THE BEDFORD SERIES IN HISTORY AND CULTURE

# Thomas Edison and Modern America

## A Brief History with Documents

**Theresa M. Collins**

Thomas A. Edison Papers, *Rutgers University*

*and*

**Lisa Gitelman**

*Catholic University of America*

*with*

**Gregory Jankunis**

Thomas A. Edison Papers, *Rutgers University*

BEDFORD/ST. MARTIN'S Boston ♦ New York

# Introduction: Edison, Invention, and Modernity

*Man's thought-machine works just like the other animals, but is a better one and more Edisonian.* —Mark Twain, *What Is Man* (1906)

Ask why Thomas A. Edison became an American of greatness, and a likely answer would be, "He invented the electric light bulb." While good for grade-school students or game show contestants, that answer is less than accurate, less than complete. There is more to Edison than light bulbs. He invented and introduced a whole system of incandescent electric lighting; he invented a means to record and replay sound; and he contributed to the development of telegraphs, telephones, motion pictures, and more. Edison obtained more United States patents than any other individual—1,093 in all. His first was issued in 1869, when he was only twenty-two, and his last patent application was filed in 1931, the year of his death. Over those decades Thomas Edison became a symbol of American know-how, a hero who seemed to rise above the messy conflicts that occur during times of change. His lifetime spanned eighty-five years of unparalleled industrialization, urbanization, and economic expansion in America, a time in which many Americans were ambivalent about the frenzied pace of change, and vacillated between enthusiasm and suspicion about it. The figure of Edison helped to affirm that technology was a force uniquely suited to make life better for all. How that occurred is a story of Edison and America intertwined.

Even as he remains rooted in the popular imagination as a symbol of American ingenuity, dogged determination, and success, Thomas Edison can help fashion questions about individualism, about who gets credit for inventions and the ways in which credit is ascribed. He can help frame questions about progress, about how (or, in fact whether) technology advances, and about the necessary contexts for technological change. And he can help frame questions about modernity, about the modern landscape of amusements and conveniences, the media, industry, and infrastructure that continue to condition everyday life today.

## CHANGING TIMES

When Thomas Edison was born in 1847, the transcontinental reach of the United States was on the brink of reality, yet most businesses were local affairs, managed by the families that owned them, and only around a million Americans worked in manufacturing. During the 1850s the nation's largely agrarian economy was based in part on westward expansion and in part upon slave labor.

Edison grew to maturity amid three large-scale transformations in the patterns of production and consumption that set the stage for his career. First was the staggering growth of transportation and information networks. Until the 1840s, interpersonal communication depended upon face-to-face meetings or the physical transport of messages. It could take three weeks to travel from New York to Chicago, if the weather was favorable. By 1860 fast, dependable rail service shortened the trip to two days. The train often carried special cars for the mail, but the invention and implementation of telegraphy opened a wholly new dimension: electrical communication.

Telegraphy reconstructed language into coded messages of dots and dashes, which were then transmitted electrically over wires. The signals came over the wire to receiving machines in telegraph offices, where operators transcribed or relayed the messages to other stations in the system. Newspapers were among the first to appreciate the use of telegraphs for receiving and distributing timely information, and armies as well as financiers were also quick to perceive the benefits of rapid communications, but telegraphy found its earliest extensive applications in connection with the railroads. From station to station and switch to switch, telegraphy helped railroad managers build and control the construction and traffic of entire systems. The first transcontinental telegraph connection was established in 1861; a transcontinental rail link came in 1869.

The modern, integrated transportation and communication infrastructure helped to support a second large-scale transformation of American life in the form of a managerial revolution that made giant corporations the dominant feature of the American economy. Manufacturers standardized goods and came to appreciate the economic advantages of large-scale production and interchangeable parts. Flour mills and meat-packing plants pioneered the use of continuous flow production, the precursor to Henry Ford's assembly line of 1914, while vast industrial processes overtook much of the manufacturing that had previously been accomplished by individual craftsmen or by relatively skilled workers in semimechanized mills. Changes appeared beyond the shop floor as well. A few large corporations began to internalize and institutionalize the process of invention in departments of research and development (also known as R&D), which were intended to give them technological advantages over their competitors. Managerial bureaucracies also increasingly supplanted owner-managers, and white-collar workers became the fastest growing segment of the workforce in America.



In addition, Edison's era was party to large-scale transformations in the processes of consumption. The patterns of what people bought and where people bought were shifting, as rural and small-town America grew accustomed to buying merchandise through mail-order catalogs, while city dwellers learned to shop at department stores. With the growth in white-collar jobs, modest increases in middle-class incomes helped to create new opportunities for leisure and material accumulation. By the late 1880s trademarks, brand names, and national advertising campaigns became more common: Western Union meant telegraphy; Bell meant telephones; and Singer meant sewing machines. These big names kept company with other product names, such as Swift (packaged meat), Heinz (pickles and ketchup), Quaker (breakfast cereal), Colt (firearms), Campbell (canned soup), Procter & Gamble (soap), and Eastman Kodak (film and photographic paper). All would contribute to the experience of American consumers over the next century.

Thomas Edison made contributions to all of the changes discussed above. Although he could not cause anything like changes of this magnitude himself, the inventor came to represent modernity, first in the eyes of his contemporaries and then in the eyes of successive generations. By the early twentieth century, Edison was positioned as securely as Christopher Columbus and George Washington in the curriculum of American schoolchildren, and he has remained a comfortably familiar icon of ingenuity. To this day, whenever the news media gather a list of the most important people in American history, Edison is there, often at the top of the list. However thoroughly technological change has altered modern life, the figure of Edison apparently continues to make its chaotic pace more palatable, marking its purpose as a distinctly American one by symbolizing the achievements of the past. Now as then, Edison resolves the contradiction between excelling and representing: he achieved great things, but he was just a regular guy, one who dressed in work clothes, smoked cheap cigars, and got his hands dirty.

## THOMAS ALVA EDISON

Thomas Edison was born in Milan, Ohio, on February 11, 1847, in a brick house designed by his father, Samuel. Milan bustled with commerce after a canal connected it with Lake Erie in 1839, and for a while it provided ample opportunities for Samuel Edison to make a trade of his carpentry skills, and dabble in land speculation. But Milan just as quickly found its best years behind it as railroads, not canals, began to dominate commerce. By 1854 the Edison family moved to the outskirts of Port Huron, Michigan, a lumber town on the Canadian border where Samuel tried his hand at several businesses. The family also farmed, growing produce for their table and for sale. As an additional source of income they rented rooms to boarders, and at one point they charged curiosity seekers to view the bustling port from an observation deck Samuel built in the family's yard.

Not much is known for sure about Edison's youth, despite a long tradition of anecdotal appreciations. The most recent scholarship challenges the established mythology, suggesting, for instance, that Edison may have been home schooled to save the cost of tuition and not, as previous accounts suggest, because he was sickly, inattentive, or addled. His mother, Mary, was a former schoolteacher, who probably made his education another of her household chores. Recent scholarship similarly questions whether Edison's partial deafness might have originated from a childhood illness and not, as lore has had it, as the result of having his ears boxed by an angry train conductor.[1]

When Edison himself recalled the events of his boyhood, he never produced a complete or continuous narrative. Instead, snippets of personal reminiscence and anecdotes were repeated and elaborated in newspapers and biographies, so that the otherwise ordinary activities of Edison's boyhood took on extraordinary significance in the context of his later accomplishments. His stories tended to present a youngster who was as hardworking as he was bold and curious, an

[1]See Paul Israel, *Edison: A Life of Invention* (New York: John Wiley & Sons, 1998).



entrepreneur-in-the-making, who connected with a generalized sense of America as a young nation. He recalled seeing immigrant trains loaded with Scandinavian settlers on their way to the Great Plains, for instance. He was also drawn to the railroad depot in Port Huron, which became his point of entry into the world of work beyond his parents' home. At fourteen years of age, Edison climbed aboard the local train to peddle newspapers, snacks, and similar merchandise. He soon after opened stands to sell periodicals, fruits, and produce in Port Huron. Bringing in a few baskets of vegetables daily from Detroit, his cargo was loaded on the mail car of the train, and carried off the books, if not for free, since the conductors who turned a blind eye to this infraction of company rules seemed to get produce at discount in return.

