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Thomas Alva Edison—battery and device innovation in response to application's needs

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Abstract

Thomas Alva Edison, the most prolific inventor in North America, with over 1000 patents, was the descendant of early settlers from the Netherlands to the Hudson Valley region of New York/New Jersey. However, his genealogical trail encompasses many cities, provinces, states, and countries, including Holland, France, Scotland, New Amsterdam, New York, New Jersey, Nova Scotia, Ontario, Ohio, and Michigan. He was motivated to develop and invent in response to perceived needs of commercial devices and was the creator of the concept of an industrial research laboratory. His activities covered a wide-range of chemical, electrical, medical, metallurgical, entertainment, and communication devices and led to the creation of major worldwide industries. However, his expressed underlying concern was the "service it might give others". This presentation reviews commercial developments in comparison with the technologies and motivations of the time and is illustrated by material from the Rutgers University 'Edison Papers Project', Edison's personal notes found in the Edison Battery Factory and preserved by Professor Salkind, and records of The Electrochemical Society.

Keywords: Biography; Thomas A. Edison

1. Genealogy of Thomas A. Edison

The genealogy of Thomas Alva Edison, as shown in Table 1, can be traced to John Edeson, his great grandfather, who was born in The Netherlands in 1727. John Edeson who came over from Holland in 1730 with his widowed mother, as nearly as can be determined, were descendants of extensive millers on the Zuyder Zee and took up patents of land along the Passaic River in New Jersey. Some graves of the family can still be found in the hamlet of Caldwell.

John Edeson settled in North America, along the banks of the Hudson River in 1740, in an area well known for Dutch settlers. John Edeson married Sarah Ogden, who was also of Dutch origin, in October 1756 in the Province of New Jersey. A child, Samuel Ogden Edison, was born to the couple in 1767 in New Jersey.

The original spelling of the Edison name was Edeson (pronounced aedison). John Edeson was a loyalist during the American Revolution and left New Jersey for Nova Scotia in 1784 (5 years before George Washington became the first president of the United States).

However, the genealogy of Sarah Ogden can be traced to Guillaume Vigne and his wife Adrienne Cuvelier, both of whom were born in Valenciennes, France in 1590 and died in New Amsterdam. There was also family migration to and from The Netherlands. This was over 250 years before the birth of Thomas Edison in Ohio.

Thomas Edison's grandfather, Samuel Ogden Edison, married Nancy Stimson in 1792 in Nova Scotia. A child, Samuel Ogden Edison Jr. was born in Nova Scotia in 1804. S.O.E. Jr., married Nancy Elliot of Acquackanock, New York in Vienna, Ontario, Canada in 1828. She was the descendent of the prominent Elliot family of New England, the daughter of a minister and had been trained as a schoolteacher. Nancy Elliot's grandfather, Captain Ebenezer Elliott, was a distinguished officer on the American side of the revolution, so therefore, T.A.E. was a descendant of grandparents supporting opposite sides in that conflict. The couple continued to live in Vienna, Ontario, where four children were born. However, Samuel Edison Jr., T.A.E.'s father, fled Canada after participating in the failed Mackenzie revolt in Ontario in 1837. Three more children were born in Ohio. Thomas Alva Edison was the seventh and last child born to Samuel Edison, Jr. and Nancy Elliot Edison

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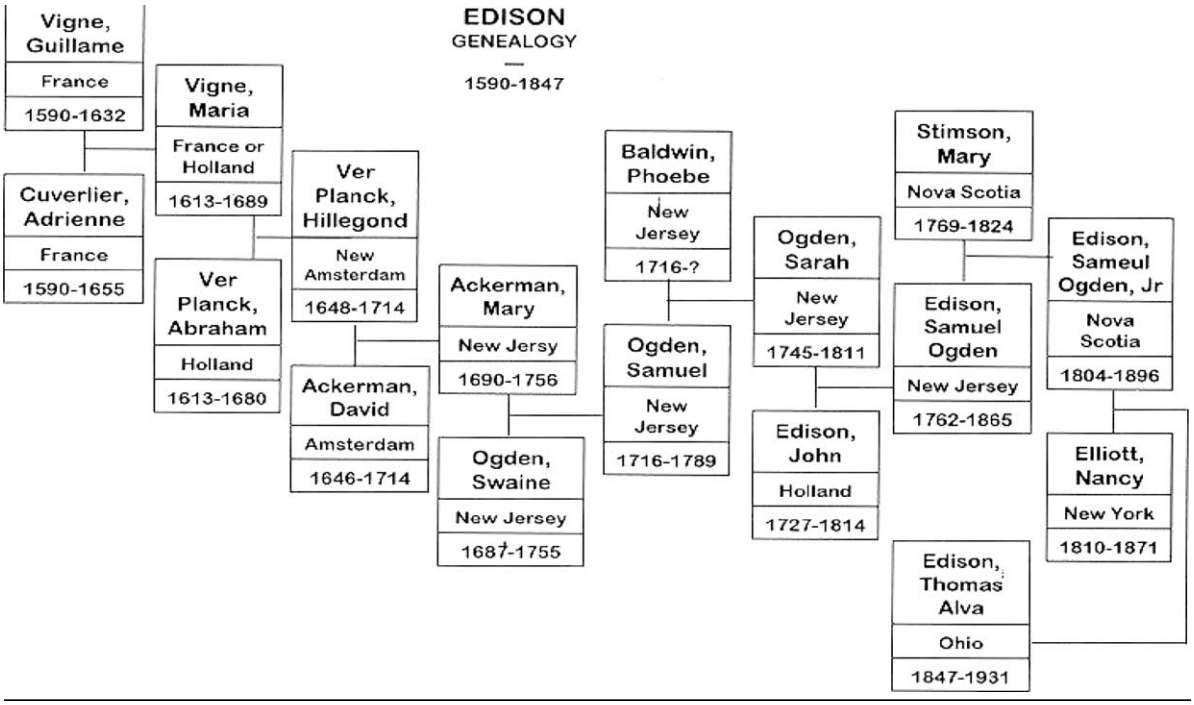
Table 1
Edison's ancestors



