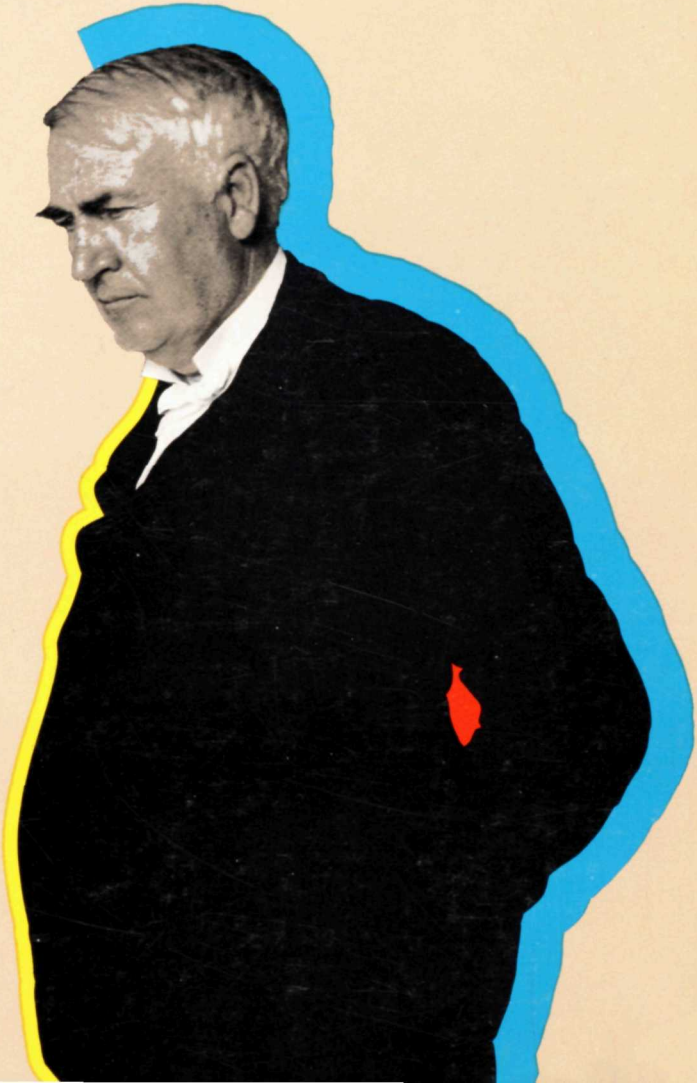
BEEHIVES OF INVENTION



Edison
and His Laboratories

BEEHIVES OF INVENTION

Edison and His Laboratories

by
George E. Davidson

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FOLK HERO

He hated the radio; he called it a "lemon." He had even less use for the electronic phonograph. In 1925 he sounded the death knell for the Edison name in the home phonograph industry by saying he would stick with his mechanical device. After much stubborn hesitation, his company brought out an electronic phonograph in 1928. But it was too late. In 1929 the Edison company stopped manufacturing entertainment phonographs and records. A last-minute venture into the mushrooming radio field failed soon afterwards.

Thomas Alva Edison belonged to the 19th century. It was there, in the beginnings of America's love affair with technology, that the dynamic and sharp-tongued "country boy" from Milan, Ohio, put his extraordinary genius to work and achieved national fame. In that age before the horseless carriage and wireless Thomas Edison made his remarkable contribution to the quality of life in America and became a folk hero, much like an Horatio Alger character.

Edison's reputation stayed with him in the early 20th century, but his pace of achievements slackened. At his laboratory in West Orange, N.J., in the 1900's he did not produce as many important inventions as he had there and at his Menlo Park, N.J., lab in the late 1800's. Edison's projects and quests became expensive, costing millions and resulting in few rewards and profits. His forays into many fields were continuing evidence of a Da Vinci-like breadth of mind, but they were not financially successful, or, one suspects, personally satisfying. Besides some financial success with a battery, it was profits from the phonograph and motion picture innovations, both fruits of his work in the 19th century, that kept Edison solvent in those later years.

His last major effort was devoted to finding a domestic source of rubber. When the British acted in 1924 to restrict the supply of Malayan raw rubber,

Edison's camping caravan partners, Henry Ford and Harvey Firestone, pleaded with him to find a practical domestic source. A long-term rubber shortage might mean disaster for both tycoons of the motorcar world. Their plea was a godsend (perhaps not in Edisonian theology) to a bored and somewhat jaded inventor. Here was a problem he could tackle with the exhaustive empirical method that had made him the "Wizard of Menlo Park." To find the right tree or plant was going to be "search, try, and discard" all the way. This was not a task for theorists and mathematicians whom Edison scorned; this was a task which fit, to some degree, the Edison definition of genius as "ninety-nine percent perspiration and one percent inspiration." This was a task which required that rare Edison combination of imagination, brilliance, and dogged determination exemplified in his successful quest for a practical incandescent lamp in 1879. The man of practical physics and electrical engineering became a botanist almost overnight. Suddenly everything was rubber—at home and at the lab. The Old Man was happy.

A new company, the Edison Botanic Research Corporation, was formed, and, with grants of $93,500 each from Firestone and Ford, was on its way by the fall of 1927. Edison began this adventure at his Fort Myers, Fla., home and lab, where he customarily spent some of the winter. At both his Florida and New Jersey labs he put a new staff of botanists and chemists to work. He sent agents to every corner of the tropical and temperate zones to look for vines, bushes, trees, shrubs, and weeds that might hold latex juices.

After two years Edison could report that he had tested more than 14,000 different plants of which about 600 contained latex to some degree. He believed that goldenrod was the most promising and narrowed his focus to that weed of countless roadsides, abandoned lots, and rural fields across America. Edison felt that he was on the track of finding a source of domestic rubber that was "sowable and mowable." He took the best varieties and began crossbreeding. In the end he developed a goldenrod variety about 14 feet tall and yielding 12

As Henry Ford and Francis Jehl look on, Edison reenacts the making of the first successful incandescent lamp. The event took place in Dearborn, Mich., on October 21, 1929, the 50th anniversary of the lamp and the dedication of Edison's reconstructed Menlo Park laboratory.

percent latex. His goal was to produce 100 to 150 pounds of rubber per acre of goldenrod.

Little did he realize that his project was futile. He made rubber from goldenrod, and Firestone even made four tires out of it, but it was expensive rubber and of inferior quality. And meanwhile, German scientists were successfully producing a synthetic rubber from coal tars.

If anyone, Ford and Firestone included, had any suspicions that Edison's experiments would not succeed, they didn't tell him. Edison probably would not have listened anyway.

Thomas A. Edison was dying. He had been suffering for years from diabetes, Bright's disease, and a gastric ulcer. Uremia almost took him in 1929, when he was 82. But, as always, he tried to work. When in bed, his assistants kept him informed of progress in the rubber experiments.

In the summer of 1931 his afflictions brought him near death. He rallied for a short time, but he suffered a relapse and died on October 18.

Edison was gone and with him an epoch in American science and technology. He had been truly a "legend in his time." Medals, busts, and ribbons, Edison claimed bushels of them, including one from Congress. Henry Ford paid him perhaps the greatest tribute by reconstructing, in Dearborn, Mich., Edison's old Menlo Park lab with virtually all the paraphernalia—bulbs, dynamos, apparatus, machinery, materials, buildings—of his early years as an inventor.

What kind of man was this hero of several generations of Americans? He was not the saintly figure of the many bronze busts and news articles of his day. And yet he was much more than "just a country boy" full of folksy sayings and homilies and the victim of urbane and unprincipled robber barons, the way he liked to picture himself. He survived and often triumphed in the patent quarrels, litigation, and vicious infighting that were characteristic of those survival-of-the-fittest years.

He had an uncanny knack for drama. P. T. Barnum could have learned something from Edison. The Old Man was a born promoter as well as creative genius, and, unlike many of his contemporaries, he

was an attractive personality to much of America. He was handsome in a rugged way. He was a small town boy who had made good, and the folks of the day loved to see their ways of practicality and down-to-earth grit put the professors and foreigners to shame. Self education and the American backwater environment were, as in Abraham Lincoln's life, superbly vindicated in Edison. Through the newspapers, he prepared the people for greater things to come. And if the bluster and ballyhoo did not square with results and performance, as with his target date for a workable lighting-distribution system, the people did not seem to mind.

The men who labored with and for this man of fantastic drive were smitten with the drama of science. They had to be. With what Edison paid, something else must have sustained them working twice as long each day as their deodorized, white-coated, 40-hour-a-week counterparts of the 1970's. They saw a side of the Old Man that the adoring public rarely viewed—profane, grossly unkempt, and with an uncertain temper. But there was a charisma about the man that inspired loyalty and sacrifice.

Science and technology became America's new frontier during the most creative and dynamic years of Edison's life. It was no coincidence.

AN OBSESSION TO CREATE

Thomas Edison was not born to a life of ease. He was pre-Civil War, small town, middle-class America. He may have been a genetic accident, for his precursors showed little of the potent drive or sponge-like mental powers of the boy who devoured the Detroit Free Library with only three months of school learning.

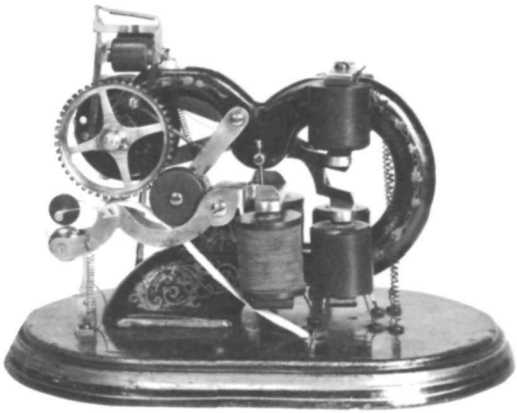
Financial insecurity was a way of life to the Edison family. To his mother, Edison attributed the "making of me." To his ne'er-do-well father, who once beat him and shamed him unmercifully in the town square, he displayed great generosity and affection in his later life.

Drive he had from the earliest—enormous power to resist physical and mental fatigue and a single-mindedness that more "well-adjusted" folk could never sustain. By his teens he was operating a lucrative business of his own by selling newspapers and goodies to passengers on the Grand Trunk Railroad in Michigan. His very youthful fascination for chemistry persisted in the lab-on-wheels he made in the corner of a stuffy and creaking baggage car.

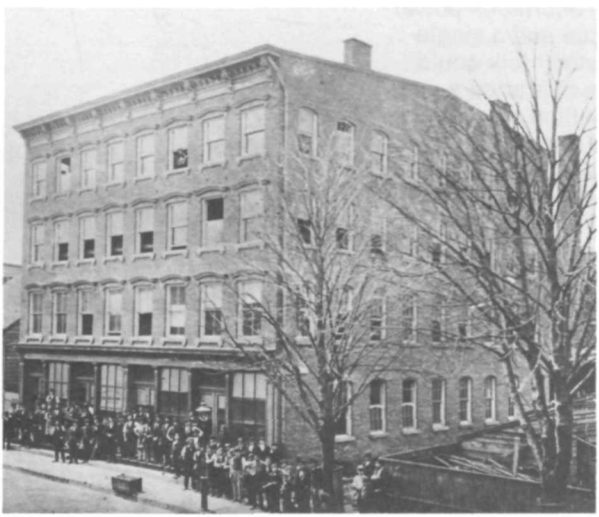
During his teens he became nearly totally deaf by accident or illness. When he began a new career as a telegrapher at 16, the deafness certainly was a disadvantage, though at times he claimed it allowed him to concentrate and not be distracted by other telegraphic circuit noises.

In his late teens Edison the telegrapher was Edison the rebel. He could not abide the discipline and strictures imposed by others. He was an expert operator, but the boredom of the work drove him to break the rules, sometimes for pure amusement. Being fired or quitting jobs was a way of life. He moved from town to town, working in such places as Fort Wayne, Indianapolis, Cincinnati, Nashville, Memphis, Louisville, and Boston.

Telegraphy problems consumed his interest in those years. He spent hours trying to work out ways

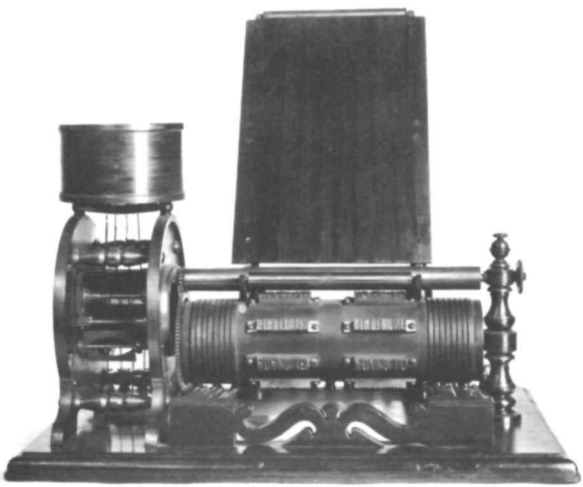


The electrographic vote recorder, below, and the stock ticker were Edison's first two inventions. He could not sell the vote tabulating machine, but he received $40,000 for his initial stock ticker improvements. He used most of that money to buy the building on Ward Street in Newark in which he produced the stock machines and numerous other inventions.



The establishment selected was wholly unpretentious and devoid of architectural beauty, but it was centrally located in Ward street, Newark, supplied with a comparative abundance of facilities and manned by a force of three hundred . . . .

W. K. L. and Antonia Dickson, *The Life and Inventions of Thomas Alva Edison*, 1894



to improve circuits, to automate, to increase the reach of that singing wire. In almost a fairy-tale fantasy he struck it rich at 23 in New York by inventing a vastly improved stock ticker, close cousin of the telegraph. He was rich, for a while, and he was on his way to a creative half century of life.

In his twenties, communications problems continued to fascinate him. In those years, John Ott, Charles Batchelor, and John Kruesi joined his staff in Newark, N.J., and gave him the dedicated craftsmen and skilled artisans he needed to translate his many ideas into objects.

