer the best improvement in the human race. Some of these sought to improve the quality of people that were reproducing while others suggested action should be taken to prevent undesirables from reproducing. Galton promoted eugenic ideas through the end of the nineteenth century, but these ideas gained additional support in the twentieth century.[11] In the 1930s, new laws that aimed to further develop eugenic control appeared in a variety of countries. The United States, Germany, Norway, Sweden, Finland, Estonia and others either passed laws legalizing sterilization or saw a marked increase in the number of sterilizations.[12]

In his early career, Tesla largely avoided incorporating any comments on these theories into his writings. Given his deep interest in the British physiological and physical theories, he was certainly aware of Social Darwinism in the late nineteenth century. In an 1897 article published in *The World's Sunday Magazine*, Tesla suggested that with "the most careful scientific marriage, a race of men and women may in time be developed in which individuals will live and retain their faculties for centuries."[13] As with his interest in automatism and physiology, Tesla's ideas on eugenics developed into far more radical proposals in his later career. In an article published in *Liberty Magazine* in 1935, Tesla explained a vision of a future utopia, with eugenics firmly established, and a society that had embraced his inventions, both real and imagined. He suggested that by 2100

> eugenics [would be] universally established. In past ages, the law governing the survival of the fittest roughly weeded out the less desirable strains. Then man's new sense of pity began to interfere with the ruthless workings of nature. As a result, we continue to keep alive and to breed the unfit. The only method

[11] Chris Renwick, "From Political Economy to Sociology: Francis Galton and the Social-Scientific Origins of Eugenics," *The British Journal for the History of Science* 44, no. 03 (2011): 344.

[12] Diane B. Paul, *Controlling Human Heredity* (Amherst, New York: Humanity Books, 1995), 72.

[13] "Man May Be Made to Live 1000 Years," *The World's Sunday Magazine*, September 5, 1897.

> compatible with our notions of civilization and the race is to prevent the breeding of the unfit by sterilization and the deliberate guidance of the mating instinct. Several European countries and a number of states of the American Union sterilize the criminal and the insane. This is not sufficient. The trend of opinion among eugenists is that we must make marriage more difficult. Certainly no one who is not a desirable parent should be permitted to produce progeny. A century from now it will no more occur to a normal person to mate with a person eugenically unfit than to marry a habitual criminal.[14]

Tesla's use of the term "eugenics", coined by Galton in the late nineteenth century, and his apparent subscription to the theory indicate how pervasive these ideas were in the early twentieth century. The promotion of this kind of eugenic program in 1935, only a month before Adolph Hitler announced German rearmament is unsettling. The underlying motivation of Tesla's theories did not seem to be motivated by anything except to improve humanity at any cost. Tesla's eugenic program centered on improving humanity, and as he outlined in detail, the best way to accomplish this was by increasing intelligence and longevity. These were the primary attributes he believed should be selected in the breeding population.

Although many of these ideas seem disconnected and impractical, Tesla only sought to apply his new theories in the best and most practical ways possible. To Tesla and other scientists in the nineteenth century, the application of scientific theories to society seemed their logical extension. As discussed previously, the conservation of energy offered powerful explanatory power for understanding free will and human physiology. Why not then apply that framework to understanding how society works? Tesla's attempts to use scientific theory to develop a model for society appeared to follow the example set by Spencer, Stewart and Lockyer. Fundamentally, all were interested in the possibilities that new and exciting theories, like the conservation of energy and evolution, might offer when applied directly to humans. Underlying all of Tesla's grand goals for the future of humanity was a dark and ruthless perspective about

[14] Tesla, "A Machine to End War."

the best way to achieve this goal. To him, the sterilization and modification of breeding programs was a theory written on paper and he chose to ignore the human cost.

Tesla's Wireless System

Tesla's wireless system was the focus of nearly all of his speculative theories in the early twentieth century. Tesla developed all of the key inventions in this system prior to the turn of the century, but none of these inventions was able to gain any significant interest. Tesla's speculations in the twentieth century did not develop out of thin air. In fact, since the inception of this system, he had considered the possibilities that the system offered. As early as 1893, before his patents on wireless power, Tesla suggested that there was great potential in the transmission of wireless. He explained: "it is practicable to disturb by means of powerful machines the electrostatic condition of the earth and thus transmit intelligible signals and perhaps power."[15] As more time passed after the invention of this system, Tesla provided detail about what he believed that his wireless system might achieve.

Tesla first demonstrated the wireless light in 1891, but initially he focused on promoting the device directly and only later did he describe the possibilities the light offered. This might have been because Tesla had still not completely conceived of the wireless system and the potential of the system. Tesla's patent for electrical lighting completely neglected any description of the wireless part of the invention. Instead, the patent application emphasized the necessity of a one terminal direct or inductive connection to the power source. In his 1891 Columbia College demonstration of the system however, he demonstrated the ease of transitioning to a completely wireless system. In an interview in 1901, Tesla praised the potential benefits his new wireless light offered. He boasted that in addition to the advantages economically, it was also the "closest approach to daylight which has yet been reached from any

[15] Tesla, "On Light and Other High Frequency Phenomena," 242.

artificial source" and this offered significant potential advantages in improving "hygienic conditions" when introduced to dwellings. Because "sunlight is a very powerful curative agent" the light would check "the development of germs […] and many diseases."[16] Although he exaggerated the potential health effects the wireless light might be able to effect for its users, Tesla spent significant effort considering the potential benefits that his inventions might be able to have on the world.

The telautomaton, patented in 1898, was the second patent in the wireless system. The telautomaton employed the same principles that his wireless transmission of electrical power system used. As explained in the first chapter, remote radio allowed the operator to control the device at a distance. The telautomaton became the cornerstone of Tesla's wireless system in part, because of how essential he considered the device to establishing the society in which the other devices could thrive. Beyond its potential application in warfare, discussed later in this section and in previous chapters, the device also had the potential to "take the place which slave labor occupied in ancient civilization."[17] At the demonstration of the device in 1898, O'Neille explains that Tesla informed a reporter that the device had applications far beyond warfare. Instead, he claimed that this was the first in a "race of robots" and that these "mechanical men […] will do the laborious work of the human race."[18] This device would utterly transform society because a new working class would be fully established by the race of autonomous machines.

The final device in Tesla's wireless system was the wireless transmission of electrical power, patented in 1900. Although he originally conceived of this invention as a method to

[16] "Tesla's Wireless Light," *Scientific American* 84, no. 5 (1901).

[17] Tesla, "A Machine to End War."