Edison learned from his experiences, both good and bad. For example, he closed the periodical stand when he felt his employee could not be trusted. In a happier instance, he made a large profit one day during 1862, while selling newspapers on the Grand Trunk Railway. As the story goes, he realized that demand for a breaking story about the Civil War battle of Shiloh would outstrip his normal supply of papers, so he arranged for credit, to get more newspapers than he could afford to buy. He then sold the papers at increasingly higher prices at every station stop along the way, charging whatever the market for war news would bear.

That spring Edison started his own newspaper, called the *Weekly Herald*. The only extant issue contains stories about railroad engineers and porters, as well as schedules for stagecoaches and horse-drawn omnibuses, among other means to make travel connections with the rails. He also printed "a peep at things generally," offering a touch of intrigue in the story of a swindle gone awry, and one item of humor, which was slipped mischievously under the title of "News." Edison produced the paper in the baggage car of the train, alongside a small chemical laboratory, where he experimented, until a mishap with his chemicals caused a fire, and he was forced to relocate the laboratory to the cellar of his parents' home. Another nearly serious accident from these days was possibly a myth, but it became a signature, life-changing event that set Edison on his path to greatness. One day Edison saw a little boy in the path of an oncoming train and pulled him to safety; to express his appreciation, the child's father introduced young Edison to the secrets of telegraphy.

Clichés jump from stories such as these, which tend to make the boy Edison into a virtual Horatio Alger character, with enough luck and pluck so that patience and industry are the wellspring of success. The real story to be gleaned from his early life may be less what really happened than how each episode retrospectively fit into the legend of an American hayseed who made good through a combination of native intelligence and homespun, "golden rule" morals. Whether strictly true or not, episodes in Edison's youth replayed the autobiographies of heroes like Benjamin Franklin and Abraham Lincoln, while they resonated powerfully with an affirmative ideology about America as the land of opportunity.

Whatever his immediate stimulus, at the age of fifteen Edison began to study and practice telegraphy in earnest. He was aware that thousands of miles of wire already connected the nation, and that the telegraph was used to coordinate rail traffic, to communicate news, and to conduct business. Most important, telegraphy was indispensable to military strategy, as both sides of the then-raging Civil War were using telegraphs to coordinate the movement of troops, supplies, and intelligence. Edison easily found opportunities to work in the world of telegraphy, since operators often were in short supply during and immediately after the war, but at least one twist made his technique as a telegraph operator unusual. Edison was already hard of hearing, and telegraph receiving instruments of the day were "sounders" or acoustic instruments. The average operator listened to the clicking and tapping, then transcribed the dots and dashes of Morse code into written text; Edison would have had to watch and feel the electrical impulses, while others relied more upon their sounds. He would also invent one of the first printing telegraphs in 1869.

Edison left home in 1863. Over the next five years he worked, trained, studied, and experimented in telegraphy at various locations. Employed first at tiny stations around Michigan and Ontario, he later worked at various offices of the Western Union Telegraph Company, which had built the first transcontinental telegraph line and was nearly a monopoly in America's telegraph industry. As Edison moved about, through Indianapolis, Cincinnati, Memphis, and Louisville, he became initiated into the informal fraternity of young, white men who frequently moved from office to office, but whose facility with the telegraph instrument or "key" assured them a job wherever they went. The best operators were highly skilled and sometimes engaged in improving telegraph technology. Several became Edison's friends and mentors, encouraged his experimental work, looked over his sketches, and helped him build and try new devices. By the time Edison arrived in Cincinnati, he was barely sixteen years of age, but



already a proficient telegrapher and sharp at the key when copying messages off the wire. He worked day and night, finding time to read technical literature and develop his experimental techniques with regard to the electrical, mechanical, and chemical components of telegraphy. One object of fascination to him was the repeater, which could relay messages automatically, over longer distances. Another was multiple telegraphy, or multiplex telegraphy, the capacity to pass more than one message over a wire at a time. He also worked on printing telegraphs and specialized telegraphs that served as fire alarms.

Although common wisdom called for ambitious young men to go west, in 1868 Edison instead headed east to Boston, where he positioned himself among the elite of telegraph operators—technicians who contributed to improving the design of machines and systems. He published a few articles about his own inventions in the *Telegrapher,* the official journal of the National Telegraph Union. By January 1869, he had found an ally to finance the introduction of his printing telegraphs, which were hotly desired for reporting up-to-date quotations on the prices of stocks and gold. Edison resigned from his job as a telegraph operator in order to become a full-time inventor. He went to New York City in April 1869, to help one of Western Union's competitors test a telegraph connection with Buffalo, and in June his first two patents were issued, one for an electric vote recorder (never successful) and the other for printing telegraphy. In August, a leading enterprise in providing financial news services made Edison its superintendent. Although this was a considerable leap of stature, Edison's tenure with the firm was short-lived, and he soon moved to Newark, New Jersey, a port and manufacturing town.

He next established a number of jointly owned enterprises and continued his experiments at several workshops in succession. The variety and pace of his alliances indicate that Edison struggled to find congenial working conditions, a suitably equipped place to work, and the capital to proceed. Along the way he hired several dozen workmen and assistants. He briefly pursued a business called the News Reporting Telegraph Company, which offered its subscribers "all general news of the world . . . in advance of all newspapers." Most traces of the firm soon vanished, except that Mary Stilwell, a sixteen-year-old girl employed by the company, became Edison's wife on December 25, 1871. Apparently in anticipation of his forthcoming nuptial, Edison had bought a house in Newark during the previous month. In February 1873, their first child was born—a daughter named Marion. Work preoccupied Edison after his marriage, just as it had previously. In the months and years after his wedding, Edison was completely immersed in the invention, testing, and manufacture of high-speed automatic telegraphy, chemical and mechanical printers, and additional matters related to telegraphy. Two months after the birth of his daughter, business beckoned abroad. Edison headed to England, where his "universal stock ticker" was already in use at the Exchange Telegraph Company of London, to demonstrate his automatic telegraph system for the British Post Office.

Edison's breakthroughs with various versions of the stock ticker dazzled investors and earned him repute as an inventor. The subsequent contracts enlarged his inventive and manufacturing capacities, as well as increasing his personal income, although his expenses often seemed to outstrip his resources. Edison never seemed to have quite enough money, technical staff, laborers, or equipment to keep pace with his ideas. His contacts with leading executives in the industry were widening, however, and at the beginning of 1873, his labors in the field of multiple telegraphy paid off. When Edison showed his designs to William Orton, president of Western Union, the inventor gained access to that company's facilities for making and testing experimental apparatus. Western Union had already embraced an improved system of duplex telegraphy, invented by Joseph Stearns, and it had practically doubled the company's ability to carry messages without adding the cost of new wires and their maintenance. Orton's interest in Edison lay in the hope that the young inventor would discover potential breakthroughs in multiple telegraphy, so that Western Union could control any new development that otherwise might undermine its current advantage.

In 1874 Edison successfully developed a "quadruplex" telegraph, exactly the kind of innovation that Orton had anticipated and desired. It would handle four messages over the same wire, carrying two in each direction at once. But because Orton's understanding with Edison was never put in writing, Edison was free to offer his invention to Western Union's arch rival, the Atlantic and Pacific Telegraph Company, controlled by the brilliantly ruthless financier and railroad magnate, Jay Gould. Gould was a singularly controversial figure of the Gilded Age, whose personal fortune at the time was perhaps as much as $25 million, and who was determined to undercut Western Union's dominance. He paid Edison the astronomical sum of $30,000 for the quadruplex. However, whatever hard feelings there might have been, Orton continued to respect Edison's technical ingenuity, and, in an



attempt to be sure that his oversight was not repeated, Orton established a contractual relationship with the inventor, making him a paid consultant for Western Union. The contract provided a weekly salary and future royalties for Edison, an independent inventor, in exchange for the exclusive rights to those inventions that could be used on the land lines of telegraphs or upon cables in the United States.

