Invention (device or process)

I INTRODUCTION

Invention (device or process), creation of new devices, objects, ideas, or procedures useful in accomplishing human objectives. The process of invention is invariably preceded by one or more discoveries that help the inventor solve the problem at hand. A discovery may be accidental, such as the discovery of X rays by Wilhelm Conrad Roentgen while he was experimenting with cathode rays, or induced, such as the invention of the lightning rod by Benjamin Franklin after he proved that lightning is an electrical phenomenon.

In common usage the term *invention* is applied only to the production of new materials or operable devices, and the term *inventor* is applied to a person who has produced a new device or material. Less frequently, the term *invention* is applied to a new procedure; thus a person may be said to have invented a new game or a new system of accounting. Under strict definition, however, anything produced by humans that is new and unique is an invention; this definition was recognized by Johann Sebastian Bach, who gave the title *Inventions* to a series of his short keyboard compositions.

In most countries, certain classes of inventions are legally recognized, and their use is temporarily restricted to the control of the inventor. In the United States, any new and useful art, machine, manufacture, or material, or any new and useful improvement of these, may be protected by patent; written material, music, paintings, sculpture, and photographs may be protected by copyright. The protection afforded by this legal recognition is limited; in many cases, if a person alters an invention and thereby improves or changes it, that person may be eligible for a new patent or copyright. Patent and copyright laws do not provide coverage for all inventions. Many processes and ideas lacking clear-cut characteristics, such as psychological concepts useful in advertising, cannot be legally protected.

II ADAPTABILITY

Restricted to *Homo sapiens* and perhaps a few of the higher animals, inventiveness implies a continued ability to adapt discoveries to use. Many lower animals have, at some time in the history of their species, acquired the ability to produce complicated devices and have continued this ability from generation to generation. In humans, however, the development of construction methods is preceded and followed by discoveries of natural laws that facilitate the construction. The pattern of discovery followed by invention followed by further discovery, which results in continual development of new concepts, procedures, and devices, is characteristic of the inventiveness of the human species.

III EARLY INVENTIONS

The earliest artifacts show evidence of human inventiveness. The names of the great archaeological ages—the Stone Age, the Bronze Age, and the Iron Age—are derived from the inventive use of stone and metal implements (*see* Archaeology). Early stone implements were crude, but the purposes they served—protection and food gathering—were instrumental in humans' growing domination of the earth. Many of the most significant inventions and inventive developments occurred before the period covered by written history. These include the invention of crude tools, the development of speech, the cultivation of plants and domestication of animals, the development of building techniques, the ability to produce and control fire, the ability to make pottery, the development of simple political systems, and the invention of the wheel.

The period of recorded history began with the invention of writing, and writing as a means of mass communication became important with the invention of movable type in the 15th century. Invention proceeded steadily throughout the period of written history, but since the advent of printed books, people all over the world have been able to obtain records of the discoveries of the past for use as a basis for further discoveries and inventions.

IV THE MACHINE AGE

The machine age, which began with the Industrial Revolution and continues to this day, developed from a group of inventions, of which the most important include the use of fossil fuels such as coal as sources of energy, the improvement of metallurgical processes (especially of steel and aluminum), the development of electricity and electronics, the invention of the internal-combustion engine, and the use of metal and cement in construction work. Current developments in the use of energy promise to introduce a new age in human inventiveness.

Early inventors were usually isolated and unable to support themselves through their inventions. In some cases, although two individuals working independently achieved the same innovation simultaneously, only one was recognized for the discovery. For example, the American inventors Elisha Gray and Alexander Graham Bell applied for a patent on the telephone on the same day. Credit for the discovery of the calculus was fought for bitterly by the

English scientist and mathematician Sir Isaac Newton and the German philosopher and mathematician Gottfried Wilhelm Leibniz.

Today most modern inventions and discoveries take place in large research organizations supported by universities, government agencies, private industries, or privately endowed foundations. Because of this, ascribing any single invention to a specific person has become difficult. Researchers in modern laboratories are often members of a project; the planning and development of the project is usually the work of many individuals. The atomic bomb, for example, was developed during World War II (1939-1945) under the guidance of a small group of leading scientists of many nationalities who directed a much larger group of scientists and technicians, most of whom were unaware of the purpose of the project (*see* Nuclear Weapons). Another example of collective effort in producing an important invention is the development of the electronic digital computer, a device essential to storing, retrieving, and manipulating vast amounts of information.