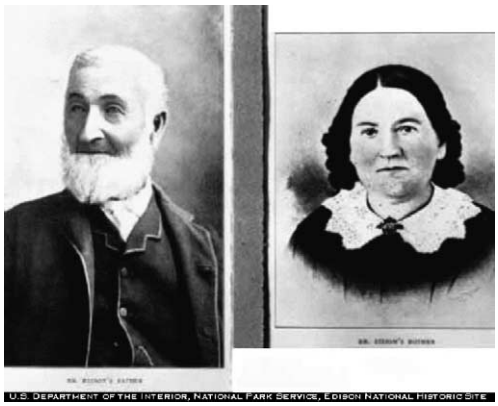


Fig. 1. Edison's parents.

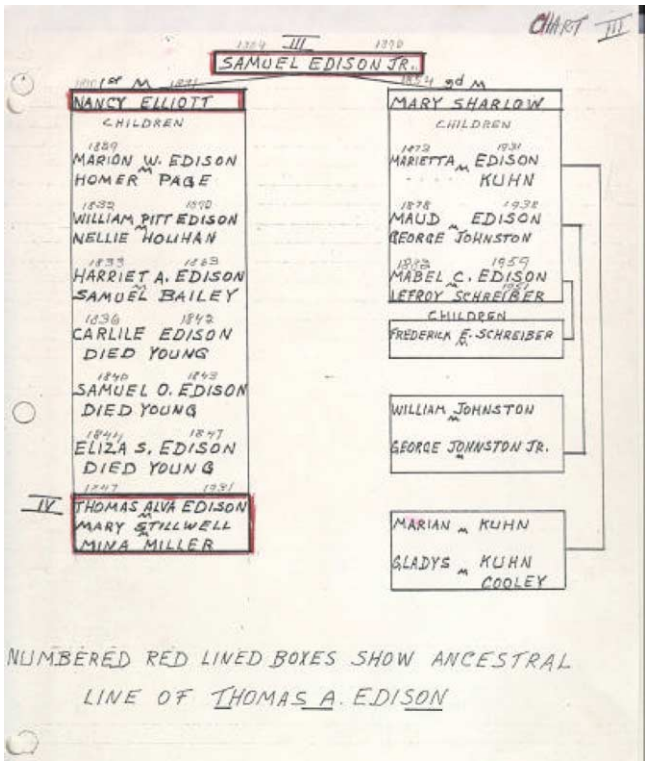
(Fig. 1). However, only four of the seven children lived beyond the age of 6.

2. Thomas A. Edison—boyhood and early career

As shown in the family tree, Table 2, T.A.E. was born in 1847 in Milan, Ohio. He was taught to read at a very early age by his mother and throughout his life was an avid reader. The family moved to Port Huron, Michigan, a shipping town, when T.A.E. was 7 years old.

He had many childhood illnesses and his formal education was delayed. When he was enrolled in a regular school

Table 2
Edison's siblings



at the age of 8, his intense curiosity made him incompatible with the educational methods used at the time and he quickly became bored and rambunctious and was considered a poor student. His formal education ended after 3 months. His mother decided to teach him herself. Her methodology included reading world history and classics. By the time he was 10, he was a rapid reader and included science in his interests. He set up a laboratory in his bedroom, using chemicals purchased at the local pharmacy, scraps of metal he found, and homemade electrical batteries.

T.A.E., known as " little Al" was almost a generation younger than his surviving siblings; Marion, William Pitt, and Harriet Ann were respectively 18, 16, and 14 years older.

It is of interest that William Pitt was named after the English Politician. His father encouraged him to read many of the books that the family owned and rewarded him with a 10 ¢ reward when he finished reading a book. Edison was influenced by Paine's "Age of Reason", which encouraged him to be a free thinker.

Edison's fascination with both telegraphy and chemistry shaped his entire career. He began working at 13, selling newspapers and candy on trains out of Port Huron. This brought him into contact with telegraph operators at train stations (Fig. 2). Operators let him try out their instruments and at 15, he became good enough to hold a job as a railroad telegraph operator. Whenever a lull occurred, the operators would send each other a joke or a story. It was the Internet of its days. As his proficiency improved, Edison took telegrapher jobs around the country. His inventive skills developed as a telegraph operator (Fig. 3) and he eventually quit to develop his ideas for faster and more accurate equipment. In Edison's days, all telegrams were sent and received manually. The essentials were a key (switch) and an electromagnet (sounder) at each end, in series with a wire and a battery. Originally, primary batteries were used entirely as the source of electricity. The telegraph operators had the demanding and time-consuming task of keeping the batteries in good working condition.