Edison had employed as many as 120 workers in 1874, but there was never enough time or money to pursue his own ideas fully. By early 1876, however, his profits from the quadruplex were already on the account books, and his improved "electric pen" (a stenciling device used to make multiple copies of business documents) was bringing additional income. The inventor finally seemed to have sufficient financial resources to establish his own laboratory, with a pared down team of fewer than twenty associates. Toward the end of 1875, Edison decided to retreat from urban life and devote himself to experimental work exclusively. In early 1876 he moved with his family and a select team of technicians and craftsmen to the small village of Menlo Park, New Jersey, where he transformed a cluster of buildings into a state-of-the-art experimental complex, including his own electrical and chemical laboratories, machine shop, and library. An isolated place, Menlo Park offered cheaper land and fewer interruptions than the city. It answered Edison's need for an environment in which he could fully investigate and develop his ideas. Yet it was also near enough to New York so that he and his associates could meet clients and invite journalists and investors to visit when Edison wanted to demonstrate his latest breakthrough.

During his first months at Menlo Park, Edison was preparing to exhibit the best of his inventive output at the U.S. Centennial Exhibition, scheduled to open during May 1876 in Philadelphia. A few weeks into the exhibition, Alexander Graham Bell demonstrated his astonishing new twist on acoustic telegraphy, the telephone, which allowed the electrical transmission of speech. Whereas most people reacted to Bell's telephone with absolute amazement, Edison and the men at Western Union more quickly noted its imperfections, for Bell's earliest device did not work very well. After so many years spent on improving the printing telegraphs, there were even some who dismissed Bell's telephone as a "scientific toy," since it did not result in a printed message and was therefore, presumably, of less value to the needs of business clients. Even the critics, however, were not above envy, as they were meanwhile eyeing the lucrative possibilities of Bell's discovery, and maneuvering to develop it for their own benefit.

That autumn Edison intensively honed his efforts toward improving Bell's device, while at the same time trying to invent around Bell's patents, in order to secure for himself and Western Union some of the valuable intellectual property being developed in the new field of telephony. Patents, simply put, are legal documents that protect inventors' rights to the new inventions they specify. Any unspecified improvement made by someone else is fair game. So Edison and his rivals all tried to outdo each other with new and, they always hoped, crucial improvements to each other's machines. Over the course of these efforts Edison became a household name, except that his fame did not result from his contributions to improvements in telephony. Although Edison's carbon transmitter helped to make the telephone a more practical device for general use, it was for his own astonishingly new device, called the phonograph, that the press dubbed him a "Napoleon of Science" and the "Wizard of Menlo Park."

The first phonograph was very primitive: a rotating cylinder, wrapped with a piece of metal foil, upon which the vibrations of sound were etched by a stylus and thus "captured," Edison said, so they could be replayed later at will. It was not an electronic communication device, but it printed voices in a way the telephone could not. It caused a sensation. Everyone wanted a glimpse of the speaking machine. In 1878 Edison demonstrated his device to the National Academy of Science, to members of Congress, and then to President Rutherford B. Hayes, who invited him to the White House. As one of his promoters gleefully reported, "School girls write compositions on Edison. The funny papers publish squibs on Edison. . . . The daily papers write up his life." Edison himself was delighted to capture the public eye and more than willing to cultivate the attention. From that time on, whatever Thomas Edison did, the newspapers duly took note. It helped that he understood the power of the press and greeted its representatives convivially, with plain talk and exuberant demonstrations of his nascent inventions, often long before they were ready for commercial introduction.

As Edison worked in Menlo Park, the country seemed unable to break free of a severe economic depression that began in 1873. The election of 1876 brought a constitutional crisis, as the Democratic and Republican parties both claimed victory in the presidential election. The price for ending the stalemate brought a halt to Reconstruction in 1877, a year that proved to be the nadir of the long depression and that pushed the United States to the brink of chaos. Economic woes forced railroad companies to cut the wages of their workers by 10

THE WIZARD'S SEARCH.

*The Wizard,* New York Daily Graphic *(1879)* The newspapers dubbed Edison "The Wizard of Menlo Park" and the name stuck. Here he is pictured in his search for supplies of platinum to use in his incandescent lamp. His hat and gown are covered with pictures of his early inventions.
Courtesy of the Edison National Historic Site, National Park Service, U.S. Department of the Interior.

percent, causing workers to strike, occupy rail yards, and effectively paralyze rail traffic in the United States. The first national strike in America put rifled militiamen face-to-face with angry, hungry laborers and their sympathizers. In city after city there were riotous confrontations between the militias and labor, until President Hayes authorized U.S. Army troops to put down the insurrection.

In the context of such strife, the figures of inventors like Edison and Bell sounded a reassuring note. Men like them were hailed as heroes. Their dazzling achievements suggested a better, shared future, guaranteed by technological change, which was dressed up and saluted as "progress," a hopeful abstraction to answer any doubts about the future.

As profiled in the press, inventors were great men who affirmed the values of American individualism. Edison handily helped to advance such ideals by saying that you only needed a tiny bit of inspiration and a whole lot of perspiration to succeed, and at times the unsuspecting public was lulled into thinking that anything was possible, no matter how absurd, if Edison was working on it. Consequently, after a newspaper in New York ran a story for April Fools' Day that claimed "Edison Invents a Machine That Will Feed the Human Race," the idea was spread uncritically by other papers, leading readers to believe the story was fact rather than farce. Edison nevertheless continued to startle the world with the practical possibilities of technology. He did so again by boldly announcing in September 1878 that he would introduce a new form of incandescent lighting.

It was something of an exaggeration, or at least a premature pronouncement, because Edison was speaking merely out of confidence that a few of his ideas would lead to a practical system of electrical lighting. So widespread was his acclaim on the heels of his phonograph that his electrical pronouncement caused a panic in the London stock markets that were trading the shares of gas utility companies. The gas companies were the potential casualties of an electrical system replacing gaslights. Edison wanted to produce incandescent light, in which electricity passes through a filament causing it to glow (or to "incandesce"). If someone could figure out a way to generate electricity efficiently and to get small amounts of it to pass through the right kind of filament under the right conditions, then incandescent electric lamps might be a suitable replacement for gas lamps as a form of illumination in homes, offices, and factories. Other inventors were working on the same thing, and the problem wasn't a simple one: The few experimental generators in existence were woefully inefficient, no one



knew how to "subdivide" electricity into manageable increments, and filaments were then called "burners" because electricity passing through them burned them up in an instant.

Edison started with the filament problem. Drawing on his work in telegraphy and electromagnetism, he thought he could design a way to regulate the current being fed into a filament. Just as the filament was about to burn up, an automatic regulating device would stop the flow of electricity to let the filament cool. When it had cooled and was starting to lose its glow, the regulating device would complete the circuit again. He worked feverishly with burners and regulators of every conceivable form throughout the autumn of 1878, during the winter and into the spring of 1879. Meanwhile he was drumming up financial support. He was confident. He started to work on generators.

In the course of their research, Edison and his assistants came to several important realizations. They soon knew that they were looking for a filament possessing a high electrical resistance and a small surface area, which would allow the distribution or "subdivision" of current across many parallel circuits, so that individual bulbs or components could be on or off without affecting the whole system. Edison and his assistants also thought they needed a material as durable as platinum, which seemed the best material at first, in spite of its high cost. They gradually realized that automatic regulating devices were not going to work, and beginning in January 1879, Edison began to think in terms of filaments placed inside of sealed bulbs from which the air had been removed, because nothing burns without air. Two key problems remained. First, creating a sufficient vacuum was impossible with the equipment of the day, and second, finding the appropriate filament for such a bulb.