Bell, Alexander Graham

Bell, Alexander Graham (1847-1922), American inventor and teacher of the deaf, most famous for his invention of the telephone.

Bell was born on March 3, 1847, in Edinburgh, Scotland, and educated at the universities of Edinburgh and London. He immigrated to Canada in 1870 and to the United States in 1871. In the United States he began teaching deaf-mutes, publicizing the system called visible speech. The system, which was developed by his father, the Scottish educator Alexander Melville Bell, shows how the lips, tongue, and throat are used in the articulation of sound. In 1872 Bell founded a school to train teachers of the deaf in Boston, Massachusetts. The school subsequently became part of Boston University, where Bell was appointed professor of vocal physiology. He became a naturalized U.S. citizen in 1882.

Since the age of 18, Bell had been working on the idea of transmitting speech. In 1874, while working on a multiple telegraph, he developed the basic ideas for the telephone. His experiments with his assistant Thomas Watson finally proved successful on March 10, 1876, when the first complete sentence was transmitted: “Watson, come here; I want you.” Subsequent demonstrations, particularly one at the 1876 Centennial Exposition in Philadelphia, Pennsylvania, introduced the telephone to the world and led to the organization of the Bell Telephone Company in 1877.

In 1880 France bestowed on Bell the Volta Prize, worth 50,000 francs, for his invention. With this money he founded the Volta Laboratory in Washington, D.C., where, in that same year, he and his associates invented the photophone, which transmits speech by light rays. Other inventions include the audiometer, used to measure acuity in hearing; the induction balance, used to locate metal objects in human bodies; and the first wax recording cylinder, introduced in 1886. The cylinder, together with the flat wax disc, formed the basis of the modern phonograph.

Bell was one of the cofounders of the National Geographic Society, and he served as its president from 1896 to 1904. He also helped to establish the journal Science by financing it from 1883-1894.

After 1895 Bell's interest turned mostly to aeronautics. Many of his inventions in this area were first tested near his summer home at Baddeck on Cape Breton Island in Nova Scotia, Canada. His study of flight began with the construction of large kites, and in 1907 he devised a kite capable of carrying a person. With a group of associates, including the American inventor and aviator Glenn Hammond Curtiss, Bell developed the aileron, a movable section of an airplane wing that controls roll. They also developed the tricycle landing gear, which first permitted takeoff and landing on a flying field. Applying the principles of aeronautics to marine propulsion, his group started work on hydrofoil boats, which travel above the water at high speeds. His final full-sized “hydrodrome,” developed in 1917, reached speeds in excess of 113 km/h (70 mph) and for many years was the fastest boat in the world.

Bell's continuing studies on the causes and heredity of deafness led to experiments in eugenics, including sheep breeding, and to his book *Duration of Life and Conditions Associated with Longevity* (1918). He died on August 2, 1922, at Baddeck, where a museum containing many of his original inventions is maintained by the Canadian government.

Thomas Edison: Genius of Invention

American Thomas Alva Edison patented more than 1000 inventions in his lifetime, including the electric lightbulb, the phonograph, and a transmitter that made Alexander Bell’s telephone a usable instrument on a wide scale. On the occasion of the 150th anniversary of Edison’s birth, two editors associated with the Thomas A. Edison Papers Project at Rutgers University in New Jersey took a look back at Edison’s storied career.

Thomas Edison: Genius of Invention

By Robert Rosenberg and Paul Israel

Thomas Alva Edison did not invent the modern world. He was, however, present at its creation. Having come of age just after the mid-19th century—1997 marked the 150th anniversary of his birth—he became a significant figure in the organization and growth of American national markets, communications and power systems, and entertainment industries. Today, his name still stands for inventive creativity, and his electric lightbulb is a w ell-known symbol for a bright idea, beloved by cartoonists and advertisers. His list of 1,093 U.S. patents remains unchallenged by any other inventor. It is a tribute to his talents as an inventor, businessman, and promoter that many people think that we owe our way of life to his ideas.