[18] O'Neill, *Prodigal Genius*, 167.

transmit electrical power on an industrial scale, it was ultimately more successful for transmitting energy for communication purposes. Even in the patent application, Tesla wrote about his hopes for the successful implementation of the wireless power transmission, but he realized the infrastructure required would take some time to establish. In the patent application, he described the implementation of large balloons, floating in the ionosphere and maintaining an ionized path for electrical signals to pass along. In an article from 1900, Tesla explained that the transmission of electrical power without wires would transform the economy of the planet and that "men could settle down everywhere, fertilize and irrigate the soil with little effort, and convert barren deserts into gardens, and thus the entire globe could be transformed and made a fitter abode for mankind."[19]

From the very beginning, Tesla considered how these inventions might be able to benefit humanity. Only three months after the patent office approved his wireless power system, he wrote in *Century* Illustrated Magazine about how the device would transform the entire planet. His consideration went beyond the application of his inventions on the planet earth. Tesla considered the inventions so essential to organized society that he could not imagine that he was the only one to invent the devices. In the same article, he wrote of his suspicions that "if there are intelligent beings on Mars, they have long ago realized this very idea."[20] On Mars, because of the "smaller density" of the atmosphere, the task of transmitting power wirelessly would be a far simpler task. More important, Tesla believed that the wireless transmission of power could explain a mystery of the Martian surface. Multiple astronomers in the late nineteenth century had observed straight lines crisscrossing the surface of Mars and had concluded that these must indicate the existence of canals. To Tesla, these "changes on its surface" further suggested that

[19] Tesla, "The Problem of Increasing Human Energy."

[20] Ibid.

Mars used a system of wireless transmission of energy.   The canals offered the irrigation of areas that would otherwise have been deserts, areas where farming might have otherwise been impossible had it not been for the implementation of the wireless transmission of electrical power.

The Martian Utopia

In 1877, Giovanni Schiaparelli published a map illustrating his observations of the surface of Mars. Schiaparelli's drawings indicated that there were straight lines on the surface which he labeled "canali'" or "canals."   His drawings of the Martian surface indicated a far more distinct landscape than other Martian mappers observed.   Although he was the target of some harsh criticism about his methods and techniques, his map encouraged many other astronomers to search for the canals. Other astronomers gradually began to confirm

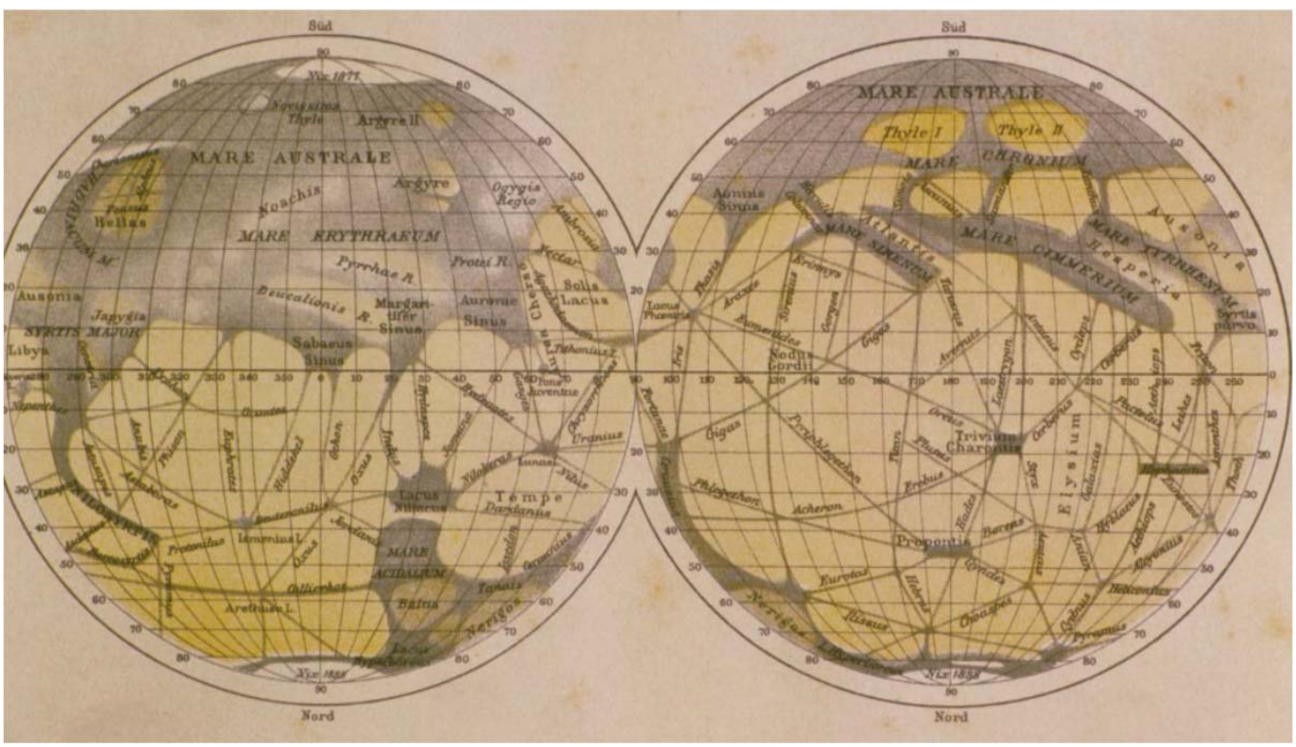

Figure 24 Giovanni Schiaparelli's map of the surface of Mars. (See Image Note 24)

Schiaparelli's observations and Schiaparelli's maps became increasingly geometric in their depiction of the canals on the surface of Mars. Although Nathaniel Green, an amateur astronomer, produced a more faithful, but less detailed map in 1878, of the Martian surface, it was Schiarparelli's more detailed map that was widely accepted. [21] Despite the reservations of some of his contemporaries, Schiarparelli continued producing maps of Mars littered with canals.[22]

Other astronomers soon confirmed Schiaparelli's sightings but it was the work of Percival Lowell in 1894 that sparked public interest in the possibility of Martian life.[23] Lowell was an American astronomer who made a close study of many of the planets. Through superior placement of telescopes in largely unpopulated areas, Lowell was able to make far more accurate observations of the planets than his contemporaries were and his telescope placement practices continue to this day. Lowell worked for fifteen years on mapping the Martian surface. His detailed maps of the Martian surface and his claims that Mars might be inhabited gained him professional and popular recognition.[24] Public fascination with the Martian canals linked them frequently to the possibility that the red planet was inhabited, and Lowell analyzed this possibility extensively. In *Mars,* published in 1895, *Lowell* provided a detailed argument outlining the possible causes of the canals on Mars. Ultimately, he reached the conclusion that the canals could not have formed naturally, they must be constructed. Lowell also claimed that

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[21] K. Maria D. Lane, *Geographies of Mars* (Chicago: University of Chicago Press, 2011), 39.. Lane analyzes the reasons for the acceptance of Schiarparelli's map over Green's, explaining that the Green map "faced the impossible challenge of demonstrating *more* authority by presenting *less* detail."

[22] J. Crowe, Michael, *The Extraterrestrial Life Debate 1750-1900: The Idea of a Plurality of Worlds from Kant to Lowell* (Cambridge: Cambridge University Press, 1986), 495.

[23] Dick, *The Biological Universe, The Twentieth-Century Extraterrestrial Life Debate and the Limits of Science*, 74.