Fig. 2. Edison as a boy.

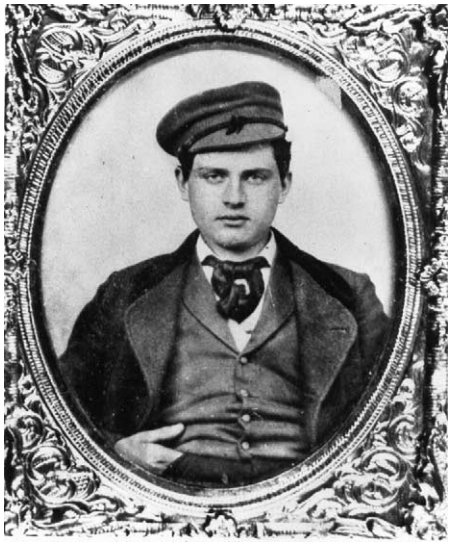


Fig. 3. As a telegrapher.

The Grove Battery and the Bunsen version were the chemistries utilized in early telegraphy. In these systems, zinc in dilute sulfuric acid was separated by a porous pot from a strong nitric acid solution.

In the Grove version, a platinum cathode was used, in the Bunsen version a carbon cathode. The oxides of nitrogen were liberated in the reaction caused the battery room of a typical telegraph station to be filled with noxious fumes. The alternative battery systems, zinc (or copper)–silver–sulfuric acid liberated hydrogen, which could result in fires or explosions.

An environmentally preferable system was made when the nitric acid was replaced by a solution of potassium dichromate in sulfuric acid. The dichromate did not harm the zinc electrode and the cell could operate with a single electrolyte without a diaphragm.

This was the system used by Edison in his early work on the electric light.

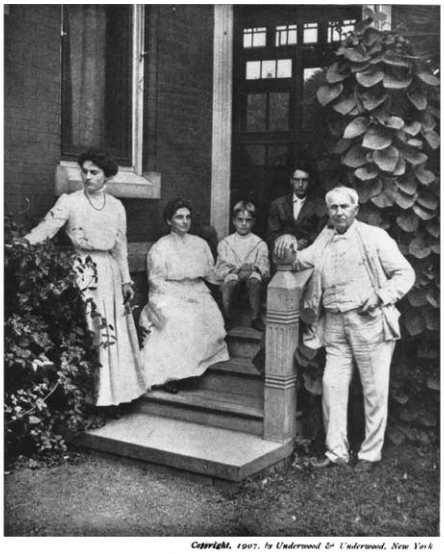
The chemical reaction is:

$$3Zn + 7H_2SO_4 + K_2Cr_2O_7 = 3ZnSO_4 + K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O$$

3. Thomas A. Edison—marriages and descendants

Thomas Edison married twice. First, to a local girl from Newark, New Jersey, Mary Stillwell. After her very early death at the age of 29, he was left to raise three young children. He subsequently married again (when he was 39) to Mina Miller, a considerably younger woman. At the age of 21, she became a stepmother to Mary's three children. It was not an easy task as she was less than 10 years older than her stepdaughter Marion.

Fig. 4. Mary Edison.



THOMAS A. EDISON AND HIS FAMILY

Fig. 5. Edison and family at Glenmont.

3.1. Mary Stillwell (1855–1884)

Mary Stillwell was a local New Jersey girl who worked at the News Reporting Telegraph Company, an Edison subsidiary, in Newark. Edison noticed the 16-year-old punching perforations into telegraph tape. She married the 24-year-old inventor on Christmas day in 1871 (Fig. 4). An apocryphal story is that Edison returned to his laboratory after the ceremony to work on his ticker tape project. Biographers have reported that Mary was beloved by the workers at Menlo Park. They were especially proud of her continuous grace after rising from their own rank. Mary died at the age of 29 after giving birth to three children.

3.2. Mina Miller (1865–1947)

Mina Miller, the 7th of 11 children, was herself the daughter of a millionaire inventor. She was a graduate of Akron High School and a ladies seminary in Boston. She married T.A.E. in 1886 at the age of 21. She gave birth to three children (Fig. 5), and her oldest daughter Madeleine is the only child of T.A.E. to have descendants.

After T.A.E.'s death, Mina Miller remarried in 1935 to Edward Hughes, a childhood friend. However, she continued to live in the Edison home, 'Glenmont'. When Hughes died in 1940, she once again adopted the name of Edison.

4. Descendants of Thomas A. Edison

Although several of the six children of Thomas Edison had distinguished careers, only one, his daughter Madeleine, produced a succeeding generation of offspring. These descendants are shown in Table 3.