What made Edison so extraordinarily successful? He was by any reckoning a brilliant inventor, but there were many other fine, clever contemporary inventors, now mostly forgotten: Elisha Gray and George Phelps in telegraphy; Emile Berliner in telephony and sound recording; Edward Weston in electrical instrumentation; Elihu Thomson, Frank Sprague, and Nikola Tesla in electric power and lighting. Edison outshone them all in the breadth of his accomplishments and the public renown he garnered. He broadened the notion of invention to include far more than simply embodying an idea in a working artifact. His vision encompassed what the 20th century would call innovation—invention, research, development, and commercialization. Moreover, he combined a prodigious creativity with a canny sense of the emerging influence of the popular press, and therein lies the key to his historical stature.

The Early Years

One can see the foundation for his success in his youth and early career. Later in life he (and others) would spin stories of mischief and misadventure, but the evidence points to a curious boy in an intellectually stimulating environment. The towns of his childhood—Milan, OH, where he was born on February 11, 1847; and Port Huron, MI, where the family moved in 1854—although small, were local centers of commerce and industry, and Edison absorbed the culture of artisans and workshops. His mother, Nancy, had apparently taught school at some point, and his father, Samuel, a political firebrand and freethinker, had a library that Edison was encouraged to read. He attended school for two brief periods in Port Huron, but was largely taught at home by his mother. "My mother taught me how to read good books quickly and correctly," he later said, "and as this opened up a great world in literature, I have always been very thankful for this early training." At the same time he was learning the entrepreneurial ways of his father, whose many careers included land speculation, shingle making, and truck farming. The same entrepreneurial attributes ascribed to his father were later applied to Edison: "a lively disposition always looking on the bright side of things" and "full of most sanguine speculation as to any project he takes in his head."

Known as Al (short for Alva) in his youth, his first work was helping in the family garden. But as "hoeing corn in a hot sun is unattractive," he found other work when the opportunity arose. In late 1859 the Grand Trunk Railroad was extended through Port Huron to Detroit, and Edison got a job with Grand Trunk as a "candy butcher," selling sweets, newspapers, and magazines. In that position he soon showed an entrepreneurial flair. He employed boys to sell vegetables and magazines in Port Huron and wrote, printed, and sold a newspaper on the train. The Civil War was raging, and when the battle of Shiloh was reported in the *Detroit Free Press,* Edison talked the editor into giving him extra copies on credit and then had the headlines telegraphed ahead to the train's scheduled stops. The crowds were so large and the demand for the papers so great that he steadily increased the price at each station, selling all the papers at a handsome profit. It is clear that young Al had already learned valuable lessons about the power of the telegraph and the press.

Learning the Art of Invention

Edison continued his education while working on the train. He read in the Detroit Public Library during his daily layover, performed chemistry experiments in a baggage car, and learned the rudiments of telegraphy. When he was 15 he rescued the toddler son of telegraph operator James MacKenzie from the path of a rolling freight car, and MacKenzie rewarded him by giving him lessons. After practicing intensively all summer, Edison took a part-time telegraph job in Port Huron.

Within a year Edison had embarked on a four-year stint as an itinerant telegrapher, a path followed by many ambitious, technically oriented young men. During those years he advanced to the front rank of telegraphers, becoming an expert receiver known for his clear, rapid handwriting. He joined the elite press-wire operators, the men who handled the lengthy, important news dispatches. He associated with journalists and editors, frequenting their offices and joining their conversations into the early morning. Some of his fellow operators later became newspaper reporters, and a few of them helped push Edison into the public eye.

Edison worked in many of the larger cities of the Midwest, centers of technical as well as commercial and political sophistication. He read technical and scientific literature ranging from telegraph trade periodicals to English scientist Michael Faraday's *Experimental Researches in Electricity,* and he moved in an atmosphere heady with inventive progress, where new devices and ideas were discussed and tried. Like all operators, Edison had to maintain his instruments and the batteries that powered the lines. He studied them and thought about ways to improve them, experimenting with discarded instruments. He purchased a small lathe and some other tools. By the time he headed home in 1867, he was thoroughly familiar with the state of the science and art of telegraphy and had begun to learn the craft of invention.