[24] K. Maria D. Lane, "Geographers of Mars Cartographic Inscription and Exploration," *Isis* 96, no. 4 (2014): 477–506.

his observations supported the conclusion that plant life and large bodies of water existed on Mars. He believed that the Martians constructed the canals to move water from the polar caps. He connected this theory to a theory of planetary development: Mars represented a planet further along in its development than Earth. [25] Using conclusions about the development of intelligent life on Earth, Lowell argued that "even now we should know ourselves cosmically by our geometrical designs. To interplanetary understanding it is this quality that would speak."[26] Tesla said of Lowell's map: it "produces the absolute and irresistible conviction, that these 'canals' owe their existence to a guiding intelligence."[27] Lowell's observations and his sensational reporting of his discoveries seized the imagination of the general population. In part, this was the result of a distinct effort to promote his own theories; he even employed a publicist at one time.[28]

Tesla's own experience with wireless communication prompted him to consider the possibility of its application to interplanetary communication. Although Tesla was deeply convinced that life could possibly exist on Mars, he did not accept the work of Lowell as definitively establishing that there was life on Mars. The straightness of the canals alone was not sufficient proof; "as a planet grows older […] ultimately every river must flow in a geodetically straight line." Like many scientists, Tesla sought a natural explanation for the Martian canals, however unlikely it might be. Instead of resting his conviction of life on Mars on the canals, he instead based it on the detection of electrical disturbances at his laboratory in Colorado. On

[25] William Sheehan, *Planets and Perception: Telescopic Views and Interpretations, 1609-1909* (Tuscon: University of Arizona Press, 1988), 5.

[26] Percival Lowell, *Mars and Its Canals* (London: Macmillan and Co., 1906), 363.

[27] Nikola Tesla, "Signaling to Mars-- A Problem of Electrical Engineering," *Harvard Illustrated*, March 1907
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[28] Lane, *Geographies of Mars*, 7.

Christmas day of 1900, Tesla wrote a letter to the American Red Cross in New York City. The letter read:

> The retrospect is glorious, the prospect is inspiring: Much might be said of both. But one idea dominates my mind. This — my best, my dearest — is for your noble cause.
>
> I have observed electrical actions, which have appeared inexplicable. Faint and uncertain though they were, they have given me a deep conviction and foreknowledge, that ere long all human beings on this globe, as one, will turn their eyes to the firmament above, with feelings of love and reverence, thrilled by the glad news: "Brethren! We have a message from another world, unknown and remote. It reads: one… two… three…"
>
> Christmas 1900
> Nikola Tesla[29]

Tesla believed that he had received a message from Mars. In an article in 1901, he stated that he had been working late in his laboratory in Colorado when he received the signals. Claiming that there was no possibility that the signals might have resulted from sunspots or the Aurora Borealis or any other form of interference, he explained that the only possibility was that they had been generated by the inhabitants of another planet.[30] Since Mars was the only planet in the sky at that point, he concluded that the signals must have generated from there. Because the signals were so deliberate he believed they had to be produced by intelligent life. Tesla continued to write articles supporting his conviction that he received communication from Mars well into the twentieth century. Nevertheless, despite his best efforts he was never able to detect another signal. In part, he blamed this on the increasing popularity of wireless messages that interfered with any signals that the Martians might potentially be sending. If a message could only be sent back to Mars, perhaps it would be possible to receive a stronger signal. He understood that any signals that were sent from Mars traveled for quite some time to reach Earth and he also knew

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[29] The Tesla Society, < http://www.teslasociety.com/airportbelgrade.htm >, Accessed on May 3, 2013.

[30] Nikola Tesla, "Talking with the Planets," *Collier's Weekly* XXVI, no. 19 (1901).

that any return signals would take quite some time to reach Mars. This communication gap was responsible for the delay in further signals from Mars.

Lowell's work on the Martian canals did not just draw the attention of the public, but also seized the imagination of other astronomers. William Pickering, a professor with Harvard College, spent much of his research time in 1894 in Peru with Lowell studying the surface of Mars, much to the chagrin of his employers at Harvard University. Pickering's observations were particularly important to Lowell's theory of life on Mars because of his focus on determining the amount of water on the surface of the planet by observing the polarization of the light reflected from different locations on the planet.[31] He later explored potential ways to develop a device that would make communication possible with Mars. In particular, he suggested in 1909 that with ten million dollars it would be possible to send a message to Mars.[32] In an interview featured on the front page of the *New York Times*, Pickering suggested "the use of a series of mirrors so arranged as to present a single reflecting surface toward the planet."[33] In an artist's representation of Pickering's proposal, the mirror is shown sitting above several houses and reflecting the sun's rays towards the Red Planet (Figure 26). Pickering's proposal was one of many. A 1909 article outlined the suggestion of

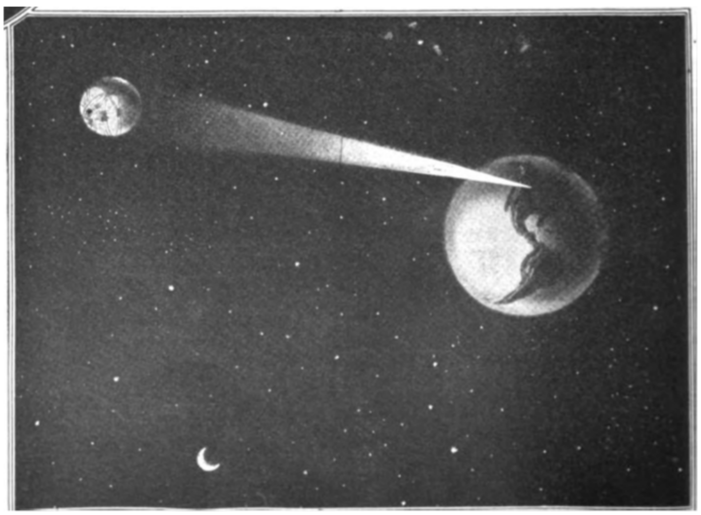

Figure 25 Attempts to communicate with Mars involved all manner of ways to transmit information directly to the planet using light.

[31] William Graves Hoyt, *Lowell and Mars* (Tuscon: University of Arizona Press, 1976), 63.

[32] "Plans Messages to Mars," *The New York Times*, April 19, 1909.

[33] Ibid.

William R. Brooks, a professor at Hobart College, who suggested the best method might be to use artificial rays reflected and focused off of mirrors. This system would work better than Pickering's because the rays would be visible to Mars even at night. Professor R.W. Wood of Johns Hopkins, suggested that a large desert on the earth be covered with strips of black cloth that could be wound and unwound using motors (Figure 27). These large strips of cloth would completely cover the surface of the desert and motors could wind and unwind them in union. This would result in a "series of winks." Professor Eric Doolittle of University of Pennsylvania suggested that a series of geometric figures be employed. These geometric figures would be visible to an observer on Mars in much the same way as the canals on the surface of Mars were visible to an observer on Earth.