4.1. Comments on Table 3

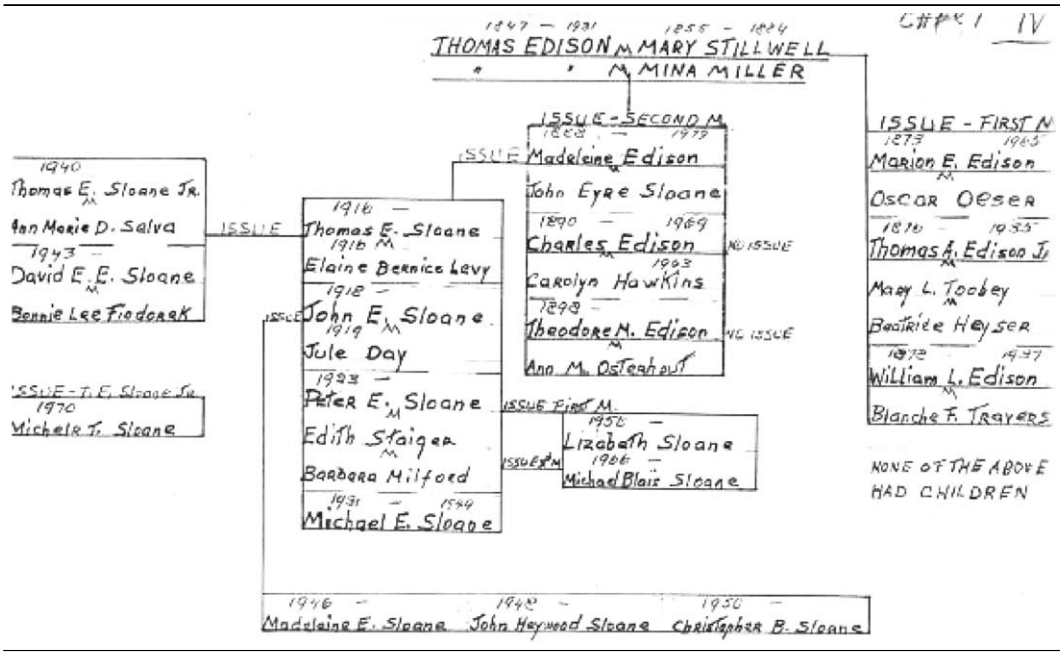
Charles Edison became president of Thomas A. Edison Inc. in 1927 and governor of the state of New Jersey in 1940. He also served in the cabinet of President Franklin Roosevelt in the mid-1930s. Theodore earned a Physics degree from MIT and had his own research company in Orange, NJ. He received over 80 patents. His wife had also attended MIT.

5. Technical overviews and motivations

When Edison was 21, while living in Boston, his first patent (US Patent 90,646), covering an electrographic vote recorder, was issued. A model was exhibited before congressional and state legislatures, but it was turned down on the basis that it would 'interfere with filibusturing' [1]. He also developed his ideas for a duplex telegraph and carried chemical experiments including a modification of Nobel's work on taming nitroglycerine. However, a sample stored behind a stove exploded and Edison hastily discarded the remainder of the trinitrate. His most successful Boston invention was an improved stock ticker (Fig. 6).

Edison left for New York, to arrange for a field test for a duplex telegraph, but the test failed because of a procedure misunderstanding with the remote site. He was befriended by Franklin Pope, chief engineer for the Gold Indicator Company, which rendered ticker service on gold prices to stockbrokers using equipment developed by Dr. S.S. Laws. One day, T.A.E. was able to repair a major equipment outage and Edison was hired as Pope's assistant. When Pope resigned in 1869 to become a consulting electrical engineer, Edison took over his position. When the indicator company

Table 3
Edison's descendants



was bought by Gold and Stock, Edison briefly joined Pope in his consulting venture.

Gold and Stock engaged Edison to improve their equipment, which he accomplished in about 3 weeks. He received US$ 40,000 and an order for 1200 of the improved universal stock tickers which he had developed.

In 1870, Edison (at 23), set up a factory in Newark, New Jersey which soon employed over 50 people (Fig. 7). Edison spent about 5 years in Newark as a developer and manufacturer of diverse products, mostly for stock tickers, automatic telegraphs, and related instruments.

He considered his compensation from the business associates inadequate and he gave up manufacturing operations in 1875, and set up independent operations in Menlo Park, New Jersey the next year. This experience was common to many earlier inventors, such as Charles Goodyear, Samuel Morse, and Alexander Bell. In 1873, Edison traveled to England to sell his inventions to the British Post Office. This trip renewed his interest in chemistry and electrochemistry (Figs. 8 and 9). He studied and admired the works of Michael Faraday for his knowledge of electrochemical science and technology.

In 1876, Edison was issued a patent on his electric pen (Fig. 10), the first business product to utilize an electric motor for power. The facility at Menlo Park was likely the first industrial research laboratory in the world (Fig. 11). By the

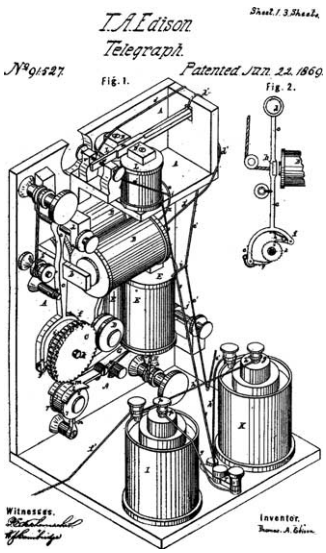


Fig. 6. Boston ticker patent.