A message from an operator friend induced Edison to travel to Boston in early 1868, where he took a job with Western Union. In Boston he saw for the first time the complete telegraph community: not only expert operators, but leading inventors, major manufacturing shops with skilled experimental mechanics, important industry officials, and capitalists looking for promising inventors and inventions. Edison spent a year in the Boston Western Union office. During that time, inspired by the activity and potential of his surroundings, he worked on more than half a dozen telegraph devices. He found financial backers and mechanics able to help him realize his ideas. He acquired working space in the shop of Charles Williams, a leading telegraph manufacturer who also provided laboratory facilities to the prominent electrical inventor Moses Farmer. Edison applied for two successful patents that year—a vote recorder the state legislature would not buy, and a printing telegraph that was used in a stock quotation service. On January 30, 1869, five day after signing the patent application for the latter, Edison resigned his operator's post to "devote his time to bringing out his inventions."

Setting Up Shop

In order to test one of these inventions, a "double transmitter" for sending two simultaneous telegraph messages on a single wire, Edison traveled to New York City in the spring of 1869. There he found the movers and shakers of the telegraph industry. Western Union was headquartered in Manhattan, and the lawyers, bankers, and inventors at the heart of the business were collected there. Edison immediately fell in with Franklin Pope, a prominent telegraph engineer, with whom he formed a partnership. They established three successful businesses based on a series of printing telegraphs—businesses that placed them at the center of a struggle to control the technology for the distribution of financial information. Over the course of nine months Edison proved himself to the principals of that struggle—Western Union and the Gold & Stock Telegraph Company—to the extent that the latter contracted with him not only for a new printing telegraph but also for a facsimile telegraph system.

With money from the contract, Edison and mechanic William Unger opened a small telegraph manufacturing shop in Newark, NJ. From that time on, Edison was never without a shop, a signature of his inventive style. When he had first arrived in New York, he had written to his Boston capitalist, "What delays me here is awaiting the alteration of my instruments which on account of the piling up of jobs at the instrument makers have been delayed." He would not wait again if he could help it.

Another key element of Edison's style was his propensity for working on several projects at once. In the fall of 1870, in addition to his printing and facsimile telegraphs, he began work on automatic telegraphy, a high-speed system using punched paper tape with mechanical transmitters and receivers, intended to compete with the standard manually keyed Morse telegraphy of Western Union. He never devoted his attention to a single project; later, during the most intensive work on electric lighting, which was itself a series of related problems, he developed a new telephone receiver and a method of ore separation. One result of his multidirected activity was a constant cross-fertilization of ideas and insights. Edison tried methods and devices from one avenue of research in others. Often these imported concepts came from months or years earlier; some had worked in other contexts, some had not. It was this mode of working and thinking that contributed largely to Edison's ability to find solutions where others found none.

Genius Recognized

During the first half of the 1870s, Edison established himself as the foremost telegraph inventor in the United States. Several companies competed for control of his work. In October 1870, backed by the group of wealthy financiers who formed the Automatic Telegraph Company, Edison established the American Telegraph Works, a large shop equipped with new machine tools and highly skilled mechanics. The following May he became the "consulting Electrician and Mechanician" for Gold & Stock. In the fall of 1873, after a trip to England to promote his automatic system there, he sold a British syndicate the rights to that system.

Under an oral arrangement with Western Union President William Orton, Edison developed multiple telegraphy systems (systems capable of sending simultaneous messages on one wire) in 1873 and 1874. As 1875 opened, he became embroiled in an attempt by the notorious financier Jay Gould to build a network to compete with Western Union, an association that led to years of litigation. A year after successfully developing a quadruplex (fourmessage) telegraph in 1874, he agreed to a contract with Western Union that assigned all his work in multiple telegraphy to the company. By 1875 the chief U.S. credit reporting agency, R. G. Dun & Company, reflected the telegraph industry consensus when it called him a "genius in this line."

Orton and Marshall Lefferts, the president of Gold & Stock, were particularly important to Edison during these years. Not only did their companies provide crucial support for his inventive work, but both men served as mentors to the young inventor. Lefferts taught him important lessons about the patent system and the role of patents as a business tool. Edison's style of patenting to "cover the field" was learned from Lefferts, who followed that policy as president of Gold & Stock. Lefferts introduced Edison to Lemuel Serrell, a leading patent attorney, with whom Edison worked for a decade and from whom he learned the importance of keeping "a full record" of "all new inventions." Lefferts was also responsible for introducing Edison to the automatic telegraph investors. Orton maintained a fondness for Edison beyond respect for his inventive talent. Even after having his feathers ruffled by Edison's dalliance with Jay Gould (when he declared that the inventor had "a vacuum where his conscience ought to be"), he remained Edison's champion against the considerable jealousy of Western Union's house electricians. Lefferts died in 1876, and when Orton died two years later, Edison declared, "If I get to love a man he dies right away. Lefferts went first, and now Orton's gone, too."