In an unpublished and undated article from the Nikola Tesla Museum Archives, Tesla disputed the practicality of all of these suggestions. He explained that the apparatus proposed by Pickering would result in a light "27,400,000 times feebler than that of our full moon or 1,000 times weaker than that of Venus."[34] Lowell, a "trained and restless observer" had failed to detect any signal of a similar magnitude on Mars, which suggested to Tesla that such a system was impractical. He particularly cited the difficulty of detecting Phobos, Mars' moon, as an indicator that an artificial reflection system on Earth would be unsuccessful. He also doubted the practicality of completing the project for less than ten million dollars and believed that the funding could be more practically spent in the construction of one of his devices.

Tesla considered Wood and Doolittle's suggestions far more briefly. In his mind, they would require a very large surface area in order to make any impact on the overall amount of light reflected by the earth. Brooks's suggestion that artificial light be used was discarded

[34] Tesla, Nikola, "Interplanetary Signaling" Box 15, DOI 202-1, Activity - High Frequency Engineering - Interplanetary Communication, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia..

because of the scattering caused by artificial rays. In Tesla's judgment these rays would never reach the surface of Mars. Ultimately, he discarded all of these declaring that by use of his wireless transmitter he had already "produced disturbances on Mars incomparably more powerful than could be attained by any light reflector, however large."[35]

Tesla did not consider his belief in the existence of life on other planets to be outside the realm of reason. He emphatically explained that

> Of all the evidences of narrowmindedness and folly, I know of no greater one than the stupid belief that this little planet is singled out to be the seat of life and that all other heavenly bodies are fiery masses or lumps of ice.[36]

To Tesla, probabilistically it seemed impossible that there did not exist life on other planets. The proximity of Mars and the apparent existence of canals on its surface suggested the best potential for life in this solar system. He asserted that the stages of planetary development that Venus, the Earth and Mars represented "youth, full growth and old age." To him, this suggested that Venus had not yet reached a stage in its evolution whereby it could support life. However, Mars had

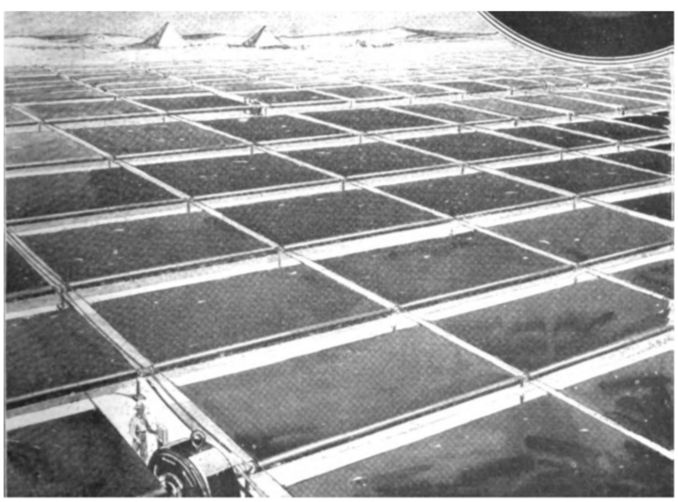

Figure 27 An artist's representation of Wood's blinking motorized strips of cloth.

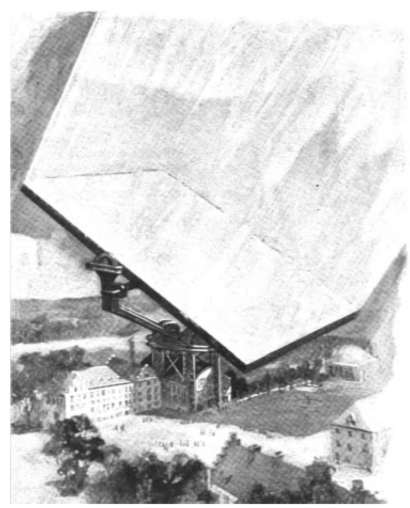

Figure 26 An artist's representation of Pickering's proposition.

[35] Ibid.

[36] Ibid.

already passed through the same phase of planetary and evolutionary development that the Earth was currently experiencing, an idea from Lowell. To Tesla this suggested that the evolution of the Martian species had surpassed the present stage of human evolution, suggesting they might have technological advances far and above our own. Furthermore, Martians had likely reached a later stage of biological evolution. The potential that this aged planet might hold the key to the future of humanity seemed incredibly tempting to Tesla.

> It is logical to assume that the biological evolution of the Martians more or less parallel that of the human species, although they may have reached a stage far in advance of ours. Their perception of the external world must correspond more or less to ours. They see, smell, feel, hear, life through the same sense as we. It is no strain on the imagination to assume some super-Tesla on Mars, perfecting at this very moment some new system of communication with us, since we have been deaf to all previous signals. [37]

As discussed in Chapter 2, Tesla's understanding of evolution likely tended toward a similar hybrid of Darwinian and Lamarckian evolution as that suggested by Herbert Spencer. Regardless, both demanded a significant passage of time. If biological evolution paralleled that of the human species, then reaching a shared phase in the evolution of man and Martian in which communication was possible was one of the greatest challenges to interplanetary communication. Tesla understood the relative brevity of human society in comparison to the age of the Earth. As Tesla explained, there could be no "intelligible or intelligent intercourse between an Amoeba and a Goethe or a Shakespeare."[38] Moreover, Tesla imagined that Mars existed as a counterpoint to life on Earth. On Mars, there existed his counterpart, a Super-Tesla, who had reached a more advanced stage of biological and technological evolution. His Martian counterpart had

[37] Tesla, Nikola, "I Expect to Talk to Mars" Box 9, DOI 202-10, Activity - High Frequency Engineering - Interplanetary Communication, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[38] Ibid.

successfully convinced his planet to embrace the possibilities of wireless and so they were able to move into the future.

Tesla's fascination with Mars and the possibilities that life on the planet might offer serve to emphasize some of his ideas on evolution. Most notably, the life forms on Mars were automata just like humans; humans were not unique in the solar system. That the evolution of intelligent life might have occurred radically differently on Mars than on Earth did not even occur to him. The eye appears here again as essential to life. Even in imagining life on other planets, Tesla's emphasis was on the necessity of the eye to the development of intelligent life:

> The chief controlling agent in this process must be radiant energy acting upon a sense organ such as the eye. Which conveys a true conception of form. We can therefore conclude with certitude that however constructedly different may be the automata on other planets, their response to rays of light and their perceptions of the outside world, must be similar to a degree so that difficulties in the way of mutual understanding should not be insuperable. [39]

Once again, the eye and the detection of vibrations in the ether were of supreme importance to the development of any form of life. Indeed, as he explained in other texts outlined in Chapter 2, vision was a requirement for intelligence. Therefore, if intelligent life had developed on another planet than its automata inhabitants must possess the ability to detect waves in the ether, they must possess some organ similar to an eye. Tesla's insistence that evolution on other planets must have progressed in a manner similar to life on Earth allowed him to ignore many of the challenges of interplanetary communication. In his mind, Martians must have many of the same senses as humans and thus must perceive the universe very similarly. This simplified the process of interplanetary communication to the mere matter of overcoming the challenge of distance. Then, Earth Tesla could communication with the Martian Super-Tesla.

[39] Tesla, NIkola, "Interplanetary Communication" Nikola Tesla Museum Archives.