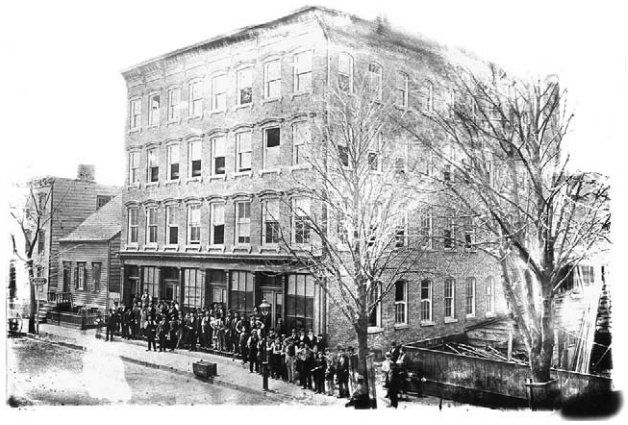


Fig. 7. Newark telegraph works.

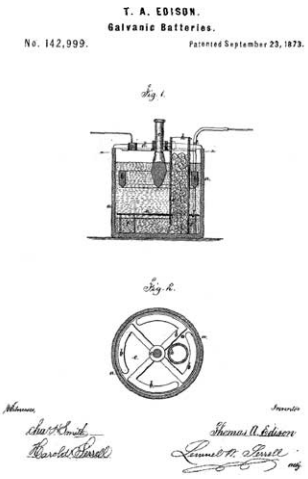

T. A. EDISON.
Galvanic Batteries.
No. 142,999. Patented September 23, 1873.

Fig. 8. First battery patent, 1873.

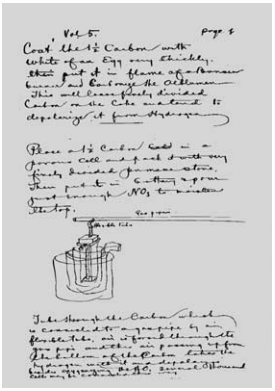


Fig. 9. Carbon electrode fuel cell, 1875.

winter of 1879, about 30 people were employed, including the physicist Francis Upton, a graduate of Princeton University who had also studied with Hermann von Helmholtz in Germany. Many well-known devices were developed at Menlo Park including the electric light. In early experiments, primary cells were used as a source of current. Later, dynamos, supplied by William Wallace, were used. Subsequently, Edison developed a much improved dynamo of his own. Edison suggested that the electric generators be called Faradic machines to honor Michael Faraday, but this name did not catch on. In 1882 and 1883, patents were issued to Edison dealing with 'equalizing electric force in a system' and 'developing a 3-wire system to enable higher voltage in feeder lines'. At nearly the same time, the latter development was conceived independently by Dr. John Hopkinson of England and Dr. Werner Siemens of Germany. Other activities during the Menlo Park years related to ore mining, telephone transmitters, the phonograph, and an electric railway.

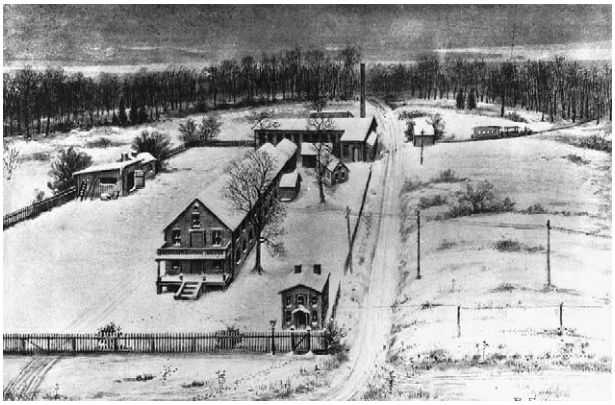


Fig. 11. Menlow Park complex.

The Menlo Park facility was closed in 1882 and Edison relocated his laboratory to New York City for 5 years before opening his last laboratory in West Orange, New Jersey in 1887 (Fig. 12) near his home, 'Glenmont' in Llewellyn Park, New Jersey.

He needed money to keep his invention factory going, so he offered to do research and development for other companies.

In addition, many of his devices required batteries for their operation. Thus, Edison spent considerable time and energy perfecting reliable and consumer friendly primary cells as part of marketing systems. Such devices included 'the elec-

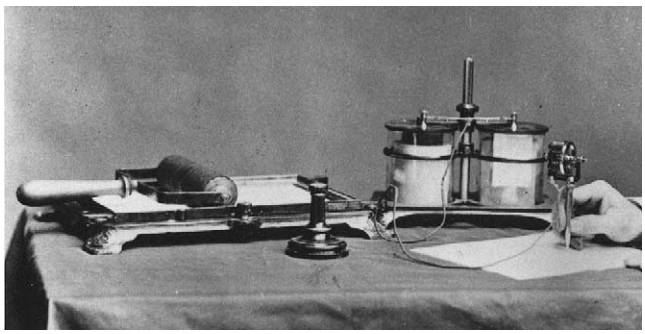


Fig. 10. Electric pen and battery.