Mary and Mina

Something of Edison's character shows in the relationship of his laboratory work to his two marriages. A brief business venture at the end of 1871 was the occasion of his meeting Mary Stilwell, a 16-year-old employee he married two months later on Christmas Day. By early February he was distressed enough to record in a laboratory notebook, "Mrs Mary Edison My wife Dearly Beloved Cannot invent worth a Damn!!" and (on Valentine's Day, no less) "My Wife Popsy Wopsy Can't Invent." These laboratory notebook entries are his only recorded statements regarding Mary until her death 12 ½ years later, unless one counts doodles where "Stilwell" becomes "Stillsick," which might be construed as comments on her increasingly delicate health. By all accounts he was devoted to Mary; the cause of his early distress is illuminated by the very different way in which his second wife's name appears in his notebooks.

Mina Miller was the well-educated daughter of a cultured family, and on their honeymoon in 1886 she signed a number of notebook entries as a witness. In the following months she recorded results of lamp tests in his laboratory. Although she didn't develop anything new, she could apparently "invent worth a Damn." This did not prevent Edison from spending the same long hours away from her and the children as he had in his first marriage. Nevertheless, he reassured her, "You & the children and the Laboratory is all my life I have nothing else."

Menlo Park

At the end of 1875, as a result of a lawsuit brought by a Newark landlord, Edison purchased land in rural Menlo Park, NJ, where in the ensuing months his father supervised the construction of a building that embodied the lessons Edison had learned about invention. One crucial lesson was the importance of an experimental laboratory, something Edison had come to appreciate after his 1873 trip to England. There he had first seen the sensitive, precise products of the European scientific instrument makers and had also encountered problems (notably the baffling electrical properties of undersea cables and the difficulty of recording the rapid signals of automatic telegraphy) that required systematic research in electricity and chemistry. On his return from that trip he set up a laboratory in his machine shop, where he had "every conceivable variety of Electrical Apparatus, and any quantity of Chemicals for experimentation."

The top floor of the Menlo Park building was a grand version of that first laboratory. The first floor was an equally superb machine shop, stocked with fine precision machine tools, for although the automatic system had finally failed to supplant the Morse, and the American Telegraph Works had closed, Edison had kept most of the machinery. Edison's early shops also yielded a core of expert machinists and experimenters who joined Edison at Menlo Park, among them Charles Batchelor, John Kruesi, John and Fred Ott, Charles Wurth, and James Adams. Together, the shop, laboratory, and staff constituted an unparalleled facility for invention, where the 29-year-old Edison, with 100 U.S. patents already to his credit, planned to turn out "a minor invention every ten days and a big thing every six months or so."

Most of the first year's work at Menlo Park focused on various systems of multiple telegraphy for Western Union. In January 1877, Edison proposed to Western Union President Orton that the company support the machine shop with a weekly stipend, and in March they signed an agreement that gave Western Union the rights to all of Edison's telegraph inventions in return for $100 a week in laboratory expenses. In the meantime, at Western Union's request, Edison and his staff had turned their attention to the telephone—the speaking telegraph that Alexander Graham Bell had unveiled the previous spring.

Bell's invention, though it transmitted the voice clearly, was too weak to use practically in the electrically noisy urban environment, nor could it send a signal any distance. Edison took a different approach to the problem of capturing the voice: "Bell," he said, "got ahead of me by striking a principle of easy application whereas I have been plodding along in the correct principle but harder of application." As his multiple telegraph research tailed off, Edison's telephone research intensified, culminating in the spring of 1878 in one of his most enduring products, a transmitter that was used for nearly a century.

That transmitter, which was built around a small button of carbon, is an exemplary instance of Edison's ability to make good use of an earlier failure. In 1873, while trying to understand the subtleties of cable telegraphy, he had devised and built a high-resistance rheostat (a device that regulates current by varying resistance) made of carbon-filled glass tubes. Unfortunately, he "found that the resistance of carbon varied with every noise, jar or sound," and the rheostat was useless for cable experiments. Of course, in a telephone, such sensitivity was exactly what he needed, even if it took 12 months of hard work in order to make it a practical instrument.