Perhaps most interesting was Tesla's insistence that Mars had reached a level of technological evolution beyond our own. Most notably, he believed that the canals on the Martian surface might indicate that the inhabitants of the planet had been able to accomplish something he sought: wireless transmission of electrical energy. Ever since his 1897 speech at Niagara Falls, Tesla had sought to perfect the wireless transmission of power. He was able to patent the system in 1900, but was never able to achieve high enough efficiency to make it a commercially viable. He had failed to convince his investors that his system of wireless communication, electrical transmission and the telautomaton would be successful. Tesla believed that were his system of wireless properly adopted, and it was possible to transmit electrical power wirelessly, then "men could settle down everywhere, fertilize and irrigate the soil with little effort."[40] Mars represented the possibility of the successful application of this technology. He reasoned that if there were canals on Mars it would indicate attempts to irrigate otherwise inhospitable land, land that was able to receive electrical power, but not water. Tesla concluded that Martians had perfected wireless transmission of power.

To Tesla, Mars was the opportunity to see into the future of Earth. Mars was a total counterpart for Earth; it was simply further progressed in its evolution. Tesla was able to invent an entire civilization on Mars that had embraced the possibilities of his inventors. The "super-Tesla" whose work was successfully applied on Mars did not face the same difficulties that Earth-Tesla faced. His work on wireless transmission of power and the telautomaton were part of a system that he envisioned would dramatically improve the condition of mankind. But his vision went beyond the transmission of electricity wirelessly; he also considered the potential application of wireless electricity in homes and medical establishments. Mars, a planet Tesla believed had surpassed Earth's level of technological evolution, offered the possibility of a place

[40] Tesla, "The Problem of Increasing Human Energy."

where Tesla's system had been successfully adopted. His counterpart had convinced his investors of the great potential benefits the wireless system offered. Mars, far ahead of earth technologically and evolutionarily, fully embraced the possibilities that the wireless system offered.

Warfare

Most notable in Tesla's plans for achieving the same utopia on Earth as that he envisioned on Mars was the necessity to bring the end of warfare entirely. Part of increasing the total human mass was reducing or eliminating the casualties from war. His proposed method to achieving this was not based entirely on diplomacy, but instead on making the consequences of war so great that it would be foolish to pursue it. Tesla presented two major ideas for attaining peace, diplomacy through improved communication or peace attained by making war so awful as to be impossible. Again it is clear that Tesla sought to promote his ideas for the improvement of humanity at any cost. Nevertheless, he deeply considered the possibilities of pursuing both options and his wireless system offered possibilities for achieving both. Tesla's system for wireless communication aimed to "annihilate distance" and he believed that this "would be most helpful in the establishment of universal peaceful relations."[41] The technology of the telautomaton presented the potential for warfare conducted primarily from a distance. The telautomaton would be

> an arm for attack as well as defense may be provided, of a destructiveness all the greater as the principle is applicable to submarine and aerial vessels. There is virtually no restriction as to the amount of explosive it can carry, or as to the distance at which it can strike, and failure is almost impossible. But the force of this new principle does not wholly reside in its destructiveness. Its advent introduces into warfare an element which never existed before—a fighting-machine without men as a means of attack and defense. The continuous

[41] Nikola Tesla, "The Transmission of Electrical Energy Without Wires As a Means for Furthering Peace," *Electrical World and Engineer*, January 7, 1905.

> development in this direction must ultimately make war a mere contest of machines without men and without loss of life—a condition which would have been impossible without this new departure, and which, in my opinion, must be reached as preliminary to permanent peace.[42]

The triumph of the telautomaton would be when it would act completely independently, replacing human soldiers on the battlefield.

Despite his hope for peace, Tesla warned that warfare would continue to become more vicious, particularly with the involvement of modern science in warfare. Primarily warfare arose as a concern of Tesla's during the midst of World War I. In a 1914 interview, he explained that modern science and machinery were responsible for the "calamity." He hoped that science would be able to undo this work, and wrote about the possibility of science discovering something that would "furnish irrefutable proof of the folly and uselessness of carrying on this brutal fight."[43] He suggested an invention or discovery similar to the fabled reflected sunrays that Archimedes used to set fire to attacking Roman ships. At the same time he warned that were some *deus ex machina* to end the conflict than it would ultimately result in a more problems after the conclusion of the war. He worried, however, that the potential for more disastrous future wars only increased as science became further integrated into the military.

> The advance of science to this point, however, is attended with terrible risks for the world. We are facing a condition that is positively appalling if we ever permit warfare to invade the earth again. For up to the present war the main destructive force was provided by guns which are limited by the size of the projectile and the distance it can be thrown. *In the future nations will fight each other thousands of miles apart. No soldier will see his enemy. In fact future wars will not be conducted by men directly but by the forces which if let loose may well destroy civilization completely.*[44]

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[42] Tesla, "The Problem of Increasing Human Energy."

[43] Nikola Tesla, "Science and Discovery Are the Great Forces Which Will Lead to the Consummation of the War," *The Sun*, December 20, 1914.

[44] Nikola Tesla, "Nikola Tesla Tells How We May Fly Eight Miles High at 1000 Miles an Hour," *Reconstruction*, July 1919.

Science presented both the problem and the solution. Science could make warfare more horrific but would also force mankind to consider more deeply their options. Had Tesla lived to see the development of science in World War II, he would not have been surprised by the direction taken with the Manhattan Project and the development of the atomic bomb. Although a super-bomb was not the type of weapon he suggested would be developed, he did speculate that a horrific super weapon would be constructed.

Tesla carefully studied the present and past wars in his efforts to understand how it would proceed in the future. Just as he had modeled human society on the new energy equations, he considered mathematical understanding to be the best way to study warfare. He again turned to energy as the framework for developing a mathematical understanding of an abstract idea. In an interview that took place during World War I, he explained that war was "essentially, a manifestation of energy involving the acceleration and retardation of a mass by a force."[45] Using these principles, he reasoned that it would be possible to predict the duration of the conflict by performing a calculation of energy. For the energy of warfare it was necessary to consider the size of the armies, or the total mass, and their resources available, the total velocity. He also considered external factors that would contribute negatively or positively to the length of the war. For example, he wrote that distance and poor communication lengthened the Russo-Japanese War. Other factors he considered affecting the length of wars were the effectiveness of weapons and the modernity of the equipment used. By using the examples of the American Civil War, the France-German War, the Russo-Japanese War, and the First Balkan War he was able to estimate using the numbers from each, how long World War I might last. He considered the number of combatants and the duration of each war as well as the number of combatants in the

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45 Tesla, Nikola, "Some Aspects of War- Complete Draft" Box 9, DOI 441-1, Activity - Articles - About War, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

present war. These wars suggested that World War I would last somewhere between 5 to 10 years. By averaging the predictions from each of these calculations, he predicted that the Great War would last 8 years and 6 months. He overestimated the length by about double. Despite these bold predictions on the length of the war, Tesla was very careful about his predictions for the future of warfare and his predictions on the conclusion of World War I. He explained that what he did was not "prophesizing" but "scientific forecasting" and that anyone that cultivated their powers of observation would be able to offer predictions on the future.