Like several other researchers before them, Edison and his assistants soon understood that carbon made the best filament material. It had none of the durability of platinum or nickel, but it would be safe inside an evacuated glass bulb. Months of work led finally not only to a workable bulb, but also to the component parts of a workable system. Nonetheless, the question of Edison's contribution in the field of electric lighting would often revolve around his originality in designing the bulbs. Other inventors had tried a vacuum, had figured out the need for high resistance, and had used carbon before he did. Indeed, many arguments could be had over whether Edison actually invented a new technology. What Edison invented lay in how he drew together the parts and wholes of a system that worked, designing a place to "plug in" those first workable bulbs, the processes to make them, the generators to power them, while also stringing the wires, connecting the fuses, and figuring out how to measure the current (so they could charge money for it).[2]

Any debate concerning Edison's originality is both suggestive of the competitive contests that regularly occur in the technological marketplace, and indicative of the excitement that surrounded the introduction of electric lighting. Moses Farmer, William Sawyer, Hiram Stevens Maxim, and Joseph Swan all worked to develop incandescent lamps, exhibiting their inventions to the same forums and investors as Edison, who unveiled his electrical lighting system at Menlo Park on December 31, 1879. Edison subsequently offered demonstrations in London and Paris yet chose to perfect every detail of a reliable system before installing a fully operational service. Other rivals were meanwhile installing a related technology for outdoor electrical illumination, called arc lighting, which was much brighter than incandescent bulbs. Arc lighting already lit the night sky at amusement parks, among other urban spaces, and, while Edison worked feverishly to complete his incandescent system, Charles Brush's brilliant arc lights were installed in New York City, making Broadway the "Great White Way." Hiram Maxim and Joseph Swan were meanwhile developing and demonstrating their own versions of incandescent lamps, raising doubts among investors as to whether Edison's incandescent lighting was much different. By the time Edison finally opened the first central power station to generate electricity in lower Manhattan in 1882, there was abundant debate concerning the uniqueness of his claims. There was also widespread anticipation that a new era was opening for electrical illumination, which would "light up mankind from China to Peru." Those who sought to introduce the most practical, accepted form of electrical lighting would also fight to protect their intellectual property, wanting to lay claim to the singular originality of their ideas, and, when necessary, seeking ways to discredit the innovations of rival inventors.

The system that Edison developed was different from his competitors, yet there were also some striking similarities among the various inventors' approaches. The Englishman Joseph Wilson Swan, for instance, had labored intermittently on incandescent lighting since

[2]This is the assessment arrived at by the United States judiciary, when it evaluated Edison's patent claims in *Edison Electric Light Company versus United States Electric Lighting Company* in 1891. It is also the interpretation richly documented in *Edison's Electric Light: Biography of an Invention,* the book by Robert Friedel and Paul Israel with Bernard S. Finn (New Brunswick: Rutgers University Press, 1986).



1848. Swan displayed a lamp in December 1879 that closely foreshadowed Edison's design, using a carbon filament, vacuum chamber, and glass bulb. Also like Edison, Swan relied on a combination of particularly useful new scientific discoveries, including the vacuum pump devised in 1855 by German glassblower and instrument maker Heinrich Geissler, which was improved by Heinrich Sprengel in the 1860s. Such pumps were among several key reasons why Thomas Edison succeeded, as his team developed a Geissler-Sprengel pump that was superior to the one used by Swan and capable of making a better vacuum for more effective lamps. Likewise, the English scientist, Michael Faraday had discovered the principles of electrical generation in 1831, and by the mid-1870s dynamos could convert motion into electricity. Much the same as Charles Brush before him, Edison began testing the best machines then available on the world market. These included the generator designed by the Belgian-born Frenchman Zenobe Gramme, as well as a dynamo made by the Siemens company in Germany, and generators from William Wallace of Connecticut, which had been developed in collaboration with Edison rival Moses Farmer. Each was practical for various purposes, but none fully suited Edison's needs. In the process of testing them, Edison and his team also learned how they worked, then modified various elements. They soon produced a more efficient dynamo called the "Jumbo" (it weighed 27 tons) that could generate up to 100 kilowatts and illuminate up to 1,200 lights.

Only fifteen associates were on hand at Menlo Park when Edison began his electric light "campaign," as he called it. By 1881 the laboratory staff at Menlo Park consisted of more than eighty men. An additional forty men worked in the nearby lamp factory, which began production during the summer of 1880. Several among Edison's closest co-workers had worked with him in Newark, including his dedicated laboratory associate from England, Charles Batchelor; his accountant, William Carman, and the master machinist and shop foreman, John Kruesi. Others on the team had joined Edison's enterprise over the course of his electric light research, including the instrument maker and glassblower Ludwig Boehm (also spelled Bohm), a craftsman who had worked with Geissler in Germany. Edison also hired a German chemist, Alfred Haid, a college graduate. A few others on Edison's team had graduated from college, including the mathematic-minded American, Francis Upton, but most of the workers at Menlo Park, like Edison himself, learned and sharpened their skills on the job. By late summer 1880, as many as thirty-five workers were employed at the laboratory in assorted skilled and unskilled roles. They did a variety of jobs, if not always under Edison's direct observation, at least in response to his creative mind, his singular authority, and his motivation. The laboratory work was notably intense, often running round-the-clock, as Edison characteristically worked with little sleep. The routine was punctuated by jokes and pranks, through which the inventor intuitively kept morale high, despite the physically grueling and mentally taxing work. Edison's "muckers," as he eventually called his crew, generally shared a sense of pride and anticipation. In hindsight, many who assisted Edison felt privileged to be working with the charismatic Wizard.

Away from Menlo Park, a variety of important allies were also backing Edison. These included Wall Street attorney Grosvenor P. Lowrey, who represented Western Union. Lowrey proved crucial in assembling a blue-chip roster of venture capitalists to finance the development of Edison's electric lighting system. Among the emerging investors was Hamilton McKay Twombly, whose father-in-law was railroad heir William K. Vanderbilt, the major stockholder in Western Union and American gas utility companies. An even more significant new figure in the crowd of Edison backers was John Pierpont Morgan, the forty-two-year-old scion of a financial dynasty, and cofounding partner of the prestigious Drexel Morgan banking house, which later became J. P. Morgan and Company. Pierpont Morgan was hardly prone to speculative investments. He was, however, a director of Western Union and well acquainted with Lowrey, whose legal offices were in the same building as Drexel Morgan in New York, and whose early reports of Edison's lamp left Morgan imagining that something materially historic could come from it.

The Morgan seal of approval gave Edison precious advantages over his competitors, while a battery of Morgan partners also kept pressure on Edison to produce timely results. Morgan partners Egisto P. Fabbri and James Hood Wright became directors of Edison Electric Light Company, a firm organized in October 1878 to fund Edison's experiments, and the bankers formed the Edison Electric Illuminating Company of New York, the company that financed Edison's first permanent power station and distribution system. Morgan interests also promoted the exhibition of Edison's system abroad, protected his foreign patents, and founded Edison's electric light enterprises in England, then guided the corporate merger that eventually resolved patent disputes between Edison and Joseph Swan. Indeed, the first lights to be lit by Edison's pioneering central station in New York City



were in the offices of Drexel Morgan, which had been outfitted with 106 lamps.

Groundbreaking for the world's first central power station and lighting distribution system had begun in 1881, in lower Manhattan, at the heart of the financial district and what was then the center of New York City's newspaper industry. The power station on Pearl Street was outfitted with six Jumbo dynamos, built nearby at the newly established Edison Machine Works. As Edison and his key research associates supervised construction and testing of the entire system, the center of the inventor's activities shifted away from Menlo Park. By September 4, 1882, when he opened the Pearl Street Station, the inventor had moved his lamp company to East Newark, and by November 1882 his Menlo Park laboratory was abandoned in favor of working quarters in Manhattan. His family moved to New York City as well, and the family by now consisted of his wife and three children: daughter Marion and sons Thomas Alva Jr. and William Leslie.

Edison unquestionably preferred the culture of his work to the pleasures of his family. In 1878, for instance, when the newspapers reported that he and Mary were expecting their third child, Edison was quoted as saying, "The phonograph is my baby," giving a good indication how work and family would compete for his attention, and which would win. Later that summer, evidently suffering from exhaustion as a result of his breakneck pace in developing and promoting the phonograph, the inventor left home for a long trip that combined research and professional engagements with a vacation. Mary stayed in Menlo Park, pregnant and ill with "nervous prostration," a condition for which there is no reliable medical definition today, yet was frequently the diagnosis for symptoms of depression, anxiety, and, where women were concerned, "hysteria." By the time William Edison was born in October, the inventor was completely preoccupied with electric lighting. Edison did take winter vacations with his family during 1882–84, and the rest was meant to benefit the health of himself and his wife, who continued to be plagued by idiopathic symptoms during these years. She died from unknown causes in August 1884. Edison did not stay widowed for long. By the following autumn, he proposed to Mina Miller, whom he married in February 1886.