Phonograph and Fame

In the process of his telephone work, Edison surprised himself with the invention that brought him world fame—the phonograph. The telephone, which was initially perceived as an instrument to be used by telegraph companies to transmit messages between operators, had the disadvantage of leaving no written record. Speech was too fast to be written down, so Edison devised a way to record the vibrations of the receiving instrument, allowing them to be played back more slowly and the words written down. Only after writing this idea in his notebook did he and his staff realize that he had found a way to record not just a telephone message but sound itself. The press of their telephone work kept them from developing the phonograph for five months, but in early December 1877 they demonstrated their talking machine at the offices of *Scientific American* in New York City.

Although Edison and some backers formed a company to exploit this new marvel, he was unable to transform this early exhibition machine into a commercial product (ten years later he would take it up again and succeed, inaugurating the sound-recording industry). Nevertheless, the phonograph transformed Edison instantly into an international celebrity—the Wizard of Menlo Park. His familiarity with the press and his rapport with journalists enabled him to maintain and manipulate that celebrity for the rest of his life.

Electric Light

Edison's next major project, launched in the fall of 1878, brought together everything he had learned about invention. The creation of an electric light and power system, which began as the search for a lamp that could replace gas lighting, required massive financial backing, numerous teams of researchers, expanded laboratory and shop facilities, the creation of large-scale manufacturing plants, and a marketing organization. At the center of all this activity, Edison worked feverishly to solve problems ranging from filament materials and dynamo designs to marketing strategies and hiring questionnaires. As the work expanded, it transformed Menlo Park. Edison hired university-trained scientific researchers like Francis Upton and Otto Moses, increased the size of the machine shop staff, and built factories. By 1881 Edison's focus shifted from research and development to manufacturing, marketing, and installation, and he moved his headquarters into New York City. Although lamp manufacture and some research continued at Menlo Park, within two years Edison abandoned the original "invention factory."

At the outset, Edison's electric lighting venture was a subject of controversy. Others had tried and failed, and the scientific and technical communities were divided over his prospects. His reputation, though, was formidable, as British scientist John Tyndall indicated in a lecture at London's Royal Institution early in 1879: "Edison has the penetration to seize the relationship of facts and principles, and the art to reduce them to novel and concrete combinations. Hence, though he has accomplished nothing new in relation to the electric light, an adverse opinion as to his ability to solve the complicated problem . . . would be unwarranted. . . . Knowing something of the practical problem, I should certainly prefer seeing it in Mr. Edison's hands to having it in mine." With the successful installation of his first lighting and power plants in the early 1880s, Edison lived up to his reputation as the Inventor of the Age.

West Orange Lab

For several years Edison had no single, central laboratory. He conducted research at his electrical manufacturing shops in New York and Harrison, NJ. When Mary died in 1884, he withdrew somewhat from electric light work, but after his 1886 marriage to young Mina Miller he returned to full-time research. By 1887 he had decided to build a new facility near his home in West Orange, NJ, several times larger than the Menlo Park laboratory had been. The new laboratory embodied everything Edison had learned about the process of invention. He wrote: "I will have the best equipped & largest Laboratory extant, and the facilities incomparably superior to any other for rapid & cheap development of an invention, & working it up into commercial shape with models patterns special machinery—In fact there is no similar institution in existence."

In its early years, the new complex served as the research and development center for Edison's electric lighting companies. But Edison also saw the new laboratory as a place to invent other products. The first significant new product was an improved phonograph. Spurred by research done at Alexander Graham Bell's Volta Laboratory, Edison had been working hard on his machine for several months when the new laboratory opened in November 1887. He fully exploited his new resources, putting one team of researchers to work developing materials for the records, while other teams worked on the duplicating of recordings, the phonograph's mechanics, the motor and battery, and the recording and playback devices. He also erected a phonograph factory next to the laboratory.

Edison financed this venture largely on his own. After years of conflict, both petty and great, with financiers and managers in the electric light businesses, Edison no longer wanted to give outsiders control of his affairs. However, with his money tied up in the electrical industry, he found himself unable to bring the new phonograph to market, and he was forced to sell his marketing rights. After he left the electrical business following the 1892 merger of his companies into General Electric, he had the personal resources to retain controlling interest in his new technologies.