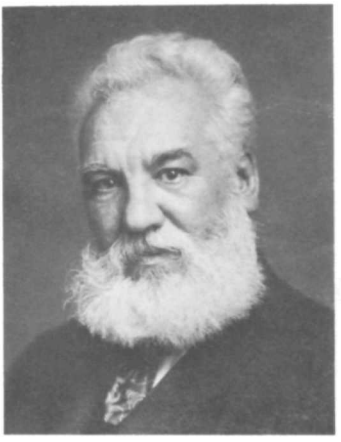
Innumerable small improvements in telegraphy apparatus came out of the shop where the money-making stock ticker was produced. He worked hard at developing a two-message-at-a-time-on-one-wire device called a Duplex and was temporarily crushed when Joseph B. Stearns finished his improvement first and beat him to the Patent Office.

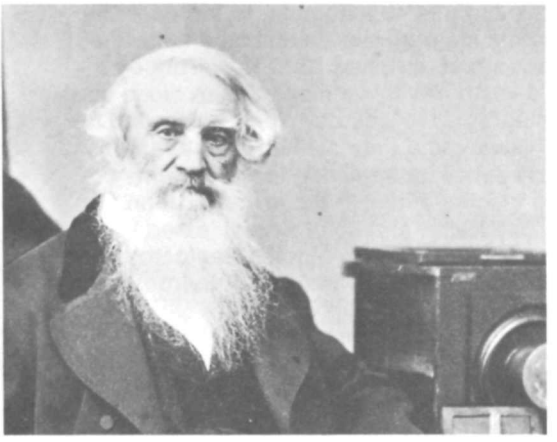
Edison later pursued a long-held dream of perfecting a device which would handle four messages at one time on the same wire. It was the Edison method: try, change, try, change, again and again. He had to complete the Quadruplex to his own great satisfaction and profit, for Western Union was as anxious as the young inventor to see this device materialize.

They saw it finished in 1874, and fortune, fame, and future were made almost certain for Edison. He was becoming experienced at surviving the patent lawsuits, lies, idea-thievery and humbug that then typified the industrial life of America.

Years earlier, a more idealistic Edison had produced a clever electric vote tabulator for use by legislative bodies. But the members of those institutions did not want the device; it was too efficient, it would prevent dealing while voting. He rarely made the error of invention-for-its-own-sake again. Instead, he set his sights on fulfilling both the desire to create and the very human passion for fame and fortune.

America's inventors of the day were a rough and tumble lot. They bore little resemblance to such scientists of an earlier day as Joseph Henry, who was so self-effacing, scholarly, and gentlemanly





Alexander Graham Bell, left, and Samuel F. B. Morse were like Edison in that they concentrated their inventive energies on goods which would ease man's daily toil. Bell is best known for inventing the telephone and Morse for the telegraph.

that he would not lower himself to making money on a new idea by obtaining a patent. Henry considered science a Christian calling, and if the 19th century witnessed a dichotomy between pure and practical science it was best illustrated by the contrast between Henry on the one hand and Goodyear, Bell, Morse, McCormick, and Edison on the other.

Alexander Graham Bell was a contemporary of Edison and a competitor in the communications field. He was born the same year as Edison and lived nearly as long. Bell had an intense interest in teaching the deaf. To communicate with them he envisaged an "harmonic telegraph" and was fascinated by reports of Stearns' duplex telegraph in 1872. His wrestling with perfection problems brought him to envision further the manufacture of a "phonoautograph," a device which would translate sound waves into a meaningful pattern of curves on a smoked glass. All these hopes, combined with thousands of hours of work, brought Bell a patent in 1876 for the first device to transmit human speech by electricity—the telephone. Only a few hours after Bell filed for a patent, Elisha Gray filed a very similar sketch. Bell made a fortune; Gray did not.

One suspects some understandable jealousy on Edison's part regarding Bell's success. Edison had

tinkered in the field, and Western Union soon engaged him to invent a better telephone. Edison was confident he could do much more with Bell's very crude instrument; its tinny squeaking was human speech only to those with vivid imaginations.

Edison's improvement, a carbon transmitter combined with Bell's magneto receiver, was a much more distinct instrument. But Edison was just one of many inventors seeking to improve Bell's instrument, and only a few weeks earlier Emile Berliner got the jump on some aspects of Edison's improvements in a caveat he filed with the Patent Office. After a 15-year court fight Edison was credited with developing the successful carbon transmitter.

Bell's conflict with Gray and Edison's with Berliner were typical of those days. Inventors were competing with each other all the time. They often would take another's idea and try to refine or change it in such a way that they could call the idea their own. Major firms such as Western Union and Bell Telephone would buy the ideas and in turn compete. It was the era of idea thievery, and great profits were the stakes. Edison admitted to being among the most vigorous of the idea thieves, but he added, one imagines with a twinkle, "I know how to steal."

CRUCIBLES OF CREATIVITY: THE LABS

When Thomas Edison began his career as an inventor, the profession was a solitary one. When he died, inventing had become essentially a team effort. He had launched a concept that eventually led to the modern industrial research lab.

As a young man, Edison dreamed of leaving the dreary world of industrial production for full-time creating in a secluded spot. In Menlo Park he realized his dream. His lab in the quiet New Jersey countryside became a crucible for creativity of unparalleled intensity.

It would be foolhardy to write too bold the label of "team effort" over Menlo Park, for the lab was dependent on his personal drive and flow of innovative ideas. His assistants were not mindless lackeys, but neither were they Edison's peers. He had no peers.

His staff was fluid; many came and went. Some men were unable or unwilling to devote all waking hours to the endless questing. Some men wore out and left, but many were fiercely loyal to Edison and stayed for years.

The atmosphere at Menlo Park was always intimate and often intense and heated. Edison was in complete control. At a glance he could oversee the work of a handful of employees. Each of his muckers, as he often referred to his men, reported to him personally.

Some of his staff at the old Newark plant stayed with him; among them were John Ott, Charles Batchelor, and John Kruesi. Ott had been with Edison for years. A young man of 21 when Edison interviewed him in Jersey City, Ott demonstrated his inherent mechanical skill by assembling on the spot a pile of machine parts and won himself a job. Charles Batchelor was an Englishman who had completed a machinery installation job for a textile mill in Newark and went to Edison for work. He was hired for his remarkable skill as a mechanical draftsman. And in John Kruesi, Edison had the

master craftsman. This Swiss clockmaker was able to make any instrument suggested to him.

These men began with Edison and learned with him in the strange new world of controlled electrical energy. They worked at times near the extreme limit of human endurance. Edison biographer Matthew Josephson relates the story of the "bugs" in one of Edison's stock printer devices in the early 1870's. Edison received a rush order for $30,000 worth of a newly improved model of the printer. At the last moment the model was found to have some maddening problems. Not wishing to lose this big order, Edison took characteristic action. He gathered together, in the Newark plant, his top assistants, Batchelor, Ott, Kruesi, and Sigmund Bergmann, and told them: "I've locked the door and you'll have to stay here until this job is completed. Well, let's find the bugs." After 60 hours without sleep and with little food, they had the stock printers working smoothly. No one quit. This was part of the Edison method, the sweat he claimed as the basis of genius.

Menlo Park is popularly remembered today for one invention, the incandescent lamp. Because of its ultimate significance to the 20th century and all of its allied mechanisms and devices, this honor is well justified. Edison, of course, did not invent electricity or the electric light, *per se*. Electric power was man-controlled long before his adult years and electric lights had already seen some urban use before his adventure at Menlo Park. The lights of the period were of the arc type, an illumination produced only by enormous expenditure of power. In an arc lamp, the electricity jumped a gap between two carbon rods and steadily burned up the rods in brilliant incandescence. The arc lamp gave a dazzling light, a light too brilliant to be practical for widespread home use. These devices used extremely heavy amperage, were dangerous, and gave off noxious fumes.

Edison also was not the first to think of developing a glowing filament in an airless glass globe. Other scientists had envisioned an electrically activated substance which would glow without rapidly disintegrating or emitting fumes. Yet no one had

EDISON'S TOP ASSISTANTS

Mr. Kruesi was the superintendent, a Swiss trained in the best Swiss ideas of accuracy. He was a splendid mechanic with a vigorous temper, and wonderful ability to work continuously and to get work out of men. It was an ideal combination, that of Edison, Batchelor, and Kruesi. Mr. Edison with his wonderful flow of ideas which were sharply defined in his mind, as can be seen by any of the sketches that he made, as he evidently always thinks in three dimensions; Mr. Kruesi, willing to take the ideas, and capable of comprehending them, would distribute the work so as to get it done with marvelous quickness and great accuracy. Mr. Batchelor was always ready for any special fine experimenting or observation, and could hold to whatever he was at as long as Mr. Edison wished; and always brought to bear on what he was at the greatest skill.

Francis R. Upton, as quoted in *Edison: His Life and Inventions*, 1910

Mr. Charles Batchelor was Mr. Edison's principal assistant at that time [at Menlo Park]. He was an Englishman, and came to this country to set up the thread-weaving machinery for the Clark thread-works. He was a most intelligent, patient, competent, and loyal assistant to Mr. Edison. I remember distinctly seeing him work many hours to mount a small filament; and his hand would be as steady and his patience as unyielding at the end of those many hours as it was at the beginning, in spite of repeated failures. He was a wonderful mechanic; the control that he had of his

The main laboratory at Menlo Park was a plain, two-story clapboard building. Three key men who started working for him at Newark and who stayed with him for many years were, clockwise from left, John Kruesi, John Ott, and Charles Batchelor.

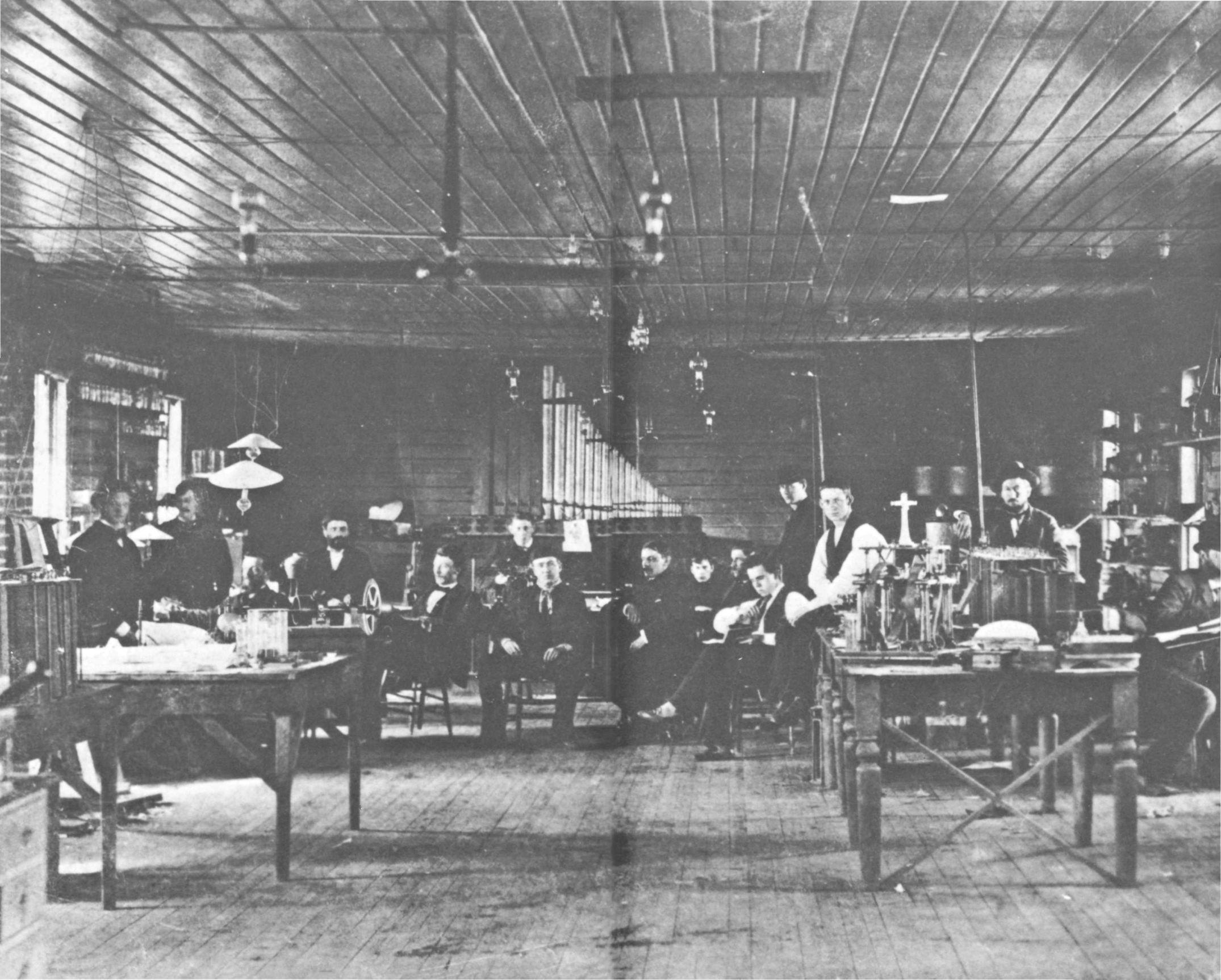
fingers was marvelous, and his eyesight was sharp. Mr. Batchelor's judgment and good sense were always in evidence.

Francis R. Upton, as quoted in
Edison: His Life and Inventions, 1910

John F. Ott was another bright and industrious worker coming to the Menlo Park machine shop from Edison's Ward Street shop in Newark. Ott was an expert mechanic to whom Kruesi generally confided the making of the more delicate apparatus or instruments required in research work at the laboratory. He was a pleasant and agreeable man, and though he had plenty of opportunities like others at Menlo Park, for he was a master of the trade he plied, he remained content in the sole ambition of loyally serving his master as fine-instrument maker.