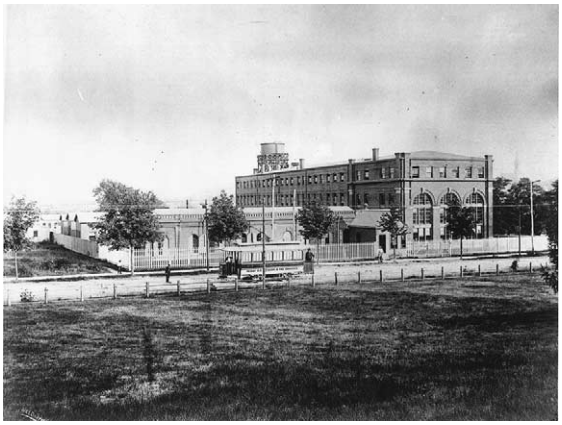


Fig. 12. West Orange Laboratory complex.

Fig. 13. With phonograph and primary battery.

tric pen' (Fig. 10) and 'a medical stimulator'. In 1889, the Edison–Lalande battery was used for electric phonographs and other purposes (Figs. 13 and 14).

Experimental work on storage batteries began in the summer of 1899 and the Edison Storage Battery Company was organized in 1901. His motivation was Electric Vehicles. Earlier in 1882–1883, Edison had experimented with storage batteries for electric lighting (Figs. 15–17). In 1902, he successfully conducted road tests of electric vehicles equipped with his batteries (Fig. 18), as illustrated. Production of the "E" type nickel–iron alkaline storage battery started in 1903. In 1904, he suspended production because of can leaks and capacity losses on cycling. A completely new design, the "A" type, in which nickel flake replaced graphite powder and the positive active material was encapsulated in tubes, rather than flat pockets, was introduced in 1909 (Fig. 19). In 1910, a two electric vehicle tour started from New York and ended with a climb of Mt. Washington in New Hampshire. Design and production of improved batteries continued (Fig. 20) until the 1960s when the product line was purchased by the Electric Storage Battery Company from the McGraw–Edison Company, and the production facility moved to South Carolina.

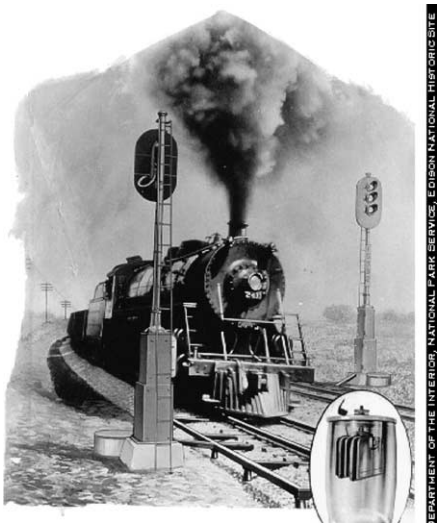


Fig. 14. Primary cell for railroad.

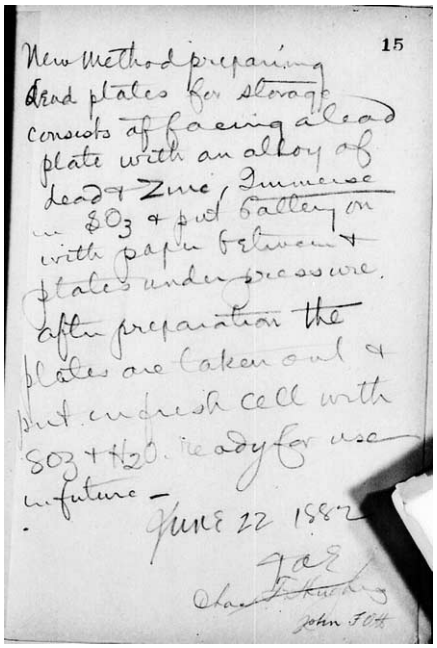


Fig. 15. Lead storage battery notes, 1882.

Other developments in this period related to motion pictures, pharmaceutical iron, phonographs and recording devices, and botanic research. He experimented with X-rays, molded houses of concrete, and radios. He was able to find new applications for materials he developed, e.g. a paraffin coated paper intended for the perforated tape for the automatic telegraph was successfully used as a candy wrapper. His 'Black Maria' motion picture studio became operational in1893, and his famous film, "The Great Train Robbery" was made in 1903.

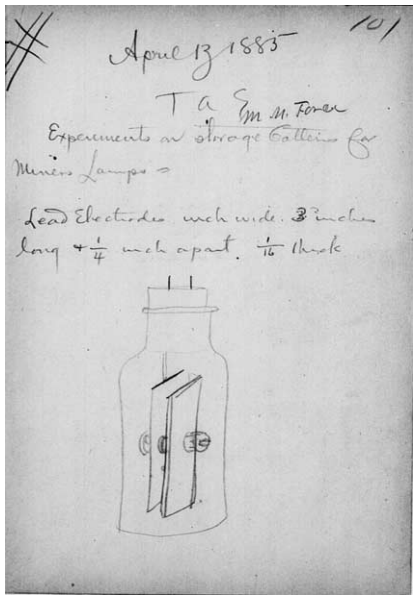


Fig. 16. Storage battery for miner's lamp, 1885.