Ore and Movies

In the two decades following the opening of his new laboratory, Edison pursued several large projects. Through the 1890s much of his time was spent at an iron mine in northern New Jersey, where he used his ore-separation technology to concentrate low-grade ore into high-grade briquettes suitable for steel mills. Initially financing it with the sale of General Electric stock, Edison kept it going with the profits from two new industries, his (repurchased) phonograph business and motion pictures. He spent about $2.5 million of his own money on the project. When, unable to compete with the rich ore of the immense Lake Superior iron finds, the venture failed at the century's end, Edison was characteristically sanguine. A year later someone pointed out the rocketing value of the stocks he had sold; he replied, "Well, it's all gone, but we had a hell of a good time spending it."

Edison founded the American motion picture industry in the mid-1890s when he and W. K. L. Dickson developed a camera and a peep-show "kinetoscope" for viewing the films. However, Edison had little personal involvement in the business that sprang from those inventions beyond lending his name to the production company and participating in lengthy patent battles.

Baby and Big Feller

In contrast, Edison was intimately involved in the sound-recording industry. In 1878 he had declared the phonograph his "baby," which he expected "to grow up to be a big feller and support me in my old age," and it was doing just that. After he and his staff perfected a method of duplicating records at the turn of the century, the business mushroomed, with Edison's company the clear leader. He used that income to finance two other innovations: a cement manufacturing process, which introduced important industry-wide innovations but did not become financially successful until the 1920s; and a storage battery, originally intended to power electric automobiles but which found wider applications for various industrial purposes and became the highly profitable mainstay of Edison's businesses within a few years.

In 1907, on his 60th birthday, Edison announced his intention to "give up the commercial end . . . and work in my laboratory as a scientist." His health was not good, and he wanted time to investigate some of the curious phenomena he had encountered over the years. Although he retired from the business of innovation, he continued to work on the phonograph and engaged in one last inventive campaign to produce a disk phonograph and record to match those produced by the Victor Talking Machine Company, which supplanted Edison as the industry leader. In 1899 he had remarked that "commercial reasons when it comes to the phonograph dont count with me. Its the only invention of mine that I want to run myself." After the consolidation of his various enterprises into Thomas A. Edison, Inc., in 1911, the phonograph business was the one part of the company in which he was involved at the day-to-day level. Despite his near-total deafness, he even assumed responsibility for the selection of all the music and artists recorded for the Edison phonograph, a truly disastrous policy. The fortunes of the phonograph business declined steadily until it was finally abandoned in 1929.

Living Legend

The success or failure of Edison's later ventures had no effect on his status as a living American legend. Beginning with the Edison Speaking Phonograph Company in 1878, every business he founded—and some that he licensed or bought—had his name associated with it. It was not just Edison's ego at work—his name, often used illegally by others, sold nearly anything.

In the last two decades of his life he became the nation's inventor-philosopher. Reporters sought his opinion on any and all subjects, from the role of inventions in World War I to the technologies of the future to questions of diet and the existence of God. The secretary of the Navy appointed him head of the Naval Consulting Board in 1915 to review inventions submitted for the nation's defense, and Edison conducted his own defense research after the United States entered the war. He received a special congressional medal and socialized with presidents. In 1929, the 50th anniversary of the electric lamp, Henry Ford staged a ceremony attended by President and Mrs. Herbert Hoover and broadcast across the country. On Edison's death in 1931 the president asked the nation to dim its lights in his honor.

Edison lived the second half of his life in the glaring light of modern celebrity, under a spotlight he welcomed (and sometimes directed) and most certainly had earned. The bankers who financed his first great undertaking—the electric light—were buying his accomplishments as a leader in telegraph invention, as the man who made Bell's telephone a practical instrument, and as the creator of the marvelous phonograph. Even more, they were backing the work of the man most responsible for what the eminent English mathematician and philosopher Alfred North Whitehead called the greatest invention of the 19th century—the invention of the method of invention.

About the authors: Robert Rosenberg and Paul Israel are associated with the Thomas A. Edison Papers Project at Rutgers University in New Jersey—an archival cataloging and publishing venture encompassing some 5 million documents, including Edison's handwritten notebooks, and 400,000 artifacts relating to the inventor and his work. Rosenberg is the director of the project and the editor of *The Papers of Thomas A. Edison* (Baltimore, The Johns Hopkins University Press, 1989—). Israel is the managing editor of the book edition of the *Papers* as well as the author of books on Edison and the history of invention in the United States.