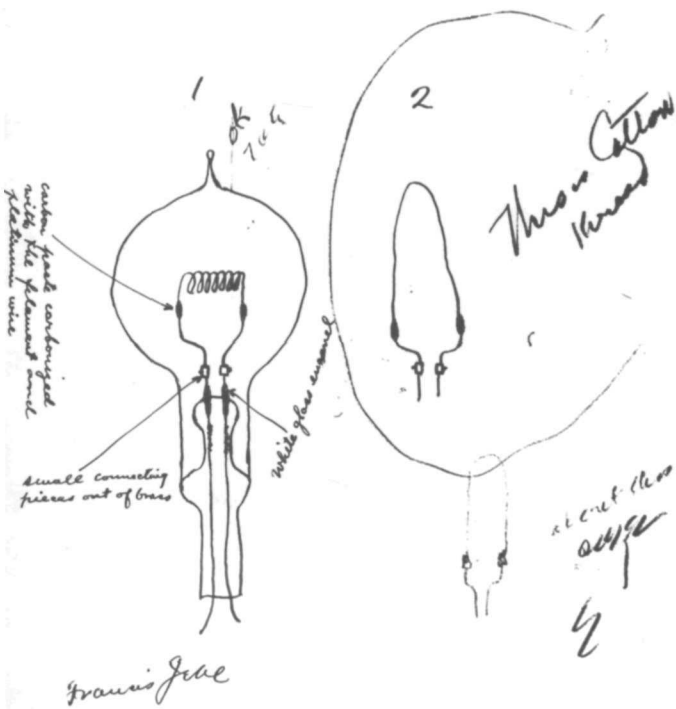
Francis Jehl,
Menlo Park Reminiscences, 1936

Next page: Edison sits with a group of assistants on the second floor of the main building at Menlo Park in February 1880. Shown, from left, are L. Boehm, C. Clarke, C. Batchelor, W. Carman, S. Mott, G. Dean, Edison, C. Hughes, G. Hill, G. Carman, F. Jehl, J. Lawson, C. Flammer, C. Mott, and J. Mackenzie. Note the incandescent lamps, hanging from gas fixtures, and the organ.



made a filament that would not burn out quickly.

In 1878, the pressures of mixing inventing with manufacturing were crushing Edison. He got away from it all briefly on a trip to Wyoming. He had invented a device for making precise heat measurements and wanted to test it during an eclipse of the sun. His experiments were not successful, but the respite from the lab and stimulating conversation rejuvenated his fatigued spirit. He returned to New Jersey determined to realize the dream of a practical electric lighting system for the homes of America.



THE SEARCH FOR THE RIGHT FILAMENT

Whenever we made an incandescent lamp for our experiments, we had to go through the following processes:

First, the raw material for the filament had to be chosen. . . . Edison tried everything he could lay his hands on, and when some material exhibited good qualities, he noted in his book "T.A."—Try Again. *Among the other materials, he once tried common cotton thread from a spool. It was not satisfactory; yet he perceived something that prompted him to mark it for later trial. The second test was made with a special thread from the Clark Thread Mills in Newark, where Charles Batchelor and Will Carman had at one time worked.*

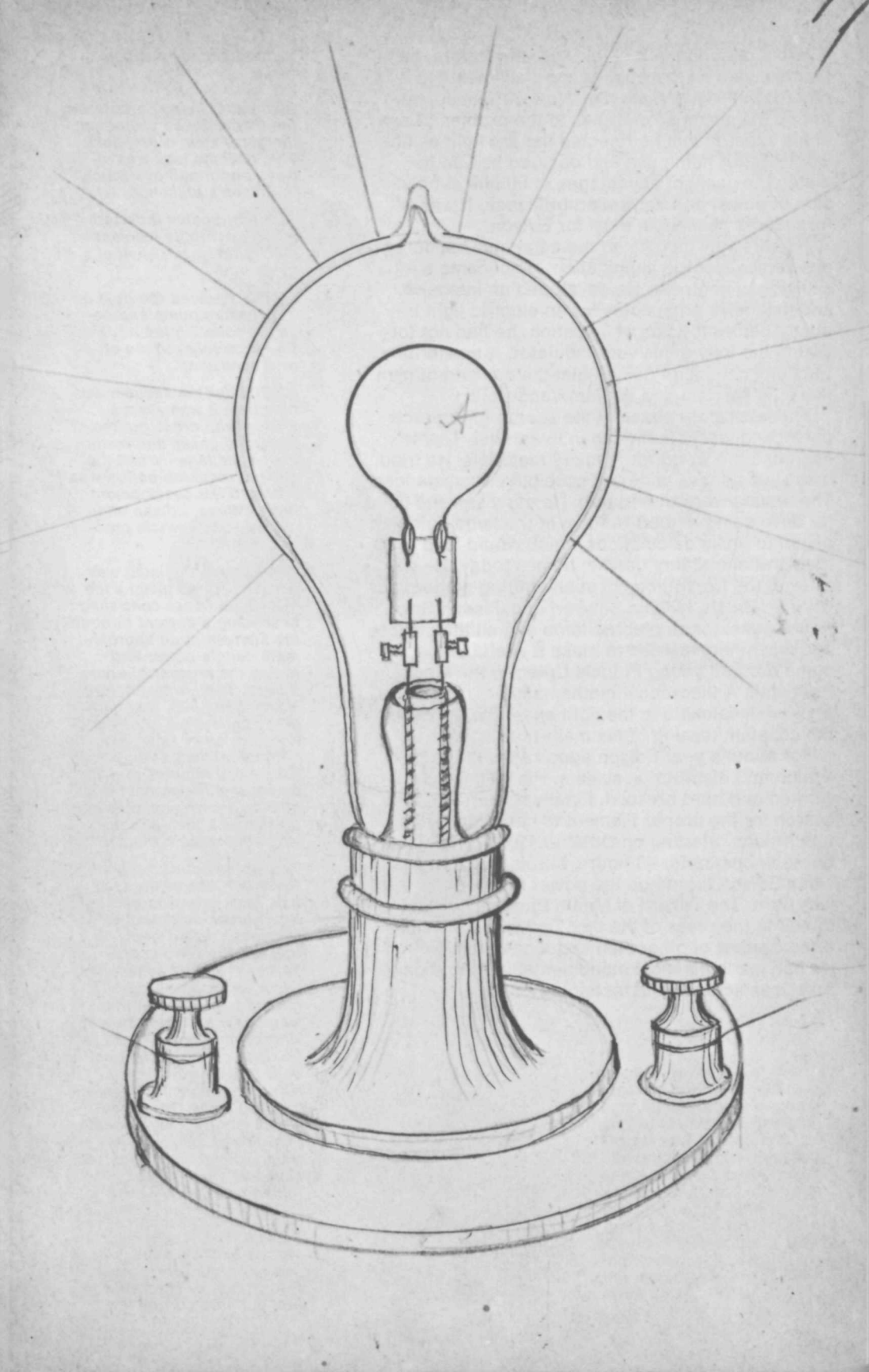
The second step was the preparation of the raw filament. This work Edison always did himself . . . .

Third, each filament had to be carbonized, a process he attended to personally on the experimental lamps. Only after he had mastered the art thoroughly and desired carbons in quantity did he instruct "Basic" Lawson [Lawson became chief carbonizer at the first commercial lamp factory] and some of the new men in the art and assign them to the job.

Fourth, [John] Kruesi supplied the copper wires, on the end of which short pieces of platinum had been twisted.

Fifth, [Ludwig] Boehm blew the glass stem, inserting

Francis Jehl drew sketches 1 and 2 of early experimental filaments in October 1879. Edison sketched the third one and made these notations: "OK, TAE," "This is Cotton thread," and "about this size, E." The drawing of the incandescent lamp, right, appears in a Menlo Park notebook and is dated September 20, 1879.



While dabbling in the field the year before, he had met with all the frustrations well known to others who tried before him. Now, refreshed, he turned his immense energies to the problem. Early in his experiments he rejected the arc light as unworkable for home use and decided he had to match the gaslight advantages of infinite subdivision of power and controlled brilliance. It was a formidable challenge, even for Edison.

He shrewdly calculated the economic aspects of gas versus electric illumination. He became a skilled gas engineer. He developed an intensive and extensive prospectus for an electric light industry before the fact of invention; he had not forgotten the folly of his vote tabulator. A masterful publicity campaign gained him the backing of men like J. P. Morgan and William Vanderbilt.

The laboratory phase of the search for a practical incandescent lamp began in earnest. Teams searched the world for filament materials. He tried many substances under all possible circumstances. The results were distressing. He early saw the need for developing a good vacuum in the lamp bulb and began to make calculations which would lead to the parallel circuitry used in homes today. He was reliving the frustrations of such lighting pioneers as Charles Brush, William Sawyer, and Joseph Swan.

The quest for an electric lamp and all the devices and machinery needed to make it useful in the home brought young Francis Upton to the Menlo Park staff. A theoretical mathematician, Upton was to prove invaluable in the light experiments, despite the constant teasing of his math-poor boss.

For about a year Edison agonized with the bulb design and distribution system. His staff was overworked and hard pressed. Finally he narrowed his search for the proper filament to carbonized cotton threads. Starting on October 19, 1879, a bulb burned nonstop for 40 hours, burning out only. when Edison turned up the power level. A new age was born. The Wizard of Menlo Park, as he was touted in the press of the day, had taken the shattered dreams of other men and made them work. He had made his most monumental contribution to American science and technology.

in it the copper-platinum wires.

Sixth, after being carbonized the filament was placed on the glass stem of the bulb. This delicate task was always performed by "Batch" in Edison's presence.

Seventh, Boehm inclosed the stem with its filament within the fragile shell of a glass bulb.

Eighth, I placed the bulb on the vacuum pump and began evacuating the air. Martin Force relieved me on rare occasions.

Ninth, after the vacuum was obtained, it was always Edison who drove out the occluded gases and manipulated the lamp. When the difficult research period was past and the development period came, Edison often entrusted this whole process to me.

Tenth, when the lamp was finished, it was given a life test, the process consisting in sending a current through the filament at an approximate candle power and noting the number of hours it lived. The life test before November, 1879, was generally conducted in conjunction with other work. Experimental lamps would last from a few minutes to many hours, their value not becoming known until they had finished the test. A lamp was born when it died.

This outline does not convey a fair idea of the tedious, back-breaking and heart-breaking delays experienced as we went through the various processes. "Batch" sometimes spent two or three days getting a filament on the stem, only to have it break; whereupon the work had to be done over. And an accident was no wonder; for a carbon filament thin as a hair had to be connected with a length of wire equally thin! The hours spent in waiting while the carbonized filaments were in the furnace can hardly be estimated.

So with the process of driving out occluded gases. It had to be performed precisely, step by step, with at first but little current for

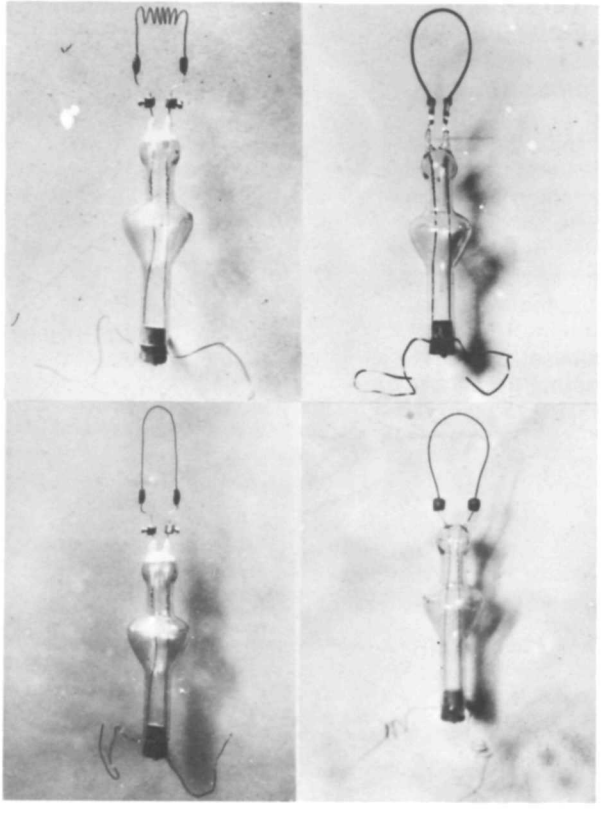
short periods and then a gradual increase during six or eight hours, when finally the filament could stand the whole heat of the electricity without disintegrating.

I have but to close my eyes to see once more the picture of our patient, painstaking, keenly observing chief carrying on his endless experiments, and at the same time educating and directing us. We never thought him wrong, whatever leading scientists said. Our quest never seemed vain or foolish.

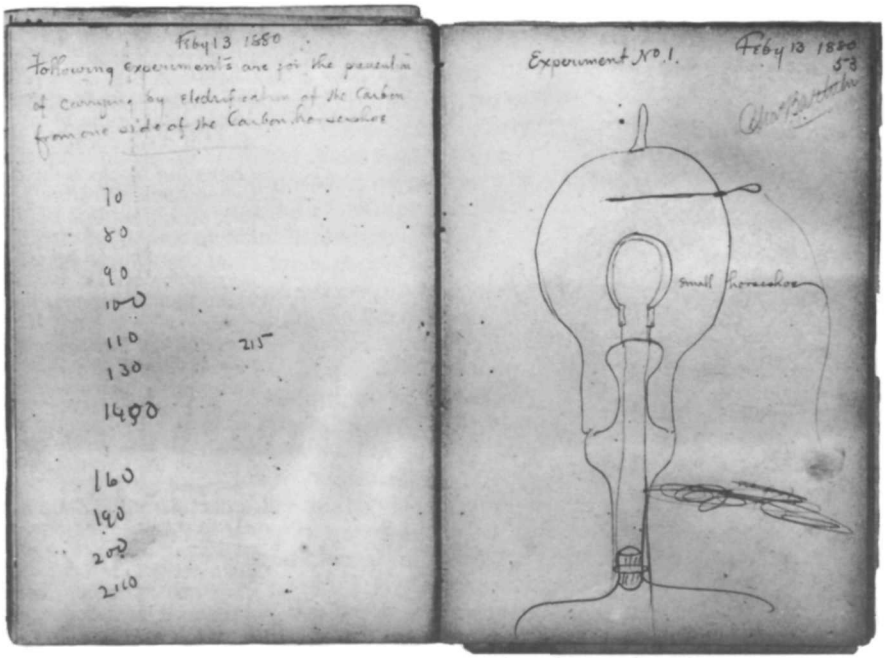
I see him tap carefully on the bulb with sensitive fingers as he watches for spots or irregularities in the carbon. If its condition appears good he proceeds even more carefully. If it does not, he is not greatly worried. I have never seen a man so cool when great stakes were at odds.