The second marriage would bring another three children—Madeline was born in 1888, Charles in 1890, and Theodore in 1898—yet Edison's second marriage differed from his first in several respects. Mary Stilwell was strictly working class, a woman whom Edison had met when he was her employer as well as a struggling inventor; Mina

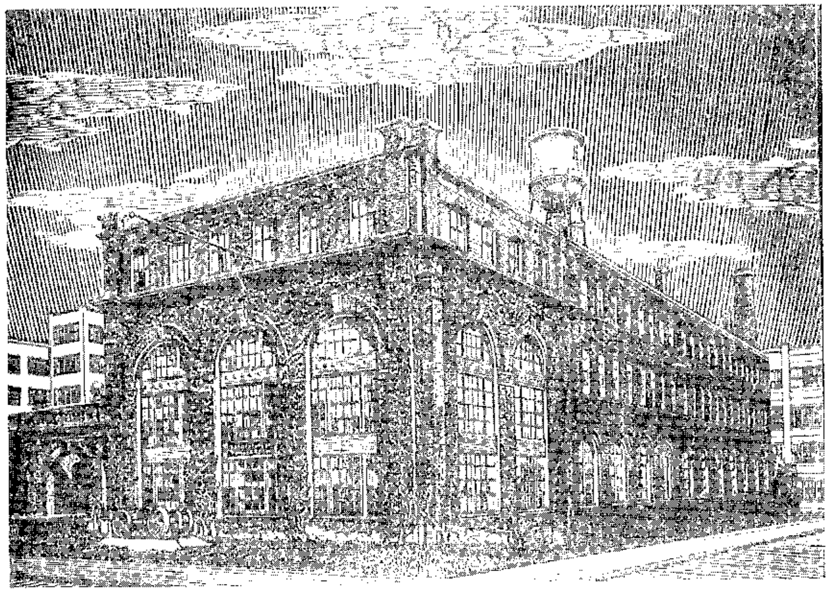
Miller was introduced to him through social rather than workplace connections, and she was the epitome of middle-class domesticity. The product of finishing school, and herself the daughter of an inventor and manufacturer of agricultural machinery from Akron, Ohio, she was also nearly twenty years younger than Edison, America's foremost inventor. Edison's second bride enjoyed many comforts her predecessor had not. She was given a mansion worth $235,000 in Llewellyn Park, an exclusive residential community in West Orange, New Jersey, and part of the couple's honeymoon took them to Florida, where Edison established a winter home in Fort Myers.

Soon after his second marriage, Edison revived his interest in establishing a central research facility, on a grander scale than Menlo Park. He purchased fourteen acres in West Orange, in the valley below his home, and proceeded to construct the most advanced laboratory complex of its kind. In 1887 he spent more than $140,000 on buildings and equipment. His library/office was an impressively spacious wood-paneled room, with an immense fireplace, arched windows, and two levels of open tiered galleries, rising above the ground level, and surrounding three of the four walls. The room could hold as many as 36,000 books. It was also the only conspicuously elegant portion of the laboratory complex. The rest of the facility boasted a different aesthetic, for it was strictly functional, although lavish in that regard, and replete with machinery and raw materials. A power plant supplied electricity for the 650 lamps within the different buildings, including a chemical laboratory, a laboratory for electromagnetic experimentation, a shop for making patterns, and a metallurgical laboratory. All together the laboratory complex soon employed as many as thirty experimenters and technical assistants, plus an additional labor force of machinists, pattern makers, draftsmen, carpenters, clerks, and others.

One of the most important research associates at Edison's new "invention factory" was William Kennedy Laurie Dickson. An engineer and amateur photographer, Dickson left his job at Edison's lamp factory to help improve Edison's phonographs and pioneer his development of motion pictures.

Edison's residence and laboratory in West Orange point out several themes concerning Edison and his era. It was an age of conspicuous consumption, when William K. Vanderbilt and his father built a pair of mansions on New York's Fifth Avenue, reportedly costing $15 million, yet most Americans lived very modestly. Annual incomes for 1890 ranged from $233 for farm laborers to $439 for manufacturing employ-





*Edison's West Orange Laboratory* Successor to Menlo Park, the West Orange laboratory institutionalized Edison's methods. The main building included Edison's library/office, as well as machine shops, drafting rooms, and a storeroom. Visible in the background are factories eventually built to manufacture inventions perfected at the lab.

ees, and from $687 for employees of gas and electrical utilities to $848 for clerical workers in manufacturing and steam railroad enterprises. Garment workers often worked eleven-hour shifts in crowded sweatshops for less than a dollar per day, while miners worked nearly as long for perhaps twice as much pay. Where Edison stood within this spectrum is not without interest. There were companies bearing Edison's name throughout the world, and his income was obviously nearer to that of a Vanderbilt than the average American, but Edison's visible display of wealth was modest among millionaires. He also had no interest in high society, he remained a mechanic at heart, and he worked days as long as any garment worker or miner.

By 1889 Edison had executed 652 patent applications with dozens more pending. His presence at the Paris Exposition of 1889 gave Americans as much pride in their nation as the French garnered from the opening of the Eiffel Tower. He had additionally formed the Edison General Electric Company, a move toward consolidating his lamp, dynamo, and lighting fixture companies into one enterprise. Edison had also entered a new phase of inventive activity, and in the years to come, though every so often he would announce his retirement, he never completely retired or quit.

In the next phase of Edison's inventing, he returned to developing phonographs, wanting to see "his baby" reach maturity after he noticed that the baby was falling behind the progeny of others. Alexander Graham Bell and Charles Sumner Tainter unveiled their "graphophone" in May 1887, the same month in which German American inventor Emile Berliner applied for a patent on his "gramophone." Not to be outdone, Edison soon revisited nearly every component in the design of his phonograph: the power supply, the recording material, the quality and volume of the sound, and the procedures for cheaply duplicating recordings. Phonographs (and graphophones) remained able to record as well as play back sound, and the most profitable application of such machines was expected to be their use as dictation devices for business correspondence. Additional uses remained conceivable but subsidiary, even though Edison had developed a "phonograph for dolls and other toys" by 1889. Further inventive contributions by Edison and others would soon help to reframe the phonograph as an amusement device that would play prerecorded musical records.

In addition, in 1888 Edison promised he would invent something to "do for the eye what the phonograph does for the ear." His interest in the nascent technology of motion pictures was stimulated by consultations with the world's two greatest experts in the science and technique of serialized action photography. One was photographer Eadweard Muybridge, whose visit with Edison in West Orange that year led the inventor to propose a device called the kinetoscope. The other direct influence on Edison was physiologist Étienne-Jules Marey, who took sequential photographs of moving figures by "shooting" them with a gun-like camera. In 1889 Edison made W. K. L. Dickson his key experimenter for motion pictures, and set him to work on various problems, thinking that photographic emulsion could attach images to a cylinder, and they could be played back like a phonograph. Edison himself spent the bulk of his time on other matters.

Mining and ore milling were capturing the greater amount of his attention during the 1890s. Edison turned much of his personal energies and considerable amounts of his financial wealth toward the problem of obtaining concentrations of iron from low-grade ores.



Undertaking a decade-long endeavor, which drew upon his patented processes of magnetic separation, it led him to experiments in mass production, while never making a profit. The better part of his venture capital came from the gradual sale of Edison's stockholdings in the General Electric Company, which was formed in April 1892, when J. P. Morgan engineered the merger of the Thomson-Houston Electric Company with the Edison General Electric. During the 1890s, Edison effectively lost all control of the industry that he had helped to start, even though the public never wavered in its association of Edison and electricity.

Moreover, the research staff at Edison's laboratory continued to develop new technical ideas for commercial exploitation. The joint work of W. K. L. Dickson and William Heise made significant advances in the development of motion pictures between October 1890 and May 1891, producing a sprocket-feed mechanism for film that was remarkably similar to a printing telegraph. They began making viewers and cameras, then experimental films, leading Edison to give a few public demonstrations of the new kinetoscope, a way of presenting motion pictures to one viewer at a time. When the first kinetoscope parlor opened in New York during mid-1894, customers looked down into a cabinet and watched very short, simple subjects through a peephole, paying a nickel for each view. In less than one year, Edison earned nearly $90,000 in profits from the sale of kinetoscopes and films.