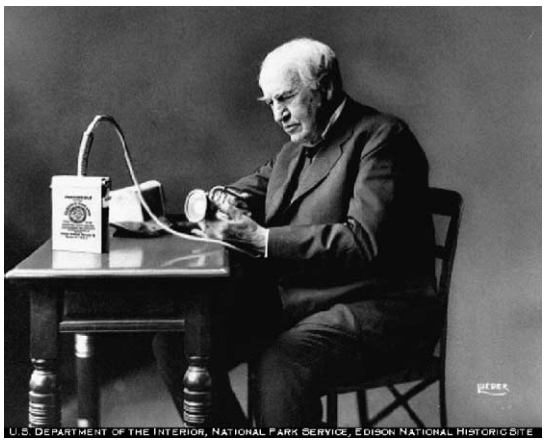


Fig. 17. With a storage battery for a miner's lamp.

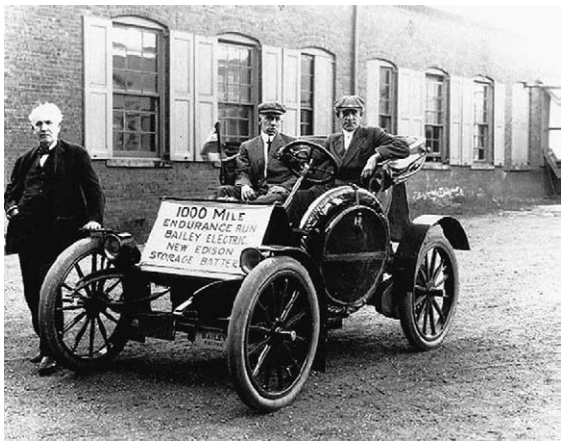


Fig. 18. Endurance test for storage battery.

What is common to all the activities was a relentless drive to learn from mistakes, and to develop materials and products that met the needs of a perceived market. What is not commonly known is that Edison was well versed in the activities of scientists in the world and did not work in isolation. Included in his contacts was Marie Curie.

6. Societal activities and recognitions

In his lifetime, Thomas Edison received many awards and recognitions from technical societies, universities, and governments.

The first academic institution to recognize his scientific achievements was Rutgers College of New Brunswick, New Jersey, which awarded him a Doctorate (Hon.) of Philosophy in 1879 (Fig. 21), when Edison was 32 years old and living in nearby Menlo Park. This was subsequently followed by degrees from other colleges, including Princeton University.

He was a founding member of the American Institute of Electrical Engineers and was elected a vice-president in 1884.

He joined the Electrochemical Society (originally the American Electrochemical Society) in 1903, shortly after it's founding. The New York Section hosted a meeting in September 1907 and Edison arranged an excursion for 140 members to his laboratory (Fig. 22).

In 1909, he received a gold medal from the Royal Academy of Sciences in Sweden for his inventions in connection with the phonograph and the incandescent light. In 1927, he was recognized by the National Academy of Science and in 1928, he was made an Honorary Member of the Electrochemical Society.

Edison was chairman and organized a scientific advisory panel for the US Navy in 1915 (Fig. 23). Included in the panel photo are: Frank J. Sprague, Leo H. Baekeland, M.R. Hutchison, T.A. Edison, Josephus Daniels (Secretary of the Navy), and Franklin D. Roosevelt (Assistant Secretary of the Navy). This panel led to the creation of the Naval Research Laboratory, whose activities continue to this day.

7. Origin and status of Edison's companies

Edison's strategies, business organizations, and management styles changed over the years. In a 60-year-period starting in 1870, he was involved in the affairs of one or more

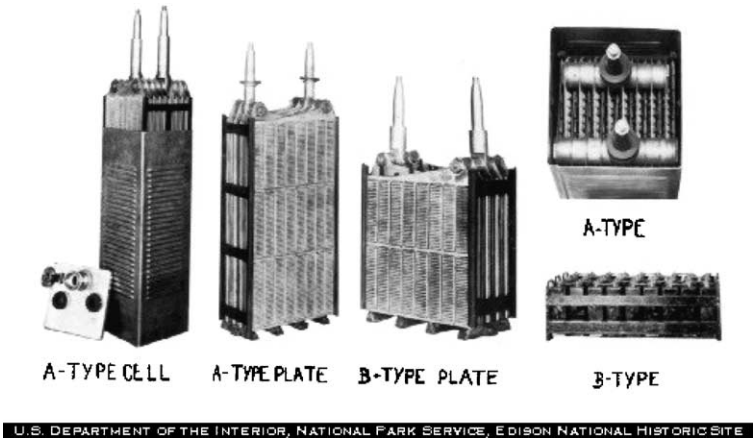
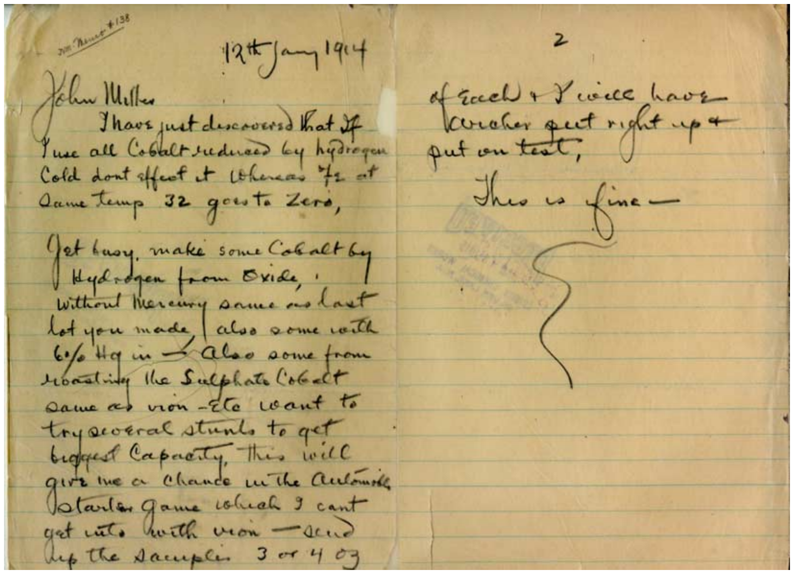