After the lamp, good or bad, has finished its test he breaks it open and takes it to the microscope to study the filaments, seeking the reason for the failure of the slender black threadlike substance.

Francis Jehl,
Menlo Park Reminiscences, 1936



Beneath a replica of the first successful incandescent lamp are four experimental filaments. They are, clockwise from top left, carbonized spiral graphite sewing thread, carbonized bristol cardboard, carbonized cotton sewing thread, and carbo-hydro. A carbonized cotton sewing thread was used in the memorable test, October 19-21, 1879.



Notebook pages for February 13, 1880, show experiments with what became known as Edison-Effect lamps, a forerunner of the radio tube. In contrast to the complexities of electronics, the electric lamp patent application seems quite simple.

For the next few years Edison was almost completely immersed in electric power distribution and use. He invented an enormous variety of the gadget and power-handling necessities for a commercial lighting system. Even with the help of the "new breed" of assistants like Upton, most of the system was born out of Edison's empirical methods.

Soon most Americans believed Edison's statement that "after this we will make electric light so cheap that only the rich will be able to burn candles." He had gained their confidence a few years before, in 1877, when he displayed the most original of all his inventions, the phonograph.

This amazing device was born out of the striving by Edison to improve the inefficient telephone transmitter patented by Bell and out of some thought-provoking experiments with an embossing device for use in recording telegraphic messages. He attached a needle to one of the vibrating diaphragms used in his telephone experiments. He ran waxed

UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY.

ELECTRIC LAMP.

SPECIFICATION forming part of Letters Patent No. 223,898, dated January 27, 1880.

Application filed November 4, 1879.

To all whom it may concern:

Be it known that I, THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America, have invented an Improvement in Electric Lamps, and in the method of manufacturing the same, (Case No. 186,) of which the following is a specification.

The object of this invention is to produce electric lamps giving light by incandescence, which lamps shall have high resistance, so as to allow of the practical subdivision of the electric light.

The invention consists in a light-giving body of carbon wire or sheets coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place.

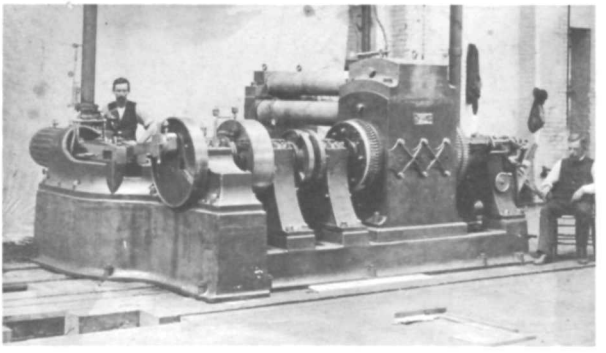
The invention further consists in placing such burner of great resistance in a nearly-perfect vacuum, to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum-bulb through platina wires sealed into the glass.

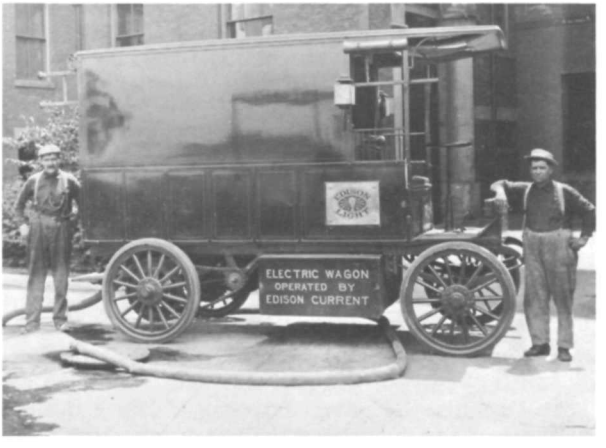
The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading-wires and the carbon conductor.

Heretofore light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels, in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon. The vessel holding the burner has been composed of glass cemented to a metallic base. The connection between the leading-wires and the carbon has been obtained by clamping the carbon to the metal. The leading-wires have always been large, so that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons have been to reduce the resistance of the carbon rod. The disadvantages of following this practice are, that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance of the lamp, the leading-wires must be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed, because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass and high in electrical resistance.

The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by "air-washing," or the attrition produced by the rapid passage of the air over the slightly-coherent highly-heated surface of the carbon. I have reversed this practice. I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled, as much as two thousand ohms resistance may be obtained without presenting a radiating-surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic composed of lamp-black and tar, its resistance may be made high or low, according to the amount of lamp-black placed upon it; that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours and afterward moistened and kneaded until it assumes the consistency of thick putty. Small pieces of this material may be rolled out in the form of wire as small as seven-one-thousandths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form.

All these forms are fragile and cannot be clamped to the leading-wires with sufficient force to insure good contact and prevent heating. I have discovered that if platinum wires are used and the plastic lamp-black and tar





AFTER THE LAMP, HE CREATED A WHOLE ELECTRIC SYSTEM

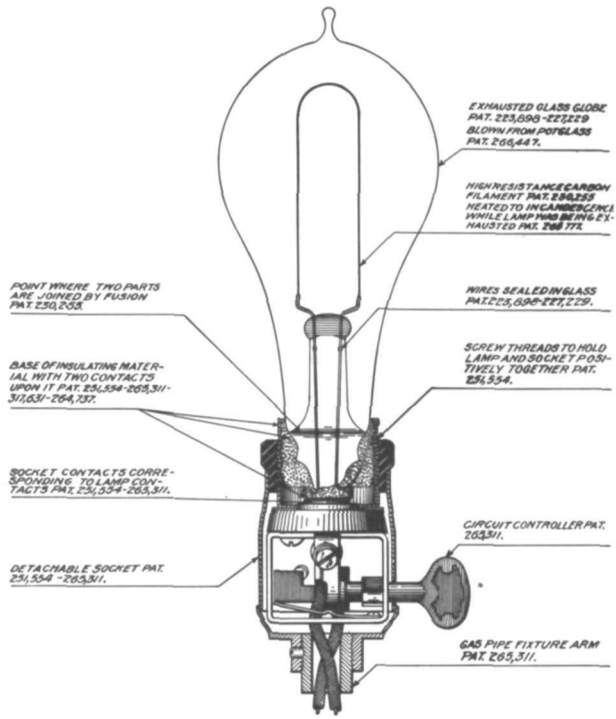
I had a great idea of the sale of electric power to large factories, etc., of the electric lighting system; and I got all the insurance maps in New York City, and located all the hoists, printing presses, and other places where they used power. I put all these on the maps, and allowed for the necessary copper in the mains to carry current to them when I put the mains down; so that when these places took current from the station I would be prepared to furnish it because I had allowed for it in the wiring. There were, I remember, 554 hoists in that district. In some places, a horse would be taken upstairs to run a hoist, and would be kept there until he died.

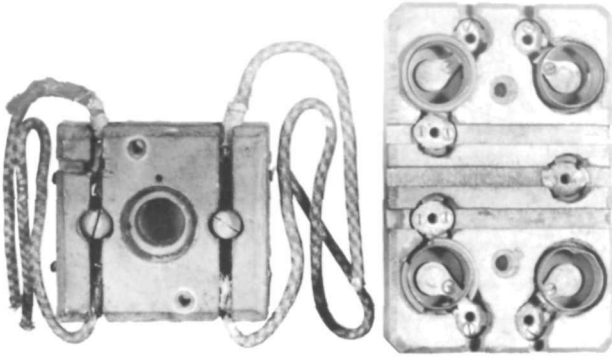
Thomas A. Edison, as quoted in *Forty Years of Edison Service*, 1922

Some of Edison's first electric power customers in New York were a bit skeptical about the accuracy of his meters that measured the electricity used. One such skeptic was one of America's leading financiers.

Mr. John Pierpont Morgan . . . wasn't at all sure about the inerrancy of that queer "wet measure"; so cards were printed and hung on each fixture in the Morgan offices in Wall Street. Each card noted the number of lamps on the fixture and the

The electric power industry called for the development of all kinds of equipment and created many new business opportunities and jobs, such as tending the Edison Jumbo Steam Dynamo at Edison Machine Works on Goerck Street in New York City. Horse-drawn wagons delivered the coal to run the dynamos in Philadelphia, but soon electric-powered vehicles were being used by Edison employees. The incandescent lamp sketch shows some of Edison's electric light patents. The socket, left, and the fuse block were made of wood.

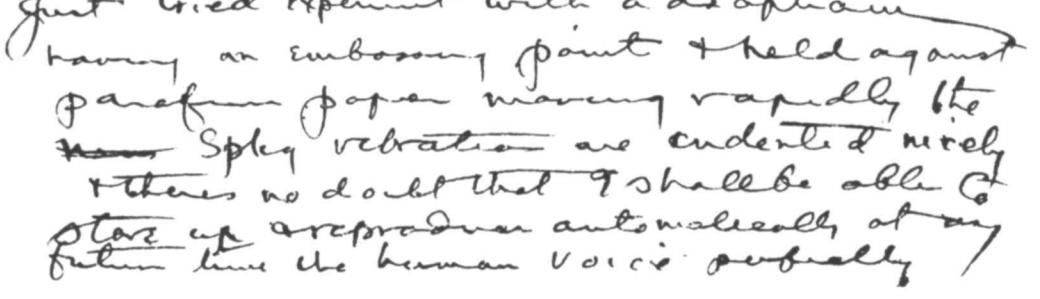




time at which they were turned on and off each day. The test was for a month, at the end of which the lamp hours were added up and figured out on an hourly basis. "Kilowatts" and "kilowatt hours" were a refinement quite unknown then to the art, the customers or the dictionaries. The total reached was then compared with the bill rendered by the [Edison] Company. One likes to think of the great Morgan, dealing in millions, thus putting a new meter on test, to check it up. The results of the first month revealed an apparent overcharge. Mr. Morgan chuckled. Edison took it quite serenely and suggested giving the little beggar another chance. Once more the same thing happened, and the chuckle became a broad grin . . . . Then Edison went "sleuthing" himself. He inspected the Drexel, Morgan offices carefully—the wires and fixtures critically—looked over the hourly records, and then asked who did the chores after dark. He was told that the janitor—really a very excellent chap—cleaned up the place. The janitor was sent for and when inquiry was made as to the light he used in mopping up the floors, pointed to a central fixture carrying ten lamps. He had made no record of its nightly use—hadn't been asked to. Told to make note every night of his use of it during a month, he did so; and when the next bill came in, it was found that the meter had registered within a very small fraction the actual lamphour consumption as computed from the cards. The joke was on Mr. Morgan, who became a highly enthusiastic advocate of a meter that could so much more satisfactorily stand interrogation than others who came after the financier's money.

Thomas C. Martin.
Forty Years of Edison Service, 1922

Edison demonstrates his tinfoil phonograph at Washington in April 1878, nine months after making his first known notation about the possibilities of such a machine at the bottom of a sketch of the improved telephone transmitter: "Just tried experiment with a diapham having an embossing point & held aganst parafin paper moving rapidly the Spkg vibrations are indented nicely & theres no doubt that I shall be able to store up & reproduce automatically at any future time the human voice perfectly." Behind the phonograph are, left, Uriah Painter, his host in Washington, and Charles Batchelor.


Just tried experiment with a diaphram having an embossing point & held against parafin paper moving rapidly the ~~Nom~~ Spkg vibration are indented nicely & theres no doubt that I shall be able to ~~store~~ up & reproduce automatically at any future time the human voice perfectly

paper under the device while shouting into the diaphragm. The shouting caused the point of the needle to make tiny impressions on the paper according to the quality and power of Edison's voice. When he ran it back under the needle at the same speed with which he ran it through originally, he got something which he and Charles Batchelor thought bore some remote resemblance to the human voice.

John Kruesi made a machine the way Edison had sketched it—a hand-cranked cylinder mounted to turn freely with a diaphragm and stylus so mounted that the tinfoil-covered cylinder would "walk" under the diaphragm. Into the machine Edison recited "Mary had a little lamb" while a disbelieving staff snickered. When he turned the machine back to the starting point and began to crank again, the smirks turned to stunned disbelief because there, squawking but clear, was the Old Man's voice. It was the first time in history that human speech had been recorded.

"I was never so taken aback in my life," Edison said later. "Everybody was astonished. I was always afraid of things that worked the first time."

He demonstrated the phonograph before members of Congress and President Rutherford B. Hayes in Washington. Thousands of people journeyed to Menlo Park to hear recorded sound. Edison considered the phonograph mainly a functional device, not a medium of entertainment. But at first he did not even pursue its functional possibilities, such as using it as a dictating machine. He put it aside for 10 years and turned his energies to electric power.

After inventing the incandescent lamp, he opened a factory to manufacture bulbs, he developed intricate equipment to generate and to distribute electric current, and he established an electrical lighting system in New York City.

By 1884 he was a young 37 but no longer the devil-may-care rebel loner. He was a millionaire responsible for a huge industrial enterprise centering around the electric light. He was a national figure and the hero of a generation. But tragedy struck in August 1884; his wife Mary died of typhoid fever at the age of 29.