Then, just as quickly, the fad faded. After Dickson quit Edison's employ in April 1895 and went to work for the rival American Mutoscope Company, the production of new Edison films came to a halt. The next major breakthrough did not emerge from Edison's staff. Thomas Armat and C. Francis Jenkins coinvented a way to project motion pictures on a screen, making it possible for many people to view films at the same time in auditoriums. Edison eventually pooled his camera patents with those of the Armat-Jenkins projector, and agreed to supply the films, as well as to lend his illustrious name to the projector, which was called the "Edison Vitascope." It was introduced to the public at Koster & Bial's Music Hall in New York City on April 23, 1896.

Edison's problems were far from over, however. The Lumiére brothers in France were making a sensation with their cinématographe, another form of projected motion pictures, which arrived stateside during the summer. British inventors William Friese-Greene and Robert William Paul were similarly active in developing the new medium. Dickson's motion pictures were meanwhile being released by the American Mutoscope Company, and playing vaudeville houses. At the same time, further renegades from Edison's invention factory formed an additional competitor, the International Film Company, and began selling pirated copies of Edison's films before entering into production for themselves.

Edison responded to the competition in several ways. He introduced a modified projector, calling it his own, and he turned to the courts in an attempt to restrain the unauthorized use of his patents and to validate the copyrights on films. He also tried to make more popular films. His team turned out exotic subjects geared to excite the interests of audiences—from vistas in foreign lands and New York street scenes, to heart-stopping thrill sequences and ribald comedies. Current events offered another avenue for production: Along with footage from the Spanish-American War, reenactments of the Boer War, and some of the last photographs of President William McKinley before he was assassinated were captured by Edison's filmmakers.

The release of *The Great Train Robbery* (1903) scored new success for the Edison Manufacturing Company's motion picture division, largely due to the innovative talents of Edwin S. Porter, its cameraman, who collaborated with George S. Fleming, an actor and scenic designer, in the artistic direction, story development, and editing of the film. They produced a suspenseful, Western crime-action story, a multiscene narrative, and one of the earliest films with a developed scenario. It was also the first blockbuster, a moment to prove that movies could find massive popularity, even if hitting upon commercial success proved hard to predict or duplicate in every film. As the new entertainment industry underwent rapid growth and attracted widespread competition during the first decade of the twentieth century, Edison struggled to keep his motion picture business viable. Fighting competition through patent litigation, he also looked to enhance the technology. He contracted experimental work with color photography, spending approximately $30,000 to find a process (for which he received a patent but which he never introduced commercially). He also devised a patented system for talking pictures that mechanically connected phonographs with cameras and projectors, but he never synchronized sound and image reliably enough for full-scale commercial exploitation. In addition, Edison's company manufactured equipment for home and amateur use. His business was also party to the Motion Pictures Patent Company, a business concern that tried to



dominate theatrical film, until it was declared to be an unlawful monopoly by the federal government.

The phonograph industry was no less vigorous than motion pictures. During the 1890s Emile Berliner and others began retailing disc record systems as a successful alternative to Edison's cylinder record system. The gramophone's sound was not as good as that of Edison's machines, but the discs were easier to handle and store than cylinders. They were also made of a more durable, thermoplastic shellac material, and they could be mass produced more cheaply than cylinders. The alternative format quickly cornered a lion's share of the market, due not only to the advantages of mass production, but also to a few key marketing policies adopted by the Victor Talking Machine Company, which took over the gramophone interests in America. Concentrating on the uses of recorded sound in the home, it ignored the business and educational markets, which Edison continued to pursue. Victor also introduced one of the most successful trademarks of the twentieth century: the picture of a dog frozen in curiosity, his ear cocked slightly toward the amplifying horn of a record player, while listening to "his master's voice" (now owned by RCA; HMV stands for "his master's voice"). The name of the Victor record player, the "Victrola," became a colloquial term for all record players. Corn flakes, celluloid, and escalators are names with similar histories, just as the trademarked Xerox®, Kleenex®, and Coke® today are considered synonymous with photocopies, tissues, and colas.

For years after the Victrola's success, Edison remained committed to the cylinder format for phonograph records. In 1912 he finally conceded that the disc recording system was here to stay. He experimented intensely and brought out his own line of disc machines and recordings, while also continuing to serve the cylinder market well into the 1920s. Edison wrote advertising slogans and reviewed promotional materials for his phonograph business. He also listened to auditions and strongly expressed his opinions, holding sway over what was recorded, despite his increasing deafness.

To some extent, Edison's experiences in the motion picture and phonograph industries were typical of his entire career. Edison was confident that his brain could solve anything it wanted to solve, yet his inventive and commercial work repeatedly produced ambiguous results. Since no one project or idea was fully isolated from another in Edison's mind, the formation of the Edison Portland Cement Company in 1899 speaks more fully to the same point. After the 1898 discovery of Minnesota's iron-rich reserves made Edison's ore-concentration scheme pointless, he closed his ore-milling plant, yet wasted no time in turning his understanding of continuous production techniques to the manufacture of Portland cement.

By the end of the nineteenth century, natural cement was being succeeded by Portland cement, a compound of calcium, silica, alumina, and iron that produced a better bonding agent in concrete. When strengthened with steel reinforcements, concrete promised to become the world's most adaptable building material. Edison's cement plant went into production in November 1903; twenty-five years later the uses of his cement corresponded to the diverse adaptability of concrete in modern construction, finding its way into bridges, tunnels, and roadways, schools, department stores, and swimming pools, as well as New York's Yankee Stadium in the Bronx. His technical contributions to the industry included improvements to machinery for crushing and screening rock, along with a significant breakthrough for the industry in 1909: his invention of a giant rotary kiln that proved to be capable of processing the ground stone mixture at five times the industry average with greater fuel efficiency. Edison also designed a method of using poured cement concrete to make affordable, quickly fabricated houses. Although few of the Edison-poured houses were built, his idea seemed to grasp emerging trends in urban renewal, modern architecture, and the beginnings of suburbia.

Nothing occupied Edison more in the early years of the twentieth century, though, than his electrochemical research with wet-cell storage batteries. The experimental work alone probably involved more than 50,000 laboratory tests conducted under Edison's supervision. One of his major goals was to produce a light, portable, quickly chargeable battery to be used in moving vehicles. More than one-third of the cars and trucks in America were electrically powered before World War I, before gasoline-powered motors became the decided standard. The task of moving vehicles, however, was not the only application for Edison's storage batteries. They could also be used for electrical power in country houses, in submarines, in trolleys, in warehouse dollies, and in portable lighting fixtures. When used to power lamps that were attached to the helmets of underground miners, Edison's battery-powered light was considered to be a significant advance for the occupational safety of miners.

As Edison approached his sixty-fifth birthday, he took a stab at updating, or modernizing, the organization of his various research and commercial activities. He formed Thomas A. Edison, Incorporated, in



1911 to coordinate the exploitation of his patents, manufacturing enterprises, and marketing operations. It hardly freed him from the day-to-day management of the businesses, for Edison found it difficult to let go of it all, even though his team of support staff had long ago grown beyond the day-to-day control of any single individual. He remained an active researcher, focused on his existing business rather than new ones, and therefore supervised and conducted experiments on various subjects related to the disc phonograph, business dictation machines, talking motion pictures, and the design and acoustic engineering of recording studios, as well as his storage battery. Then, in 1914, Edison's phonograph business was among the first American firms to be seriously affected by the outbreak of war in Europe, because it was so dependent upon German suppliers for the phenol used in its manufacture of records. If Edison was no longer inventing new industries, he was quick to resolve the problem for his own enterprise. After working night and day to find a substitute, he put up plants to manufacture the chemical himself. Those same plants were soon producing other chemicals, including toluol (one of the "t's" in TNT), which he supplied to the British through J. P. Morgan and Company. When America entered the war, Edison was named chairman of the Naval Consulting Board, a blue-ribbon consortium of military, governmental, and industrial interests that foreshadowed the "military-industrial complex." Edison went to meetings, but otherwise busied himself with experimental methods for detecting enemy submarines.