Did Tesla then believe that peace was possible? If so, how could peace be achieved? In an unpublished interview from the Nikola Tesla archives in Belgrade he was asked if he believed universal peace would ever be attained. He explained that international clashes would continue as long as "there is a conflict of ideals," particularly patriotism.[46] This was the greatest hurdle on the path to universal peace, and through the opening of lines of communication countries could be made to understand one another and patriotism would eventually begin to dissipate in favor of a more encompassing world community. Despite his reservations that patriotism would delay the establishment of universal peace, he detailed the theory of "men of great intelligence" that "the gradual perfection of the implements of destruction will ultimately make war impossible."[47] But Tesla sought a method that would actively bring about the conclusion of warfare, not because it would be made impossible, but through the establishment of peace. He stated that the wireless transmission of energy would "annihilate distance in every form of human thought and action" and through that "universal peace be attained."[48] The telautomaton

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[46] Tesla, Nikola, "Partial Interview on World War" Box 133, DOI 440-1, Activity - Articles - About War, Nikola Tesla Archives, Nikola Tesla Museum, Belgrade, Serbia.

[47] Ibid..

[48] Ibid.

would work in the interim to ensure that fewer human lives would be lost in the course of warfare, but ultimately once Tesla's system of the wireless transmission of energy was universally established, peace could be attained.

Tesla did not rest all of his hopes for the end of warfare on the inventions of other scientists and on the eventual implementation of the wireless transmission of energy. In the wake of World War I he seemed to recognize the horrifying destructive potential of scientific weapons of war. The telautomaton presented the opportunity for wars to be fought without men. He explained that the telautomaton had the potential to make war "less cruel and bloody." In this interview he explains that he "evolved the art" of Telautomatics for this express purpose. To Tesla the automation of warfare seemed a crucial intermediate step on the way to universal peace. He explained that the potential for destruction by using this type of remote controlled or autonomous device was so great that the world and civilization would not be able to endure it. "That is why there must be no more war."[49] The telautomaton then would be an agent in Tesla's pursuit of the perfection of humanity. It would serve a vital role not only in performing menial tasks and labor but also in bringing an end to war through its ability to conduct warfare remotely.

Tesla's Utopia

In all of Tesla's writings about his wireless system, he frequently considered their future applications. As early as 1900, he suggested that Mars, with the successful implementation of wireless power, had achieved a level of technological progress that Earth still sought. It is clear from other articles published near the turn of the century that his plans for a system of wireless power transmission were well developed. He went beyond simply imagining the future applications of his individual inventions; it appears that Tesla had a far more coherent and

[49] Tesla, "Nikola Tesla Tells How We May Fly Eight Miles High at 1000 Miles an Hour."

unifying vision for a future utopia that all his inventions would help to establish. In "The Problem for Increasing Human Energy," it is apparent that Tesla envisioned the telautomaton and the wireless system of power transmission as components in the same future utopia. Hints of other components begin to appear in his articles after the turn of the century: in 1904, he responded positively to another inventor's suggestion that electric automobiles might be possible. He also suggested that "a cheap and simple receiving device, which might be carried in one's pocket […] will record the world's news as it occurs, or take such special messages as are intended for it."[50]

In an article published in 1905, Tesla suggested what changes were required in order to achieve what he called "Universal Peace." Although this specific phrase appears in only a few of his publications, the use of electricity as a means to establish peace appears as a critical idea as early as his Niagara address in 1897. This helps to emphasize the transition between Tesla's work on his alternating current system and his work on the wireless system. As outlined previously, the speech at Niagara Falls marked a clear end to his inventive role in alternating current and the beginning of his work on wireless technology. This system would represent the pinnacle of electrical science and would give rise to a new utopian age. To Tesla, peace was the major hurdle toward achieving a utopia, and he was firmly committed to the idea that electrical science was the best hope for science to offer aid in achieving this goal.

In the 1905 article, "The Transmission of Electrical Energy Without Wires As a Means for Furthering Peace," Tesla emphasized many of the same key concepts from his previous article "The Problem of Increasing Human Energy" but his discussion focused in far greater detail on the potential applications of the devices instead of the mechanics or any underlying economic ramifications. In his discussion of the telautomaton he emphasized the United States

[50] Frank G. Carpenter, "A Talk with Nikola Tesla," *The State*, December 18, 1904.

Navy's reluctance to use such a device and detailed the tactical advantage the Navy squandered by refusing to implement his device. But the telautomaton was not the focus of this article. Instead, he discussed in far greater detail the possibilities that wireless electrical power might offer on a global scale. Most important this system would work to accomplish the "annihilation of distance" by the "dissemination of intelligence, transportation and transmission of power."[51] He considered the establishment of electrical means to accomplish these three goals to be of great importance. Notably, Tesla theorized that it might be possible to create an "individualization" of signals, allowing a greater number of personalized and private communications to be transmitted wirelessly. He imagined that "stock-tickers, synchronous movements and innumerable devices of this character could be worked in unison all over the earth."[52]

Although Tesla frequently wrote about the possibility of his devices propelling mankind forward toward a peaceful and more egalitarian future, he most specifically discussed the details of the utopia this would establish in a 1935 article titled "A Machine to End War." He wrote the article because he believed that he was the best equipped to predict or forecast the advances that might be achieved by the "first third of the twentieth century." He was careful to explain to his audience that these predictions were based on careful observations. Most notably, he explained that by using energy calculations it was possible to discover the simplest ways to improve the situation of humanity. By considering the progress of mankind roughly equivalent to energy it was possible to calculate humanity's total energy by multiplying the mass of humanity by the velocity of humanity squared. Although Tesla's utopia seems to the reader to be a fantasy, he emphatically explained that what he described actually prediction. He explained that he had

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[51] Tesla, "The Transmission of Electrical Energy Without Wires As a Means for Furthering Peace."

[52] Ibid.

always been "ahead of [his] time" and since he "anticipated so many important developments" he believed he could "attempt to predict what life is likely to be in the twenty-first century."[53] In particular he cited three ways in which human progress could be increased: the improvement of "food and well-being," the establishment of peace and the exploitation of the "forces of the universe."

The improvement of food and well-being could best help to increase the mass of humanity, thereby increasing the sum of human energy. Tesla suggested that the year 2100 would achieve significant advances in health and hygiene. Government offices would be established that would be responsible not only for governing the health of the environment, but also ensuring that optimal conditions existed for human health. He explained that these branches of the government would be "more important in the cabinet of the President of the United States [...] than the Secretary of War." Stimulants like tea, tobacco and coffee would no longer be used because it would "be no longer fashionable to poison the system with harmful ingredients."[54] Tesla predicted that there would be more than enough food for the entire world and that milk, honey and wheat would be the most common and popular foods because of the superiority of nutrition that they provided. In this article he also promoted his most radical eugenic theory that was described earlier. In his estimation, the eugenic efforts of the early twentieth century did not go far enough, and that "no one who is not a desirable parent should be permitted to produce progeny." He also considered that before the year 2000, "systematic reforestation and the scientific management of natural resources will have made an end to all devastating droughts,

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[53] Tesla, "A Machine to End War."