For a long time some people thought there was trickery. One morning at Menlo Park a gentleman came to the laboratory and asked to see the phonograph. It was Bishop Vincent . . . I exhibited it, and then he asked if he could speak a few words. I put on a fresh foil and told him to go ahead. He commenced to recite Biblical names with immense rapidity. On reproducing it he said: "I am satisfied, now. There isn't a man in the United States who could recite those names with the same rapidity."

Thomas A. Edison, as quoted in *Edison: His Life and Inventions*, 1910

Mary Stilwell Edison and the inventor had a daughter, Marion Estelle, and two sons, Thomas A. Jr. and William Leslie.

He had married Mary Stilwell in 1871, when she was an employee in his Newark shop. He was 24 and she was 16. Their years together were marked by long hours of solitude for Mary Edison, for he found his greatest meaning in life in the laboratory, not the home. She was often bored and lonely, even with her children, although she enjoyed the prominence of being the wife of one of America's most famous men. A woman of simple tastes and education, she tended to reinforce Edison's notion that women were inferior to men. But Edison loved her and was crushed with grief when she died.

It is always a temptation to think in terms of turning points in a man's life and to oversimplify the changes which apparently stem from an event. The temptation exists with Edison's life at this point. In a sense, his wife's death marked the end of Edison's youth and of the Menlo Park lab, to which he rarely returned again. For a brief period his interests changed. The short diary he kept during July 1885 reveals a man seeing and appreciating more of life than hard work, a partial crack in the Victorian sanctification of eternal labor. He was filled with a new appreciation of the nonindustrial world around him, a world of people, natural beauty, poetry, the arts. It was during this period that he met young Mina Miller, who married him the next February and who proved to be the ideal wife for his new station in life, a man of fame, wealth, and middle age. He bought her an estate, Glenmont, in Llewellyn Park, and a new phase of his life began.

West Orange, N.J., was "country" in those days. Edison selected this sparsely populated and quiet town to be the site of a new "invention factory" 10 times the size of Menlo Park. The lab, just a mile from Glenmont, was finished in 1887. It was magnificent. All of the main structures were brick, and the largest, Building 5, had three stories with a total of 30,000 square feet of floor space. In Building 5 were shops containing very heavy and precise machinery of many kinds, a library which eventually had 10,000 books, a music room, a darkroom, and a stockroom replete with the most common and most scarce substances of the natural world.

One-story brick buildings laid out at right angles

On the first page of the brief diary he kept in July 1885, Edison muses about Mina Miller, dandruff, and smoking.

Menlo Park N.J.

Sunday July 12 1885

Awakened at 5.15 AM. my eyes were embarassed by the sunbeams - turned my back to them and tried to take another dip into oblivion - succeeded - awakened at 7 AM. thought of Mina. Daisy. and Mamma G — put all 3 in my mental kaledescope to obtain a new combination a la Galton. took Mina as a basis, tried to improve her beauty by discarding and adding certain features borrowed from Daisy and Mamma G. a sort of Raphaelized beauty; got into it too deep, mind flew away and I went to sleep again. Awakened at 8 15 AM. Poweful itching of my head, lots of white dry dandruff - what is this d—mnable material, Perhaps its the dust from the dry literary matter I've crowded into my noddle lately Its nomadic. gets all over my coat, must read about it in the Encyclopedia, Smoking too much makes me nervous — must lasso my natural tendency to acquire such habits — holding heavy cigar constantly in my mouth has deformed my upper lip, it has a sort of Havanna curl. Arose at 9 oclock came down stairs expecting twas too late for breakfast — twas'nt. couldnt eat much, nerves of stomach too nicotinny. The roots of tobacco plants must go clear through to hell. Satans principal agent Dyspepsia

Mina and Thomas Edison had a daughter, Madeleine, and two sons, Charles and Theodore. They lived at Glenmont, a large, brick and wood estate near the laboratory. Next page: The foyer gives an idea of the massive scale and ornateness of the house. "Red mahogany, cunningly wrought, enters into the composition of floor, walls and ceiling, affording an effective background for the glowing Eastern fabrics which abound," is the way W. K. L. and Antonia Dickson described the entry hall.

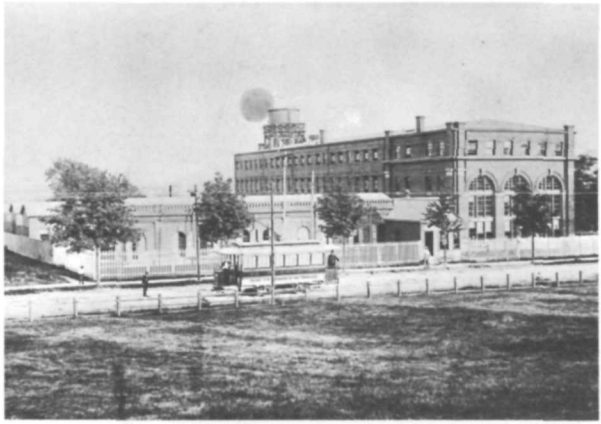
to No. 5 contained the latest equipment for making precise electrical measurements, carrying out complex chemical experiments, and developing prototype equipment parts. A picket fence enclosed the whole complex to protect the secrecy of experiments, and guards admitted visitors by invitation only. One time Edison himself was refused entrance until an assistant went to the gate to identify him.

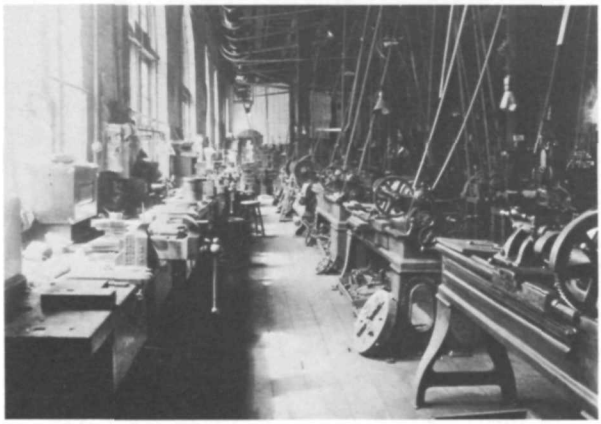
The intimacy of Menlo Park was gone. Instead of the dozen or so top assistants, Edison now had about 50. He was further removed from the front-line action, and management chores in his growing manufacturing plant took much of his time. Although he sometimes secreted himself with an assistant in a section of the lab to work out some thorny problem, he spent much time at his desk in the huge library. Often lab section heads and manufacturing management people reported to him there.

Though larger, the West Orange lab was like its predecessor at Menlo Park in that it was the only private research lab devoted to a broad spectrum of invention and not the slave of one industry. Josephson wrote that "The strategic importance of Edison's original model of the private research center, as the handmaiden of technology, was quickly grasped by the masters of some of our large industrial corporations." These new company labs, like Westinghouse and Bell, were not successful for some time, perhaps because they did not have an Edison at the helm.

The road to a new Edison product was a fairly standard one although experimentation toward one goal often would reveal something so new that the offshoot would prove more important than the original. The original idea came most often from the fertile mind of Edison, the result of creative synthesizing. Many times other theoreticians on the staff would assist in the idea formulation phase. Then the idea, embodied in rough sketches and notes, would be reduced to drawings and plans by others. Slowly a prototype model would be detailed on paper. Then the plan would go to the shops for building and to the field or lab for testing. For every successful improvement or innovation there were many dead ends and failures.

"The chemical room is a favorite of Edison," according to the Dicksons, "and here he often may be found, draped in an unsightly toga, the groundwork of which may once have been brown, but which is now embellished with strange devices in magenta, arsenic-green and yellow, the result of divers chemical catastrophes. He seems to be inhaling the evil smells with a gusto . . . ."





The main building at West Orange contained offices, a library, a large stockroom, and all kinds of experimental rooms. Both the first and second floors had a machine shop. Many of the various experiments and production activities were carried out in buildings near the compound or in other locations, such as the primary battery assembly plant and the Edison Chemical Works lab in Silver Lake, N.J. At his desk in the library, Edison often met with top assistants and with guests, in this case Rudolph Diesel, developer of the compression-ignition engine.

Next page: Edison gathers with his top employees outside the laboratory in July 1893. The men, front row from left, are Charles Brown, J. Gladstone, Thomas Maguire, John Ott, Edison, Charles Batchelor, Walter Mallory, J. Randolph, J. Harris; second row, A. Stewart, W. Miller, Jonas Aylsworth, J. Marshall, Arthur Kennelly, P. Kenny, W. K. L. Dickson, T. Banks, H. Miller; third row, S. Burn, Charles Wurth, F. Phelps Jr., Fred Ott, E. Thomas, R. Lozier, William Heise, W. Logue, H. Gagan, A. Wangemann; fourth row, L. Sheldon, R. Arnot, C. Kaiser, J. Martin, H. Reed, C. Dally, F. Devonald, and A. Thompson.

Francis Upton, top left, was one of Edison's closest assistants at newly built West Orange. About to eat a quick meal in the lab are members of an Insomnia Squad, so called because of long hours they spent on many experiments: seated from left, Johnny LaMonte, Billy Fulton, Sam Moore, Edison; standing, from left, Ed McGlynn, Bob Spahle, and Archie Hoffman. Behind his desk, tending to the voluminous paperwork, is William H. Meadowcroft. The names of his young aides and of many other hard-working employees, *top right, have* been forgotten, but all played a part in making the invention factory run smoothly. Occasionally, the employees, and even the seemingly tireless Old Man, would relax at a company picnic.

THEY WORKED FOR EDISON AT WEST ORANGE

Edison's many experimental projects and business interests kept the West Orange area humming with activity from 1887 to 1931. The refinement of the phonograph, developments in the motion picture field, experimentation with the storage battery, the search for a domestic source of rubber, and work on numerous lesser known ventures required a large staff of technical engineers, skilled workmen, unskilled laborers, and clerks. For years, Edison's chief theoretical assistant was Francis Upton.

As Edison always wanted to know what had been done before in this or that line, Upton saved himself lots of time by studying up the subject and then acquainting Edison with the facts. Edison liked and respected Upton, for the latter had acquired a brilliantly profound theoretical store of knowledge. And under Edison's guid-

ance he soon gained the necessary experience to make theory and practice meet. It was always edifying to listen to their arguments, and often a group of us would gather round and drink in every word that was spoken. Reasonings and sparrings between Edison and Upton often led to new experiments in which perhaps Batchelor's deft fingers or Kruesi's machine shop knowledge took part.

Francis Jehl,
Menlo Park Reminiscences, 1936

At times Edison the empiricist would become irritated with the theoretical approaches of Upton and others on the staff.

I was once with Mr. Upton calculating some tables which he had put me on, when Mr. Edison appeared with a glass bulb having a pear-shaped appearance in his hand. It was the kind that we were going to use for our lamp experiments; and Mr. Edison asked Mr. Upton to please calculate for him its cubical contents in centimeters. Now Mr. Upton was a very able mathematician . . . . Whatever he did and worked on was executed in a purely mathematical manner, and any wrangler at Oxford would have been delighted to see him juggle with integral and differential equations, with a dexterity that was surprising. He drew the shape of the bulb exactly on paper, and got the equation of its lines with which he was going to calculate its contents, when Mr. Edison again appeared and asked him what it was. He showed Mr. Edison the work he had already done on the subject, and told him that he would very soon finish calculating it. 'Why,' said Edison, 'I would simply take that bulb and fill it with mercury and weigh it; and from the weight of the mercury and its specific gravity I'll get it in five minutes, and use less mental energy than is necessary in such a fatiguing operation.'

Francis Jehl,
Menlo Park Reminiscences, 1936

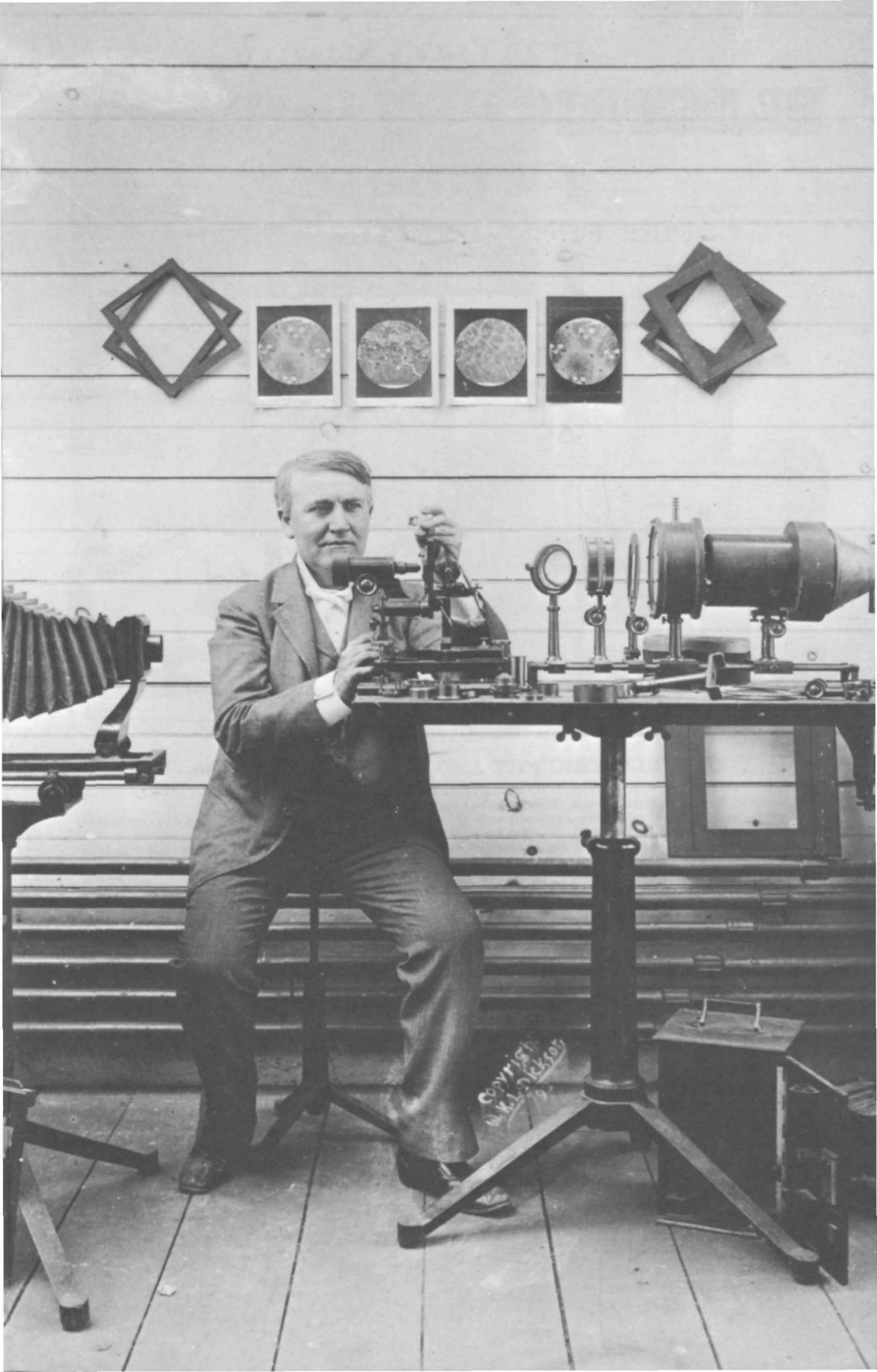
Edison seldom worked with his own hands. He had a mechanical man who did all the manipulating, while the master did the experimenting in his head. The mechanical man was named Freddie Ott, rotund, healthy, honest, exceedingly deft with his fingers; a tireless worker who felt tired all the time because he was out of sympathy with Edison's enterprising restlessness. Edison soon re-introduced himself and Freddie to me by pointing to himself as "Don Quixote" and to Freddie as "Santcho Pantcho." Edison himself was generally referred to as The Old Man. He had nicknamed his experimenters "Muckers," he himself being the chief Mucker.