War-related contracts made great earnings for Edison's businesses. His factories and laboratory accommodated as many as 11,000 workers by the end of hostilities. After that, tough times settled in. Edison abandoned his unprofitable motion pictures business, and, during the 1920s, the phonograph business stopped being his cash cow. Indeed, all of Edison's businesses suffered in the postwar recession, but the phonograph losses continued to mount dramatically after the national economy boomed. One important reason was Edison's stubbornness. Most of the competition had converted to electrical recording, while Edison clung to acoustic techniques. Radio was the next wave, and Edison refused to get involved with it. Sound and color motion pictures were nearer to full commercial introduction, yet Edison had abandoned their development as well. Also, instead of updating his technology, Edison cut the payroll, reduced advertising budgets, and trimmed contract fees to artists. By 1921 the workforce at West Orange was reduced to 2,000 employees. Edison was the last to admit that his hands-on control of the business could be detrimental to its research, development, manufacturing, and commercial operations. Although Charles Edison, the elder son from his second marriage, became president of Thomas A. Edison, Inc. in 1926, Edison did not finally retire from business until 1927. Thereafter Charles and his brother Theodore, a graduate of the Massachusetts Institute of Technology, managed to make some moves toward the latest radio-phonograph technology. Before they could release anything for a new electrically recorded catalog, the Edison phonograph business was bankrupt. Edison's entertainment-phonograph business was discontinued in 1929.

Edison spent his last years trying to develop a domestic supply of natural rubber for commercial use. A strategic material that had been difficult to obtain during and immediately following the war, rubber was critical to the business of Edison's friends, automobile manufacturer Henry Ford and tire manufacturer Harvey Firestone, who funded his rubber research, even as they both invested in rubber plantations abroad. The inventor put nine acres of land into cultivation near his home in Fort Myers, Florida, collecting more than 17,000 plants for testing; when Edison died in 1931, the results of his experiments were inconclusive.

## NOT JUST AN IDEA

Recognizing inventors and inventing is a relatively modern pursuit. No one knows who invented the wheel, the plow, or the stirrup. No one knows precisely how or when bronze, paper, or gunpowder was first created. The invention of printing with movable type is readily ascribed to a fifteenth-century Rhinelander, Johannes Gutenberg, but most of the people familiarly known as inventors are men who lived after the first half of the eighteenth century, during or after the Industrial Revolution, men like James Watt of the steam engine (1769), Eli Whitney of the cotton gin (1793), and Samuel F. B. Morse of the first American electric telegraph (1844). Although it is frequently misleading, new machines of note historically get attributed to the work of single individuals at particular moments. Invention is understood as a form or expression of individualism, although such a focus tends to promote a simplistic, romantic understanding of technology. Technological change is more properly a social process than it is the result of isolated acts of creative genius.



In some respects invention is a national concern as well as a modern one. Schoolchildren in Britain, for example, often learn that Joseph Swan, not Thomas Edison, invented the incandescent light bulb, that William K. L. Dickson, not Edison, invented motion pictures. Schoolchildren in France learn that Charles Cros, not Edison, invented the phonograph, and that the brothers August and Louis Lumière invented motion pictures.

While the fact that inventions are attributed to different people in different nations must arise in part from pure chauvinism, it also suggests that technological artifacts like light bulbs and movies may be too complex to have been invented whole, in a single, dramatic moment or by a single individual. Instead, many inventors often work on the same problem, at times secretively but at other times publishing their accomplishments in the form of patents or, like Edison, trumpeting them to the press. Many, perhaps most, innovations occur uncelebrated in the course of everyday life and labor. Many inventors can make crucial contributions to a single technology. Whoever is eventually considered the inventor depends upon a great many factors, usually including but never limited to being the first and only person to achieve a certain technological goal or result. Other factors include the social and economic advantages an inventor might possess, the legal dexterity of an inventor's patent lawyers, consumer interest, public relations, and the ongoing description of history by historians, educators, politicians, and others. The point is not so much that some histories of who invented what are incorrect (of course, some are); the point is rather that inventing is a cultural phenomenon as well as a technological one.

In many respects Thomas Edison is the person who invented inventing as historians now understand it. It can be argued that this is Edison's greatest single achievement, dwarfing all of his other innovations. Edison realized that inventing meant a lot more than just being the first person to have a good idea. While he promoted himself as the inventor of many things, he was able to marshal and even to institutionalize many of the activities and resources that inventing entails, all in the context of his own hard work and creativity. His laboratories at Menlo Park and then at West Orange were his "invention factories." They represent important points of transition, helping to locate technological innovation between the isolated tinkers and primitive workshops of the past and the more modern, corporate R&D labs of today.

Edison's Menlo Park and West Orange laboratories each had advantages of location, materials and equipment, and personnel. Both were located with easy access to New York City, the nation's preeminent financial center and its primary communications and transportation hub. Both sites possessed land for Edison's endeavors, railroad links, and available sources of labor (although Edison had to sponsor the first boardinghouse in Menlo Park in order to provide himself with a crew). Throughout his career Edison had a knack for hiring people who could do what he needed to get done. His staff always included a core group of machinists who could make anything he called for, draftsmen who could turn his sketches into working plans, and secretaries to handle correspondence and help with administration. He hired chemists, mathematicians, and other specialists as needed. When his electric light work called for glass bulbs, he hired glassblowers like Ludwig Boehm, an instrument maker trained in Germany. When his financial backers wanted assurance of his electrical innovations, he hired a young physics student named Francis Upton to do a search of all of the relevant literature. When litigation with another inventor swirled around his light bulb, he hired draftsman and inventor Lewis Latimer right out of the enemy camp (Hiram Maxim's United States Electric Lighting Company) to give himself an edge. His staff was hierarchical, with some associates sharing more responsibilities than others and having freer reign to innovate, usually along lines that Edison suggested or at least on projects he assigned to them. There were unavoidable personality conflicts. The list of sometimes disgruntled laboratory alumni is a distinguished one, including Nikola Tesla, Reginald Fessenden, and Frank Sprague, the inventors of alternating current motors, high-frequency radio, and electric traction, respectively. Edison had some close associates, like Charles Batchelor, with whom there were apparently no ego conflicts involved in collaborating on Edison's inventions. Yet for others the very act of collaboration seemed to mitigate Edison's claims as the inventor.

Like many in his generation, Edison wrongly believed the ethnic, racial, and gender stereotypes of his day, but he seems to have appreciated and rewarded the abilities of individuals as such and in some cases. Lewis Latimer was African American; Nikola Tesla was a Croat from Serbia; both Charles Batchelor and W. K. L. Dickson were Englishmen. Over the years his laboratory staff included Germans, Swedes, and Slavs. He occasionally hired Jews. He usually counted on employing Italian immigrants for any manual labor he required at



mines and mills. Women had no place at Edison's laboratory (he said of his own first wife that she could not "invent worth a damn"). Many working-class women, however, did find employment over the years in Edison's manufacturing businesses doing specialized detail work, including hand-coloring motion picture films or assembling tiny phonographs to make talking dolls. Detail-oriented manual labor was thought suitable for women, and manufacturers of the period liked to hire them for such jobs, because they could pay them less than they paid men.

Providing himself as much as possible with the necessary staff, materials, financial backing, and legal advocates, Edison worked with relentless energy on projects he deemed "practical." Practicality meant anticipating consumer demand in an existing or potential market, inventing something that people could be convinced to buy. Edison's work was goal oriented, whether he was after a new, louder version of Bell's telephone, a cheaper way to process iron ore, a replacement for domestic gas lighting, or a way to exploit x-rays. With such a goal in mind, Edison proceeded to articulate a research plan, thinking of things to try and subsidiary projects to work on. His method was trial and error, but always within a larger context. He tried hundreds of materials in his telephone receiver to see which worked best. He tried thousands of different filaments in his incandescent lamp before discovering that carbonized paper worked best, and then that carbonized bamboo fiber worked even better. Sometimes he knew what material would work best, but he wanted to find a cheaper version. Cobalt and rubber were fine for use in his rechargeable battery, but not if he had to rely upon expensive imports of both commodities. Platinum was necessary in electric lamps, but how could he use the smallest amount possible of this precious metal? He knew to vary one thing at a time, try everything, and then go back and work on another variable. And he knew that an important part of such work was record keeping. He filled hundreds of notebooks with his research notes and drawings, and his staff filled several thousand more, carefully dating and frequently signing entries that might be helpful later, either in reorienting his research plans or in defending his priority to the Patent Office or the federal courts. In one interview he called his notebooks his "novels." Together with Edison's correspondence, published accounts, and existing artifacts, this vast collection of experimental notes offers a look into the process of inventing, into the ongoing definition and redefinition of the practical.