[54] Ibid.

forest fires, and floods."[55] Some of these changes could be affected by his inventions: his work on electrotherapeutics offered distinct possibilities in the realm of hygiene and health. But others would be best established in the peacefully established utopia.

One of the best ways to improve human energy would be the abolition of warfare. Although Tesla had discussed this idea in some detail previously, he developed in greater detail how specifically the end of warfare would improve human energy. Most notably, he explained that in the twenty-first century there would be a reversal in the income spent on war and education. "It will be more glorious to fight against ignorance than to die on the field of battle."[56] Scientific discoveries would be front page news and political controversies and crime would be relegated to the back pages.

The utopian future that Tesla described in "A Machine to End War" depended on one critical conception, Tesla's death ray. Although Tesla never went beyond even a sketch of a concept for this device, he promoted it in several newspapers. Tesla alternately called the devices his "peace ray" or "death ray".[57] He explained that when constructed it would emit a particle beam that could operate effectively at distances "as far as a telescope could see an object on the ground and as far as the curvature of the earth would permit it."[58] This reflected Tesla's conflict over the best way to pursue peace. Although he seemed to hope that by establishing communication wars would end, he understood that scientists would continue to make greater weapons. Tesla hoped that the "death ray" would make war impossible. He believed the device

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[55] Ibid.

[56] Ibid.

[57] The device is mentioned in two articles, one "Tesla Invents Peace Ray" *New York Sun*, July 10, 1934 and another "Tesla, at 78, Bares New 'Death-Beam,'" *New York Times*, July 11, 1934.. It is unclear what Tesla called the beam.

[58] "Tesla, at 78, Bares New 'Death-Beam,'" *New York Times*, July 11, 1934.

could be used only for defensive purposes because of the significant amount of energy required for its operation. This would then act as a powerful deterrent for any attacking military. He believed that the death beam would "surround each country like an invisible Chinese wall, only a million times more impenetrable" yet would be impossible to use offensively because of the tremendous power requirements.[59] He predicted that it would be able to destroy incoming armies, planes, and navies. But the peace ray was never developed and appeared to have never gone beyond a concept. Although Tesla sent his plans for the device to several countries, all ultimately failed to adopt the device for use.[60]

Tesla's inventions were inextricably linked to his vision for the future of mankind. His devices exploited the most advanced scientific theories. As outlined in multiple articles, these devices would help to establish a peaceful utopia. This peaceful scientific utopia, once established, would allow for amazing scientific progress to take place for mankind. But peace was a requirement, and although he hoped that increased communication would result in peace, he prepared for the possibility that it would only be achieved through a large scale weapon. Tesla's repeated articles on his inventions and their potential future applications can only be explained as an attempt to convince his investors or the public of the incredible potential that these devices offered.

Historians often discard Tesla's discussion of the potential utopia that could be established by the implementation of his inventions as the product of an aging and deteriorating

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[59] Ibid.

[60] John J. O'Neill, "Tesla Tries to Prevent World War II (The Unpublished Chatper 34 of Prodigal Genius)," *PBS*, accessed August 8, 2015, http://www.pbs.org/tesla/res/res_art12.html.

mind.[61] These ideas, however, were developed consistently alongside the inventions. As new inventions in his wireless system were developed, he incorporated the ideas into his future vision. By 1934, when "A Machine to End War" was published, Tesla was able to fully articulate his utopian future; yet these ideas originated much earlier. As early as 1895, in his speech at Niagara Falls, Tesla indicated he was considering the potential future applications that wireless power might ultimately be able to effect. Tesla's theories on Mars and the utopian future may have been the products of an aging and eccentric inventor, but they were not the product of delusions or eccentricity. Instead, Tesla's theories on Mars were a response to increased public interest combined with his frustrations on the public's failure to embrace the great potential of his inventions. Tesla sought to achieve improvement to humanity at any cost, and believed that those who did not offer any way to improve the human energy or human mass should be eliminated from the breeding pool. The telautomaton was central in this utopian future, a future that represented the ultimate triumph of the science that Tesla so carefully integrated into the telautomaton.

[61] Carlson, *Tesla: Inventor of the Electrical Age*; Seifer, *Wizard: The Life and Times of Nikola Tesla, Biography of a Genius*.

Conclusion

Although historians are quick to discard Tesla's later work as eccentric and at odds with the work he pursued on alternating current early in his career, it is not that simple. As with his alternating current system, Tesla envisioned his wireless research as a complete system. A system for communication, warfare and health. The telautomaton was the cornerstone of this system. Although the telautomaton demonstrated the major principles of human automatism, it was also Tesla's first step toward a new system that would improve the world in much the same way as alternating current. Much of the science, technology and planning in the system was impractical and, in the case of Mars, out-of-this-world. Nevertheless, Tesla drew heavily from the scientific and philosophical discussions in the late nineteenth and early twentieth century. Instead of considering Tesla's work in the twentieth century as a decline, it is more constructive to reconsider it all as part of his magnum opus. He embraced a range of different theories and attempted to develop what he considered the ultimate invention; a system of devices that would drastically change society.

With the telautomaton, Tesla attempted to demonstrate the key principles of nineteenth-century discussions on mind and body. He considered this to be the best way to discern how automatic humans might be. His approach differed significantly from nineteenth-century scientists that analyzed and discussed the possibilities for automatism at length. Instead of spending more time inferring based on limited experimental data, Tesla set out to construct a device. If an automaton could be made to act as a human, this would offer definite information about how automatic a human might be. Because of his goal to demonstrate nineteenth-century principles, the telautomaton provides a concrete vehicle for discussing the dramatic changes in physiological understanding of human automatism that took place during the late nineteenth century. His incorporation of these concepts into his telautomaton provide a far more tangible framework for understanding Huxley, Clifford, and Spencer's work on automatism than previously existed. For the theories on automatism promoted by these scientific naturalists to be constructed and physically tested exemplifies much of the change they sought to achieve in science. Setting aside the metaphysical in favor of more material and concrete explanations of phenomena was precisely the change they wished to affect in scientific fields. The telautomaton, then is a powerful device for understanding these theories in human automatism precisely because it is an attempt at to construct a physical model.

Tesla also sought to demonstrate new principles from physics, specifically advances in electricity and magnetism and energy physics. These developments were in large part due to the research of a group of British physicists he admired greatly, including Thomson and Maxwell. He considered the work of Maxwell, in particular, to be the pinnacle of electrical science. All of his wireless inventions depended on the transmission of electromagnetic waves. As with physiological theories, I argued that Tesla sought to contribute to scientific debates by demonstrating the major principles of scientific theories in his inventions. He believed that with the demonstration of his superior wireless waves, he had shown that the signals that Hertz detected were not proof of Maxwell's theory. In his mind this secured his authority as a scientific investigator. Like the British physicists that he admired so greatly, Tesla also considered the possibility that there were aspects of the physical world that might defy conventional scientific explanation. He ultimately came to the conclusion, however, that while the scientific study of psychical phenomena was a worthwhile pursuit, he was uncertain if psychical phenomena existed.