M. A. Rosanoff, "Edison in His Laboratory," *Harpers Magazine*, September 1932

Then there was William H. Meadowcroft, who was Edison's "right arm" for more than half a century; he remained with him as his personal secretary to the day of the inventor's death. Meadowcroft's services were of incalculable value; he was for years the great inventor's contact with the public; his diplomacy and courtesy won him the love and respect of the public press and of the many distinguished guests of the inventor. To see Edison, it was first necessary to see Meadowcroft, and when you met Meadowcroft, you met a diplomat.

Francis T. Miller, *Thomas A. Edison: An Inspiring Story for Boys*, 1940

Fred Ott works on an experiment, as someone, perhaps a reporter, takes notes. Edison, while moving ahead on his major projects, usually dabbled in related fields, such as micrography.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EDISON'S

ELECTRIC PEN and PRESS

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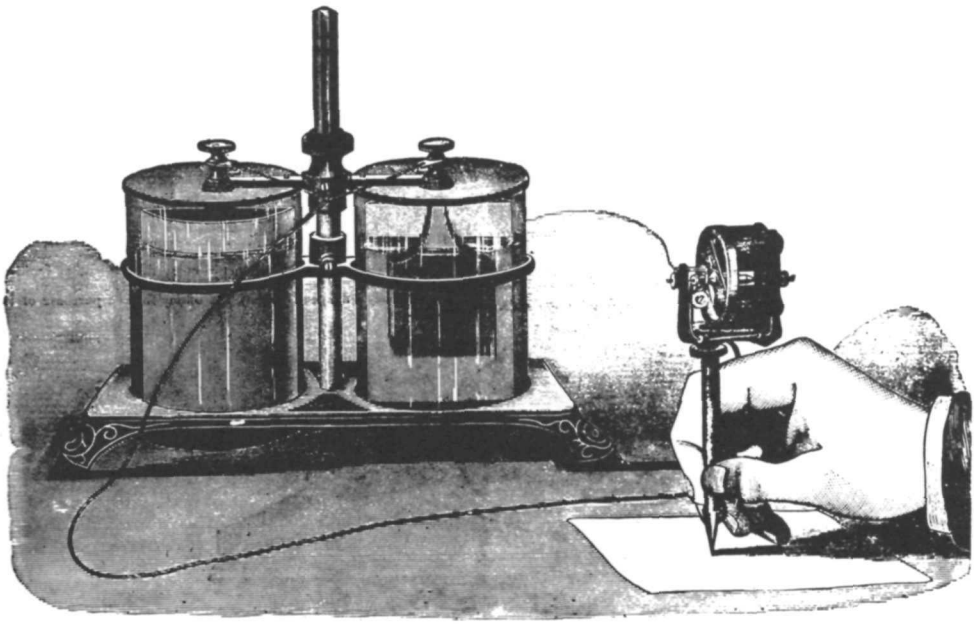


THE ELECTRIC PEN AND DUPLICATING PRESS

Was invented three years ago. Many thousands are now in use in the United States, Canada, Great Britain, France, Germany, Russia, Australia, New Zealand, Cuba, Brazil, China, Japan, and other countries.

Stencils can be made with the Electric Pen nearly as fast as writing can be done with an ordinary Pen. From 1,000 to 15,000 impressions can be taken from each stencil, by means of the Duplicating Press, at the speed of five to fifteen per minute.

The apparatus is used by the United States, City and State Governments, Railroad, Steamboat and Express Companies, Insurance and other Corporations, Colleges and Schools, Churches, Sabbath Schools, Societies, Bankers, Real Estate Dealers, Lawyers, Architects, Engineers, Accountants, Printers, and Business Firms in every department of trade.

It is especially valuable for the cheap and rapid production of all matter requiring duplication, such as Circulars, Price Lists, Market Quotations, Business Cards, Autographic Circular Letters and Postal Cards, Pamphlets, Catalogues, Ruled and Blank Forms, Lawyers' Briefs, Contracts, Abstracts, Legal Documents, Freight Tariffs, Time Tables, Invoices, Labels, Letter, Bill and Envelope Heads, Maps, Tracings, Architectural and Mechanical Drawings, Plans and Specifications, Bills of Fare, Music, Insurance Policies, Cypher Books, Cable and Telegraphic Codes, Financial Exhibits, Property Lists, Manifests, Inventories, Schedules, Shipping Lists, College and School Documents, Rolls, Examination Questions, Examples, Illustrations, Scholars' Reports, Lecture Notes, Regulations, Blanks, Official Notices, Mailing Lists, Committee Reports, Sermons, Lectures, Pastoral Information, Manuscripts, Journals, Fac-Similies of Papers, Drawings, Hieroglyphics, Programmes, Designs, etc.

Circulars prepared with the Electric Pen pass through the mails as third class matter at one cent per ounce or fraction thereof. Additional information and samples of work furnished on application.

PRICES—No. 1 Outfit, with 7×11 Press, $40.00.
" 2 " " 9×11 " 50.00.
" 3 " " 9×14 " 60.00.

Sent C.O.D., or on Receipt of Price.

GEO. H. BLISS GENERAL MANAGER, 220 TO 232 KINZIE STREET, CHICAGO.

LOCAL AGENCY, 142 La Salle Street, Chicago.

DOMINION AGENCY, 44 Church Street, Toronto, Ont.

PHILADELPHIA AGENCY, 628 Chestnut St., Philadelphia.

GEN'L EASTERN AGENCY, 20 New Church St., New York.

One of Edison's lesser known inventions was the electric pen and press, touted here in an advertisement. Two offshoots of the entertainment phonograph were the dictating machine and the talking doll. The doll did not sell very well, but that failure was minor when compared to the millions of dollars involved in his unsuccessful New Jersey ore-mining operation, shown on the next page.


A.K.L. DICKSON

The Edison of middle age tended to be less flexible than Edison the young man. He was inclined to dismiss competitors' innovations which in his early days he would have "borrowed" and refined. One cannot escape the conclusion that despite all its wonderful equipment, materials, and staff, the West Orange lab simply never approached Menlo Park in degree of creativity.

Fierce competition forced him to turn his attention once again to the phonograph. He saw others close to reaping profits from their versions of home entertainment phonographs. So, during the 1880's and 1890's, he developed improved model after improved model of the Edison phonograph. The competition was growing stiff, and holding a large share of the market was Edison's lifeline to solvency. He held on to it tenaciously.

Though the phonograph business demanded the attention of a large part of his staff, it did not completely subvert the original intent of the lab. Experimental products in diverse fields were produced. Some succeeded, but many failed.

This was a trying period for Edison. He was losing his firm grip on the electrical business. More and more people, such as George Westinghouse and Elihu Thomson, were competing with him. Edison stubbornly stuck with his direct-current system and openly sparred with Westinghouse, an alternating-current proponent. Edison's factory payrolls, meanwhile, were constantly rising and getting more difficult to meet. He decided to bolster the electrical business by joining forces with a financial syndicate. The Edison Electric Light Company became the central part of Edison General Electric Company. Edison still had some say in the affairs of the firm, but against his wishes he soon lost most of that power when Edison General Electric merged with its chief competitor, Thomson-Houston. The firm was called the General Electric Company. Edison's name had been dropped.

Edison was dejected by all these financial dealings and even before the final merger decided to leave his electric power involvements and immerse himself in a new search. By 1890 the high-grade iron ore in the eastern States had been exhausted

In a caveat filed with the Patent Office, Edison discloses that he is "experimenting upon an instrument which does for the Eye what the phonograph does for the Ear," and shows, on the next page, how this motion picture equipment would work.

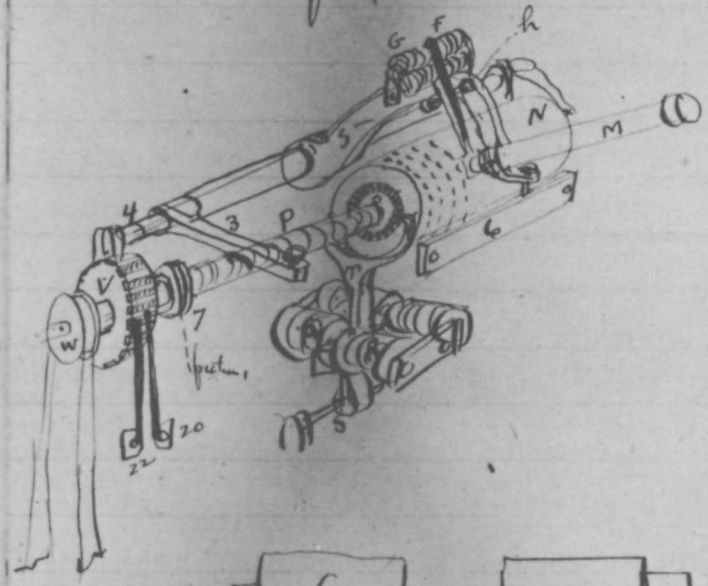
Caveat 110 Filed October 17th 1888.

Orange N.J. Oct 8 1888.

Jeckley Rushelue & Ainsworth getting Jones & Edison

I am experimenting upon an instrument which does for the Eye what the phonograph does for the Ear Which is the recording and reproduction of things in motion, and in such a form as to be both Cheap practical and convenient. This apparatus I call a Kinetoscope "Moving View" In the first production of the actual motions that is to say of a continuous Opera the Instrument may be called a Kinetograph but its subsequent reproduction for which it will be of most use to the public it is properly called a Kinetoscope The invention consists in phalographing continuously a series of pictures occurring at intervals which intervals are greater that Eight per second, and phalographing these series of pictures in a continuous spiral on a cylinder or plate in the same manner as sound is recorded on the phonograph At the instant the chemical action on the cylinder takes place the cylinder is at rest and is only advanced in rotation a single step which motion takes place while the light is cut off by a shutter. Thus there is a practically continuous rotation of the cylinder but it

fig 2



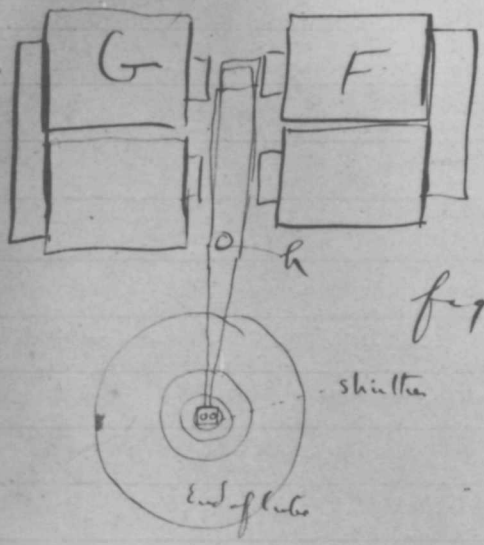
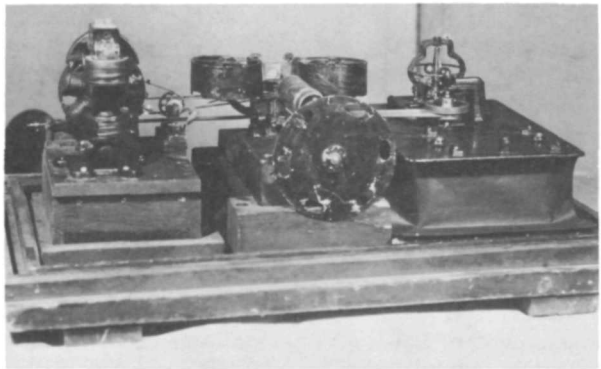


fig 3



Edison's 1889 Strip Kinetograph was the first workable motion picture camera in America to use strip film. The film ran horizontally.

and machinery had not been developed to economically utilize the great quantities of lower-grade ore. Edison decided to find a way. He purchased a large area near Ogdensburg, N.J., and constructed a huge facility for crushing, processing, and extracting iron. The facility was supposed to smash and crush boulders the size of an upright piano. Full of problems and breakdowns, it drained the money and time of Edison for years. He sank $2 million into this venture and was in debt for hundreds of thousands more. In 1899 he was laboring to keep his constantly improving machinery operating, trying to get ahead of the heavy losses he was taking. But one day Charles Batchelor brought him the news that the vast Mesabi range deposits in the Midwest were to be extracted by open-pit mining and that economical transportation eastward on the Great Lakes had been made feasible. Iron ore fell to $2.65 a ton in Cleveland. Edison's New Jersey & Pennsylvania Concentrating Works was ruined; the company was broke.