Edison proved adept at finding financial backing for his endeavors—over the course of his long, on-again-off-again relationship with Western Union, and particularly after he was famous, when he sought investors for his electric lighting project. Part of his method was pure confidence; he pronounced his imminent success to the newspapers and to anyone else who would listen. When his investors grew worried, he invited them to his laboratory for demonstrations, dinner, and a taste of his braggadocio. He could be a canny salesperson, and he knew the advantages of showmanship. Some of his first lighting installations illuminated the yachts, homes, and offices of Cornelius Vanderbilt, J. P. Morgan and other eminent capitalists and financiers. In some respects his confidence became a self-fulfilling prophecy. With the right financial backers Edison had both the money to proceed and the attention necessary to shape his destiny as the one to watch. When he did have inventions to exploit, he tended to favor privately held corporations in which he held most of the stock. He saw himself as an inventor, but he always wanted his own manufacturing enterprises to support further inventing. In cases when he did not do the manufacturing himself, he granted exclusive rights to other parties on the condition that he received specified royalty payments. He and the lawyers and executives who worked for him recognized the value of intellectual property rights—patents, copyrights, and trademarks[3]—as a means of controlling markets.

Like financing, legal strategy was a crucial element of Edison's success. He always had a lawyer and was involved with legal disputes over patent rights from the mid-1870s until his death. Patent infringement suits cut two ways; sometimes Edison sued someone else for infringing his own rights, and sometimes he himself was sued for selling something that another inventor thought was not Edison's to sell. All of this wrangling began in the official quarter of the United States Patent Office, established by act of Congress in 1790, where inventors have to convince the government that they have indeed invented

[3]Each of these is a different form of intellectual property authorized by federal law. Patents apply to inventions, copyrights apply to writings or other creative expressions, and trademarks apply to commercial marks like brand names. Edison patented the technology he invented, he sought copyrights for the films he produced, and he received a trademark on his own signature for use in promoting and labeling his manufactured goods. Of the three, patents are hardest to obtain. Federal agents called Patent Examiners evaluate an applicant's claims and assess the nature and extent of invention before they can grant a patent, an exclusive seventeen-year right (today it is twenty years) to exploit the invention in question. Patents balance rewards for inventors (in the form of exclusive rights) against benefits to the public (granting rights for only a limited term).



something new and useful. Edison would sometimes urge his lawyers to "claim the earth" or "claim the solar system" in regard to a particular invention. One federal judge, while deciding an important electric light case in Edison's favor, chided his lawyers about "the haste which has always seemed to characterize Mr. Edison's efforts to patent every improvement, real or imaginary, which he has made or hoped to make." Edison understandably wanted his legal rights to be as broad as possible in order to protect himself against competitors.

## CONTEXTS FOR TECHNOLOGICAL CHANGE

Why do some inventions succeed and others fail? What affects the "fit" (or lack thereof) between what an inventor thinks is practical and what groups of consumers embrace? Related to these questions are broader questions of technological and social change. Does technology progress in a necessary sequence, from gas lighting to electric, for instance, or is technological development more idiosyncratic? Does society merely change in response to new technology, or are there social conditions that themselves shape the direction and the pace of technological change? One particularly interesting way to address questions like these is to take a look at "failed" inventions or inventions that succeeded in completely unanticipated ways. There are plenty of devices and technical processes that have worked without ever having been successful. Or is this just another way of saying that they really did not work? It depends upon how you define success and failure.

Inventions that fail to become popular can be hard to study for the simple reason that successful ones tend to dominate the historical record. What works tends to blind us to failures and false starts along the way, warping our sense of contingency (what might have been) and therefore of change. The present starts to look inevitable: Of course there are electric lights; of course we can record sound. Even little things about technology take on an air of inevitability: Of course English-speakers say "Hello" when they pick up the telephone; of course electric wall sockets have the shape and placement that they do. One of the challenges facing the historian is to undo this sense of the inevitable, to see the past on its own terms. Every such technological development turns out to have been the result of individual interests and unplanned negotiations between innovation and the social and economic conditions that existed at the time. Alexander Graham

Bell apparently wanted people to say "Ahoy!" when they picked up the phone, but Anglo-American culture ended up with "Hello" as a form of unthinking social consensus. Wall sockets went through many different forms and only gradually arrived at the standard we recognize. Record labels, dial tones, electric currents, and the sprocket holes along a strip of film: Each of these was shaped by a complex array of forces, social as well as technological.

Because of his immense public stature, Thomas Edison provides a convenient way to see into failed inventions in two ways. First, he was so well known that his own less than successful inventions received a lot of public notice. His iron-ore processing methods, his rechargeable battery for electric vehicles, and his poured concrete house all received international attention, yet none entirely lived up to the inventor's expectations. The iron-ore concentrating mill he built in western New Jersey had to be shut down when it could not compete with cheaper ore arriving from newly discovered iron deposits in Minnesota. His rechargeable battery eventually worked well, but the automobile industry had committed itself by then to gasoline and the internal combustion engine. The concrete house just did not catch on. In each case Edison had made an astute reading of some of the pertinent social and economic conditions—the burgeoning steel industry, the increase in private automobiles and company fleets, and the need for cheap suburban housing—but there were other conditions that he did not or could not take into account, like the structure of competition and the habits of consumers. The most generous way to put this might be that he was ahead of his time.

Even some of Edison's most successful inventions did not succeed in quite the manner he thought they would. He invented the phonograph, for instance, as a device for recording as well as playback. He thought it would make a revolutionary dictation device, to assist businesspeople and replace stenographers. It might be used to preserve the speeches of "our Washingtons, our Lincolns, [and] our Gladstones," he thought, never imagining that the primary function of the phonograph would eventually be to play prerecorded music. Only when consumer demand had reshaped or reframed the device did he recognize the phonograph as the amusement device it became. Then he made millions of dollars on musical phonographs and the records his company produced and manufactured.

The second manner in which Edison can offer a glimpse of failed inventions is also the result of his celebrity. Over the years he became a lightning rod for the schemes of others, and thousands of people wrote to him with questions or ideas of their own. Whether realistic proposals or kooky fantasies, the questions and ideas that ordinary people sent to the inventor over the years provide a glimpse of futures that never arrived. Like so many science fiction stories, the letters of such would-be inventors imagine a better future, yet they were undoubtedly sincere nonfiction. Reading these letters provides a sometimes poignant reminder that technological development always has its insiders and its outsiders, and it further prompts questions about the agents of technological change. After his concrete house idea was widely publicized, for instance, Edison received inquiries from across the United States and around the world. One woman wrote from a sod house in Oklahoma, seeking a better dwelling for her family. Others, like American steel magnate Henry Phipps and the Archduke Ferdinand from Bosnia-Herzegovina,[4] wrote hoping that they could provide housing reforms for others.



The history of technology needs to be sought in the documentary record, even in primary sources like unsolicited and "crank," "begging," or "idea" letters, as Edison and his staff referred to them. Machines themselves, even a sequence of outdated machines arranged chronologically in a museum, can only offer a tiny part of their own story. There are many sources of related documentary evidence. We have only to consider the numerous ways Edison himself used paper in order to understand the great variety and suggestiveness of the documents pertinent to the history of technology. He used paper to record his work, to collect the work of his employees, to communicate his wishes and ideas, to tag and wrap up mineral samples, and to keep his accounts. But he also burned bits of paper to try as carbon filaments in his incandescent light bulbs and used paper tapes and sheets to test and retest his printing telegraph devices, "electric pens," typewriters and mimeographs. And he did all of this within the larger context of unrelenting attention from the newspapers and unflagging self-promotion to the press. All of these uses of paper resulted in documents of one kind or another. Those that have survived offer evidence of Edison's activities and their contexts.

[4]A few of the Phipps letters are included in chapter 4. The assassination of Archduke Ferdinand in 1914 was the event that precipitated World War I.