Much of Tesla's research still fell on the periphery of what British physicists defined as professional science. Faraday, Thomson and others rejected many of the ideas promoted by electrobiologists, relegating it to the realm of pseudoscience. To some degree, Faraday and Thomson rejected electrobiology more emphatically because the very name made a claim to scientific expertise. Yet, Tesla worked with several electrotherapeutic societies to develop his inventions and considered the potential for medical applications of electrical devices. The connection between his ideas for the health of the social body and the potential advantages that electrotherapy might offer to humanity mirrored some of the goals of mesmerism. Mesmerism focused on improving communication in the individual to improve the overall health of the social body. Mesmerism struggled to gain acceptance from scientific societies for the methods used to manipulate patient's energies by using animal magnetism. In contrast, electrotherapy gained significant ground as a method for treating a variety of disorders and drew the interest of the medical community. Electrotherapy was frequently administered in a clinic and gained a measure of authority. Tesla believed that there were even greater applications for electrotherapy and encouraged research that might allow electricity in every home making electrotherapy widely available. He theorized that this would dramatically improve the general health and hygiene of the social body.

But his hopes for the telautomaton went beyond that. He also envisioned the potential military applications that the device might offer. As he developed his wireless power transmission system, more potential uses for the telautomata were presented. He imagined that his wireless inventions working in concert might be able to bring about world peace. To him the use of technology to bring about world peace was an inevitability. Either through the improvement of communication or through the creation of terrible weapons warfare would end.

The achievement of world peace and the implementation of wireless power was a step in the progression of mankind. The announcement of the discovery of canals on Mars seized Tesla's imagination and he conceived of a complicated and wondrous utopia on Mars, where his inventions were applied. This was a practical conclusion because Mars was a planet far further in its evolution than Earth. Martians must have reached a far more impressive level of technological application than anything achieved on Earth.

The telautomaton and Tesla's wireless system provide a fresh way to reevaluate the connection between science and technology in the late nineteenth and early twentieth century. Instead of simply showing the connection between disciplines and inventions, or attempting to trace the rise of pure and applied science in the nineteenth century, the telautomaton shows the integration of scientific ideas into an invention. Additionally it shows this integration in several ways over the life of the invention. In physiology, the telautomaton attempted a straightforward test of human automatism. Was man an automata? Could an automata like man be constructed by an inventor? In physics, the telautomaton made use of the uncertainty surrounding the ether to push the boundaries of what was able to be physically constructed. Yet, Tesla sought to use the telautomaton to make what was psychical physical. He recognized that the telautomaton existed on the borders of the psychical and the physical and that the delineation between what was scientific and what was metaphysical was increasingly difficult to discern. Finally, in the last period of the telautomaton and the wireless system's consideration, Tesla looked toward the future his inventions. The telautomaton served as the cornerstone for his vision of what kind of future the triumph of science would develop. The future offered possibilities beyond the constraints that the present offered and the telautomaton presented the best way to seize those chances. Wireless and the telautomaton must triumph because they represented the full potential the application of science.

Image Notes:

Note 1: Nikola Tesla, "The Problem of Increasing Human Energy," *The Century Magazine* LX, no. 21 (1900).

Note 2: "Tesla's Egg of Columbus," *Electrical Experimenter*, March 1919.

Note 3: Kenneth M. Swezey Papers, Archives Center, National Museum of American History, Smithsonian Institution http://americanhistory.si.edu/collections/search/object/siris_arc_322413 (accessed August 19, 2013).

Note 4: Tesla, Nikola. System of Electric Lighting. US Patent 454622, filed on April 25, 1891, and issued June 23, 1891.

Note 5: Aritst not listed, in *Tesla: Master of Lighting* by Margaret Cheney and Robert Uth. New York: Barnes and Noble Books, 84.

Note 6: Julius Chambers, "Tesla Has Fired the Spark Flashed Round the World," *New York Journal*, August 8, 1897.

Note 7: Tesla, Nikola. System of Transmission of Electrical Energy. US Patent 645576, filed on September 2, 1897, and issued March 20, 1900.

Note 8: *The Electrical Experimenter*, September, 1917, page 293 :http://earlyradiohistory.us/1917tes.htm

Note 9: Tesla, Nikola. Method of and Apparatus For Controlling Mechanism of Moving Vessels or Vehicles. US Patent 613809 filed on July 1, 1898 and issued November 8, 1898.

Note 10: Tesla, Nikola. Method of and Apparatus For Controlling Mechanism of Moving Vessels or Vehicles. US Patent 613809 filed on July 1, 1898 and issued November 8, 1898.

Note 11: Tesla, Nikola. Method of and Apparatus For Controlling Mechanism of Moving Vessels or Vehicles. US Patent 613809 filed on July 1, 1898 and issued November 8, 1898.

Note 12: Thomas Young, A Course of Lectures on Natural Philosophy and the Mechanical Arts Vol. 1 (London: Taylor and Walton 1845), Plate XX.

Note 13: "Twenty-Five Great Names in Electrical Science and Invention During the Nineteenth Century,

Note 14: Wise, M. Norton. "The mutual embrace of electricity and magnetism." Science 203, no. 4387 (1979): 1310-1318." Electrical World and Engineer XXXVII, no. 1 (1901).

Note 15: Retrieved from http://commons.wikimedia.org/wiki/File:Knot_table-blank_unknot.svg 10/28/2013

Note 16: J.J. Thomson Electricity and Matter (London: Archibald Constable and Co 1909)

Note 17: Oliver Lodge, Modern Views of Electricity (London: Macmillan and Co, 1889).

Note 18: "Poster Advertising the mesmerist Miss Annie De Montford at the Music Hall, Barnstaple, Devon" British Library http://www.bl.uk/collection-items/poster-advertising-the-mesmerist-miss-annie-de-montford-at-the-music-hall-barnstaple-devon Retrieved on 7/16/2015

Note 19: Reproduced from Karl Reichenbach Researches on magnetism, electricity, heat, light, crystallization, and chemical attraction, in their relations to the vital force (London: Taylor, Walton, and Maberly, 1850) in Richard Noakes, "Cromwell Varley FRS , Electrical Discharge and Victorian Spiritualism," Notes and Records of the Royal Society of London 61, no. 1 (2007): 5–21.

Note 20: Nikola Tesla, "High Frequency Oscillators for Electro-Therapeutic and Other Purposes," The Electrical Engineer XXVI, no. 550 (1898): 377.

Notes 21 and 22: Nikola Tesla, "Tesla on Roentgen Radiations," Electrical Review, April 1896.

Note 23: "Source of Spring" http://www. anoldbocklin.org, Retrieved 7/20/2015

Note 24: Reproduced from Schiaparelli in Kevin Zahnle, "Decline and Fall of the Martian Empire," *Nature* 412, no. July (2001).

Note 25, 26, and 27: "Hello, Mars-- This Is the Earth!," *Popular Science Monthly* 95, no. 3 (1924): 74–75.

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