While the ore-processing fiasco had taken up the better part of Edison's creative time for a decade, all was not lost. Some of the diversions he engaged in during this time were remarkably successful. One was motion pictures.

As early as 1887, Edison had revealed his idea for a camera that would record motion to William K. L. Dickson, a young English immigrant employed at the lab. Dickson was a camera enthusiast who

FROM THE MAN WHO BROUGHT YOU THE MOVIES

In recent years Edison's role as a cinematographic pioneer has been criticized by some scholars. Here is a more traditional view of Edison's contributions:

The most that could be said of the condition of the art when Edison entered the field was that it had been recognized that if a series of instantaneous photographs of a moving object could be secured at an enormously high rate—many times per second—they might be passed before the eye either directly or by projection upon a screen, and thereby result in a reproduction of the movements. Two very serious difficulties lay in the way of actual accomplishment, however—first, the production of a sensitive surface in such form and weight as to be capable of being successively brought into position and exposed, at the necessarily high rate; and, second, the production of a camera capable of so taking the pictures. . . .

In the earliest experiments attempts were made to secure the photographs, reduced microscopically, arranged spirally on a cylinder about the size of a phonograph record, and coated with a highly sensitized surface, the cylinder being given an intermittent movement, so as to be at rest during each exposure. Reproductions were obtained in the same way, positive prints being observed through a magnifying glass. . . .

During the experimental period and up to the early part of 1889, the kodak film was being slowly de-

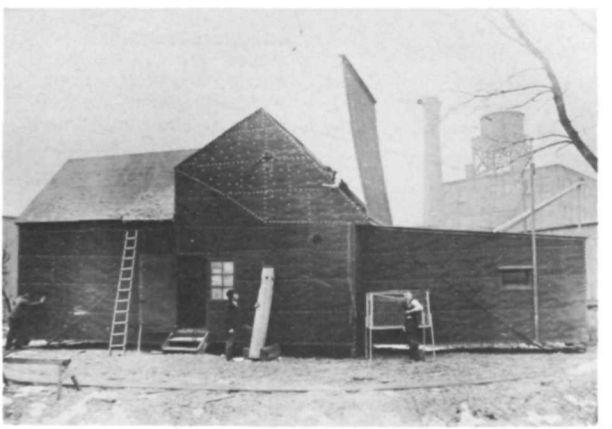
worked closely with Edison during a decade of experimentation and development of what was to become the first successful motion picture camera. Most historians believe the celluloid film Strip Kinetograph camera was first successful in 1889. Edison and Dickson also created the peephole Kinetoscope, which presented the first paid public motion picture shows in 1894.

The work on the motion picture idea went on despite the little time the ore-preoccupied Edison personally devoted to the project. Great credit is due his able assistants, especially Dickson, in this venture, much more perhaps than in any other Edison project which required much developmental work. In 1893, the Black Maria was built as the first specially designed motion picture studio. Here and in the nearby countryside the very earliest motion pictures were made.

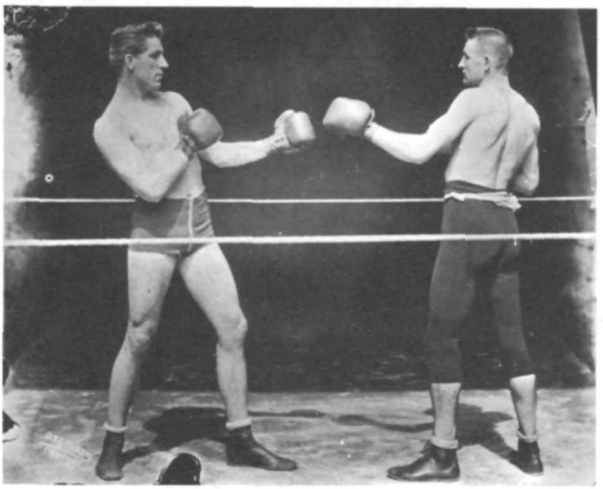
Edison, against Dickson's advice, did not actively try to create a projector-screen combination. Edison thought the use of a screen for a mass audience would diminish the market for projectors too much. While Louis Lumière, Thomas Armat, and others went on to devise systems using a screen on a wall, Edison stuck with his peep-show Kinetoscope. He foolishly lost Dickson to a competitor during this period which became rank with

veloped by the Eastman Kodak Company. Edison perceived in this product the solution of the problem on which he had been working, because the film presented a very light body of tough material on which relatively large photographs could be taken at rapid intervals. The surface, however, was not at first sufficiently sensitive to admit of sharply defined pictures being secured at the necessarily high rates. . . . Much credit is due the Eastman experts—stimulated and encouraged by Edison, but independently of him —for the production at last of a highly sensitized, fine-grained emulsion presenting the highly sensitized surface that Edison sought.

Having at last obtained apparently the proper material upon which to secure the photographs, the problem then remained to devise an apparatus by means of which from twenty to forty pictures per second could be taken; the film being stationary during the exposure and, upon the closing of the shutter, being moved to present a fresh surface. In connection with this problem it is in-



"With its flapping sail-like roof and ebon hue," the Dicksons wrote, the Black Maria "has a weird and semi-nautical appearance, and the uncanny effect is not lessened when, on an imperceptible signal, the great building swings slowly around upon a graphited centre, presenting any given angle to the rays of the sun, and rendering the operations independent of diurnal variations." In 1896, on top of a building in New York City, May Irwin and John C. Rice embrace in "The Kiss From Widow Jones." Their prolonged cinema kiss drew large crowds—and a few calls for censorship.



teresting to note that this question of high speed was apparently regarded by all Edison's predecessors as the crucial point. . . .
After the accomplishment of the fact, it would seem to be the obvious thing to use a single lens and move the sensitized film with respect to it, intermittently bringing the surface to rest, then exposing it, then cutting off the light and moving the surface to a fresh position; but who, other than Edison, would assume that such a device could be made to repeat these movements over and over again at the rate of twenty to forty per second? . . . Edison's solution of the problem involved the production of a kodak in which from twenty to forty pictures should be taken in each second, *and with such fineness of adjustment that each should exactly coincide with its predecessors even when subjected to the test of enlargement by projection. This . . . was finally accomplished, and in the summer of 1889 the first modern motion-picture camera was made. More than this, the mechanism for operating the film was so constructed that the movement of the film took place in one-tenth of the time required for the exposure, giving the film an opportunity to come to rest prior to the opening of the shutter.*

Frank L. Dyer and Thomas C. Martin, *Edison: His Life and Inventions*, 1910

Edison's "The Great Train Robbery," filmed in 1903, was one of the first motion pictures with a story line and was made to be projected in theaters. Long lines of people waiting to see such shows as a fight between Gentleman Jim Corbett and Pete Courtenay in the earlier peephole Kinetoscopes sparked demands for mass shows. The staged fight, incidentally, took place in the Black Maria.

litigations and patent infringements. But the Edison patents were to help keep him rich for many years. All inventors and improvers of motion picture cameras and projectors of the day owed much to his Kinetograph, Kinetoscope, and other early experiments.

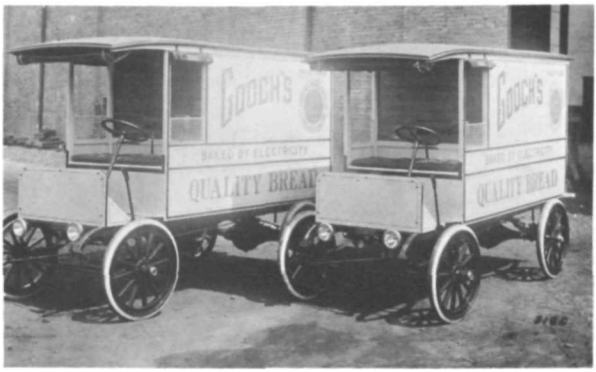
Having recovered quickly from the defeat and failure of a decade of striving in iron mining, Edison decided in 1900 to make a better battery.

Huge and efficient generators of electricity were already in use. Called dynamos, they were progeny of the first 90 percent efficient generator developed by Edison—the "long-waisted Mary Ann." A necessary auxiliary to these dynamos was a means of storing power for a long period. The storage battery was in common use, but it was of lead-acid construction, heavy, and destroyed itself in rather short order. Edison, the master innovator in the power field, saw the need for a battery which would last longer and be lighter. He believed that electric motors were superior to gasoline engines for use by the infant auto industry and that a better battery would make electric cars truly competitive.

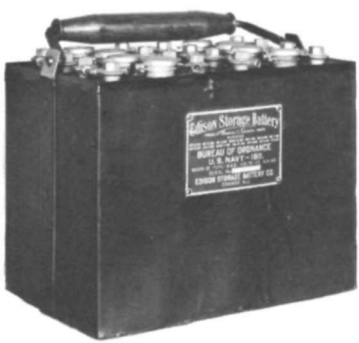
By 1901 the West Orange lab was gearing up for the new quest. He hired a staff of about 90 men under a chief chemist, gathered a huge assortment of materials to be tested by the Edison method, and began the search. For years they experimented intensively. Always, it seemed that when they had developed one characteristic in a battery which was desirable they found another which was not.

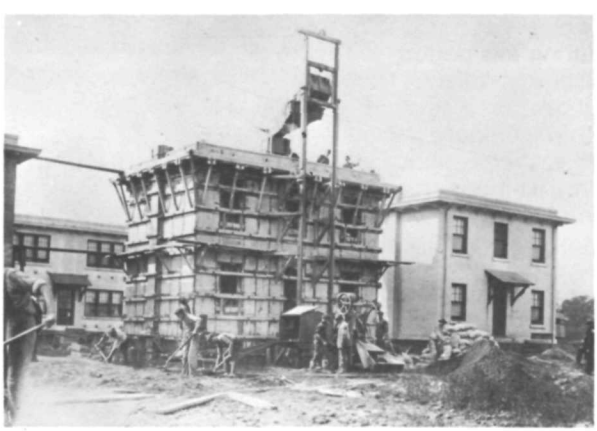
Edison obtained many patents during this period before finally coming up with a nickel-iron-alkaline battery. It was a great improvement over lead-acid types in several ways. It was slow to decompose and it was light. It also was reversible; that is, upon charging, the battery would reassume its internal physical structure. It held a charge for an extremely long time without recharging, but it was expensive and could not deliver enough power for its weight to make it useful in all-electric autos. Nor could it provide the heavy initial current needed to start a gasoline buggy.

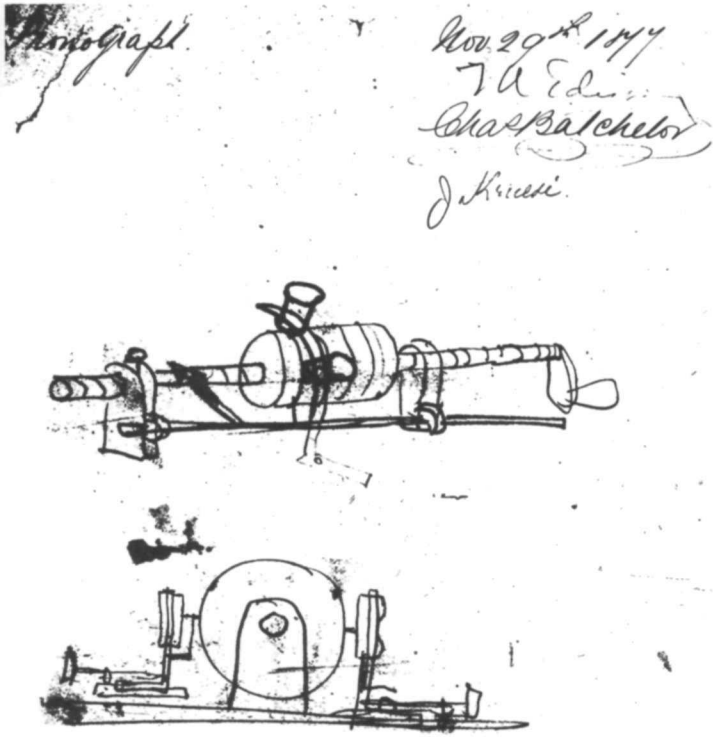
Despite these problems, the nickel-iron-alkaline battery was a magnificent example of the Edison



A bakery in Lincoln, Nebr., not only used Edison storage batteries to power its trucks but advertised its then novel way of baking bread, by electricity. While working on the nickel-iron-alkaline storage battery in the early 1900's, Edison also produced poured cement houses and, beginning in 1912, disc records, which he maintained were not as good as the cylinders.



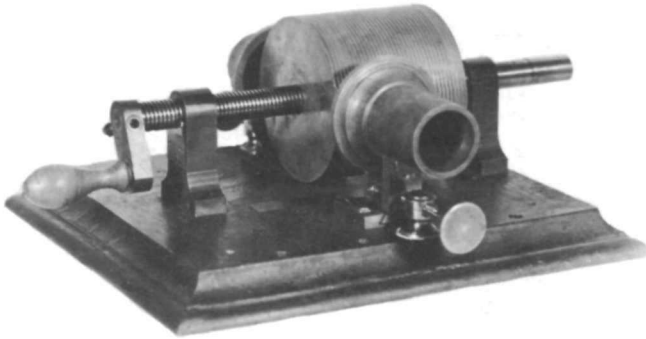




THE PHONOGRAPH BECAME AN INDUSTRY

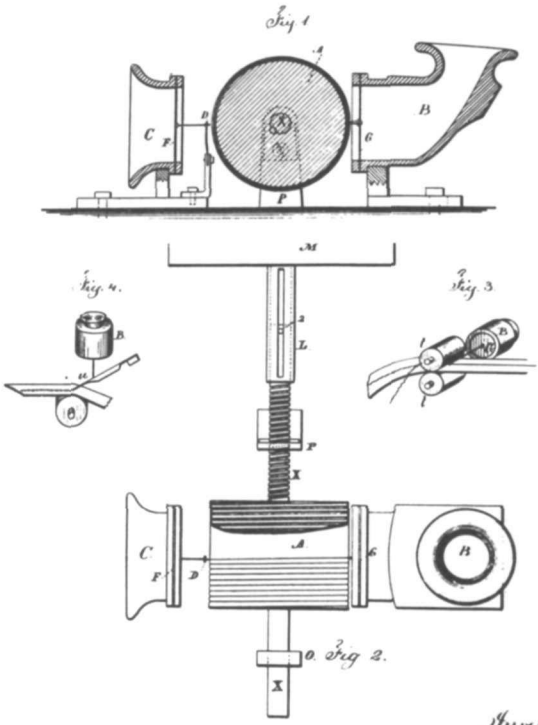
The original phonograph, as invented by Edison, remained in its crude and immature state for almost ten years—still the object of philosophical interest, and as a convenient textbook illustration of the effect of sound vibration. . . . In 1887 his time was comparatively free, and the phonograph was then taken up with renewed energy, and the effort made to overcome its mechanical defects and to furnish a commercial instrument, so that its early promise might be realized. The important changes made from that time up to 1890 converted the phonograph from a scientific toy into a successful industrial apparatus. The idea of forming the record on tinfoil had been early abandoned, and in its stead was substituted a cylinder of wax-like material, in which the record was cut by a minute chisel-like gouging tool. Such a record or phonogram, as it was then called, could be removed from the machine or replaced at any time, many reproductions could be obtained without wearing out the record, and whenever desired the record could be shaved off by a turning-tool so as to present a fresh surface on which a new record could

By supposedly following Edison's sketch, top left, John Kruesi built the first tinfoil phonograph, top right, in 1877. Though improved by Edison in 1888 and thereafter, the phonograph essentially remained the simple machine delineated in the original patent drawings. Gathered around the 1888 model after a 72-hour stint of modifications, are, seated from left, Fred Ott, Edison, Col. George E. Gouraud; standing, from left, W. K. L. Dickson, Charles Batchelor, A. Theodore E. Wangemann, John Ott, and Charles Brown.

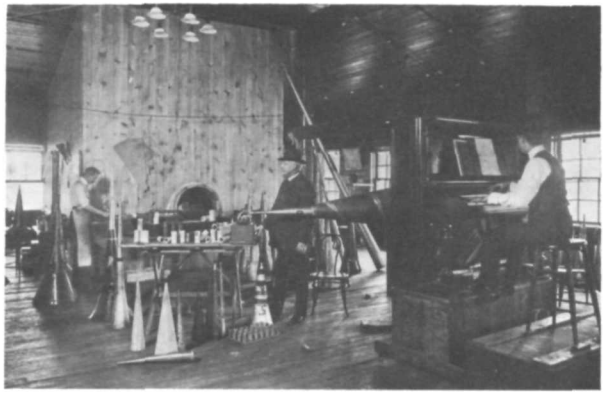


T A. EDISON.
Phonograph or Speaking Machine.

No. 200,521. Patented Feb. 19, 1878.

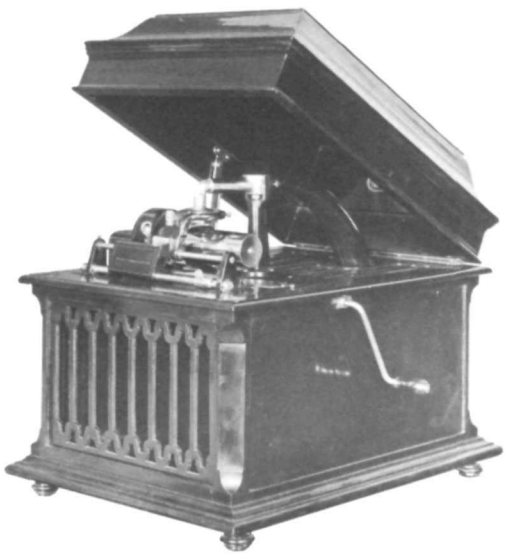


be formed, something like an ancient palimpsest. A wax cylinder having walls less than one-quarter of an inch in thickness could be used for receiving a large number of records, since the maximum depth of the record groove is hardly ever greater than one one-thousandth of an inch. Later on, and as the crowning achievement in the phonograph field, from a commercial point of view, came the duplication of records to the extent of many thousands from a single "master." . . . Another improvement . . . was making the recording and reproducing styluses of sapphire, an extremely hard, non-oxidizable jewel, so that those tiny instruments would always retain their true form and effectively resist wear. . . . After a considerable period of strenuous activity in the eighties, the phonograph and its wax records were developed to a sufficient degree of perfection to warrant him in making arrangements for their manufacture and commercial introduction. At this time the surroundings of the Orange laboratory were distinctly rural in character. Immediately adjacent to the main build-



ing and the four smaller structures, constituting the laboratory plant, were grass meadows that stretched away for some considerable distance in all directions, and at its back door, so to speak, ducks paddled around and quacked in a pond undisturbed. Being now ready for manufacturing, but requiring more facilities, Edison increased his real-estate holdings by purchasing a large tract of land lying contiguous to what he already owned. At one end of the newly acquired land two unpretentious brick structures were erected, equipped with first-class machinery, and put into commission as shops for manufacturing phonographs and their record blanks, while the capacious hall forming the third story of the laboratory, over the library, was fitted up and used as a music-room where records were made.
Thus the modern Edison phonograph made its debut in 1888, in what was then called the "Improved" form . . . viz., *the spring or electric motor-driven machine with the cylindrical wax record—in fact, the regulation Edison phonograph.*

Frank L. Dyer and Thomas C. Martin, *Edison: His Life and Inventions*, 1910



Recording George Boehme on the piano in the music room on the top floor of Building 5 at West Orange, are Albert Kipfer, left, and A. Theodore E. Wangemann, the sound engineer. Records and cylinder phonographs, such as the Amberola, were sold door to door in some places.

quality and was used in mining and railway devices. Some Edison batteries have been known to last a generation. He could well be proud of his handiwork.

A foray into the world of building construction consumed his interest for a while. He wanted to utilize the then idle heavy machinery at Ogdensburg. He converted it to manufacture cement and built a complex of factory buildings around the old lab entirely of reinforced concrete. He tried to interest the public in prefabricated, poured homes, remarkable structures which, when iron molds were removed, contained stairways, rooms, halls, cellars, and conduits—all of concrete. But the idea was too advanced for that day, and Edison gave it up.

As he took up new experiments and invented various devices, Edison would form manufacturing companies. He started almost 200 companies and corporations. Today power production utilities across America bear his name in the fashion of Consolidated Edison of New York City. McGraw-Edison Corporation is the direct descendant of Thomas A. Edison Industries, Inc., and only in 1972 did the corporation vacate the reinforced concrete production facilities around the red brick lab on Main Street in West Orange. And, of course, General Electric traces its lineage to him.

Through all the years of travail and failure which characterized many of Edison's quests at the West Orange lab, one invention, the phonograph, was always in various stages of development. Phonographs bearing the Edison name were refined there for 42 years from the earliest cylinder models to disc console models of remarkable fidelity for non-electronic devices. The competition was fierce during this time. Chichester Bell and Charles Tainter's Graphophone, Emile Berliner's Gramophone, the Victor Talking Machine Co.'s Victrola, and other devices were competing with Edison's phonograph. Edison's various models held the quality edge, but toward the end of his life the new processes and devices which he had resisted began to erode this predominance.

Nonetheless, the phonograph served Edison the middle-aged and older man in much the same way

the stock printer served Edison the young man; it was like a steady job, always there, supporting him when a spectacular venture would fail or be only partially successful. Competition constantly forced an upgrading of the Edison product and kept lab personnel challenged and innovative for almost a half-century. And this omnipresent, close-knit interaction of research and manufacturing exempified the most basic and perhaps most important Edison invention of all, the prototype modern industrial research laboratory.

HE MADE SCIENCE SERVE

Thomas A. Edison has been characterized as a lone wolf in post-Civil War America's technological revolution. Popular literature of his day tended to paint him in the colors of the rugged loner, sort of proto-Tom Swift, a frontiersman of science. In fact, this dramatic portrait is nonsense.

As Josephson suggests, mathematician Norbert Wiener's description of Edison as a "transitional figure" in American science is much closer to the truth. Edison's organization of artisans, technicians, and trained scientific theoreticians became a model for the complex research laboratories of the 20th century. The development of the Edison inventions depended not on high insights alone but on the brainpower, sweat, and imagination of a highly motivated team. The team at the invention factory helped make the Edison name the popular and real equal of a Roosevelt, a Wilson, a Grant, a Pershing, a Ford, a Cobb, a Fairbanks.

In his later years, Edison many times closed his mind to constructive criticism from his assistants. Edison got so he would not accept much of the advice he received from his employees and even his sons. He became more crusty and withdrawn. The result was that the invention factory lost much of its relevance and fell back from the vanguard of American technology during the 20th century. Creativity decreased as his visionary scope narrowed.

Edison was no social reformer, but his concept of invention for useful and practical purposes, assisting in the alleviation of human labor and boredom, was a humanizing influence on American science. In subordinating invention to commercial and popular need, Edison advanced his own fortunes and the quality of life in a nation of men, women, and children barely liberated from dawn-to-dusk labor in field, sweatshop, and kitchen.

The needs of a people and a nation and his own almost mystical unquenchable obsession to create, to improve, and to build were Edison's taskmasters.


Edison

Few men have ever worked harder and longer for any master anywhere. If he did not share the virginal and pristine ethics of a Faraday or Henry in his approach to invention, he did worlds more than both men to bring increased pleasure and comfort to the people of his day. He made the business of inventing both productive and less hazardous through both the genius he debunked and through the hard work and sweat he claimed.

And he put to rest forever the assertion of an earlier day that invention was a "divine accident."

Edison examines the Projecting Kinetoscope, or movie projector, in the library of his West Orange laboratory.

POSTSCRIPT: THE EDISON SITES

Thomas Edison's research laboratory in West Orange, N.J., was closed shortly after the inventor's death on October 18, 1931. The laboratory and Edison's home, Glenmont, were maintained for many years by Thomas A. Edison, Inc. From 1948 until 1955, the Thomas Alva Edison Foundation administered the laboratory.

On December 6, 1955, Glenmont became a national, non-federally owned historic site. The laboratory was established as a national monument by President Eisenhower in 1956 after the property was donated to the Federal Government by Thomas A. Edison, Inc. Glenmont was given to the Government on July 22, 1959, by the McGraw-Edison Company and both areas were combined by an act of Congress on September 5, 1962, as Edison National Historic Site.

The National Park Service, which administers the site, conducts tours of the laboratory buildings and Glenmont. The site has many Edison inventions on display, a massive collection of Edison notebooks and papers, a replica of the Black Maria motion picture studio, and numerous other memorabilia.

Several other sites connected with Edison's early days and growth as an inventor are open to the public.

The Milan, Ohio, house in which he was born on February 11, 1847, is preserved by the Edison Birthplace Association, Inc. Edison's father, Samuel, had the three-story, red-brick structure built on the side of a hill in the canal town in 1841. The house is furnished with many family pieces and contains some models of Edison's inventions.

The Edison Winter Home and Botanical Gardens in Fort Myers, Fla., are maintained by the City of Fort Myers. In 1885 Edison purchased this 14-acre site mainly because of its natural source of bamboo, which he used as filaments in some of his early incandescent light bulbs. Here Edison constructed two houses, which he had prefabricated out of spruce in Maine, and a chemical laboratory. One house was used by the family and the other one by the guests, who usually had to stay for a month because they were dependent on the month-

ly boat to the then distant location. From 1885 until his death, Edison spent part of each winter at Fort Myers. Many years he stayed for five or six months. He carried out many of his natural rubber experiments here and at one time had 6,000 species of plants in the gardens. Today, the gardens contain more than 400 species. Tours are given of the houses, laboratory, office, museum, and gardens.

By far the most complete collection of Edison material from his early creative life is at Greenfield Village in Dearborn, Mich. In 1927 Henry Ford recreated board-by-board the entire Menlo Park laboratory as a tribute to the man he idolized. Much of the material was moved from the original Menlo Park site, and a substantial collection of Edison's inventions, papers, and equipment is preserved at Dearborn. Besides the main laboratory buildings and shops, Greenfield Village has several other buildings associated with Edison's life. Among these structures, some of which are reproductions, are: Sarah Jordon's boardinghouse, a phonograph experiment building from West Orange, the first Edison Illuminating Co. plant in Detroit, the original Fort Myers laboratory, the Ontario, Canada, farmhouse in which Edison's grandfather lived. Greenfield Village also contains houses, stores, laboratories, and shops of many leading American figures in the fields of manufacturing, transportation, and agriculture.

At the original site of the Menlo Park laboratory, the State of New Jersey operates a small museum and a 131-foot tower commemorating Edison. The tower, which was built of steel and Edison Portland Cement, is capped by a 14-foot-high replica of the first incandescent lamp. It is illuminated nightly.

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Nearly all the photographs in this book are from the collection at Edison National Historic Site in West Orange, N.J. A grant from the Eastern National Park and Monument Association helped cover the cost of making prints from negatives in the park's files. The photographs of the stock ticker and the vote recorder on page 8 and the filaments on pages 18 and 21 come from the collections of Greenfield Village and the Henry Ford Museum in Dearborn, Mich. The photographs of Alexander Graham Bell and Samuel F. B. Morse on page 10 are from the Library of Congress.

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