Fig. 19. Storage battery cells.



12th Jany 1914

John Miller

I have just discovered that If I use all Cobalt reduced by hydrogen Cold dont affect it whereas 72 at same temp 32 goes to Zero,

Get busy. make some Cobalt by Hydrogen from Oxide, without Mercury same as last lot you made / also some with 6% Hg in — also some from roasting the Sulphate Cobalt same as iron - etc want to try several stunts to get biggest Capacity, this will give me a chance in the Automobile starter game which I cant get into with iron — send up the samples 3 or 4 oz

2

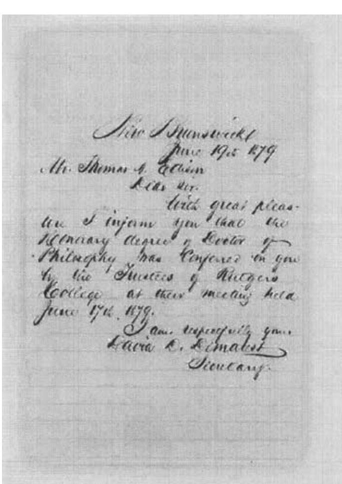
of each & I will have Archer put right up & put on test,

This is fine —

Fig. 20. Letter from Edison to Miller, 12 January 1914, concerning improved batteries.

commercial activities he created from his inventions; including telephone and telegraph, lighting and power, sound recording, motion pictures, ore milling, Portland cement, primary and storage batteries, and rubber.

A number of dominant worldwide companies evolved, mainly through mergers. In 1892, the Edison General Electric Company was merged with the Thomson–Houston Electric Company to form The General Electric Company. A later photograph shows Edison in a discussion with Charles Steinmetz. His German licensee for his storage battery technology in the 1904 was the Deutsche Edison Akkumulatoren Gesellschaft (now Varta) and Edison was nominally a director. Among Edison's European activities was the creation of the Milan Electric Company (later called Montecantini–Edison) in 1882, which provided the electricity generation for the city.



New Brunswick
June 19, 1879
Mr. Thomas A. Edison
Dear Sir,
With great pleasure I inform you that the Honorary Degree of Doctor of Philosophy was conferred on you by the Trustees of Rutgers College at their meeting held June 17th 1879.
I am respectfully yours
David D. Demalist
Secretary

Fig. 21. Doctorate from Rutgers College.

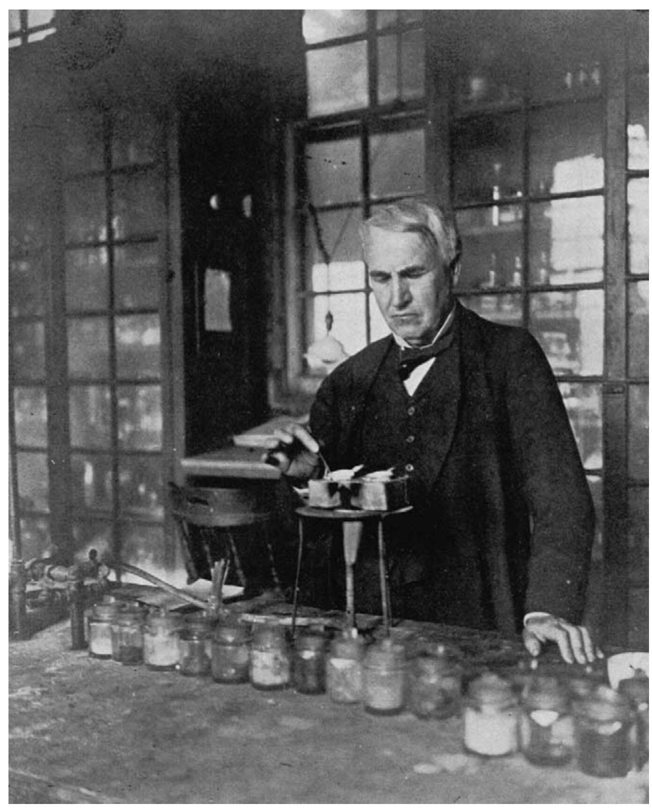


Fig. 22. Edison in his chemical laboratory.

8. Quotations and philosophy

The motivations and philosophy of Edison can be understood by a review of his quotations. Samples of these are shown below:

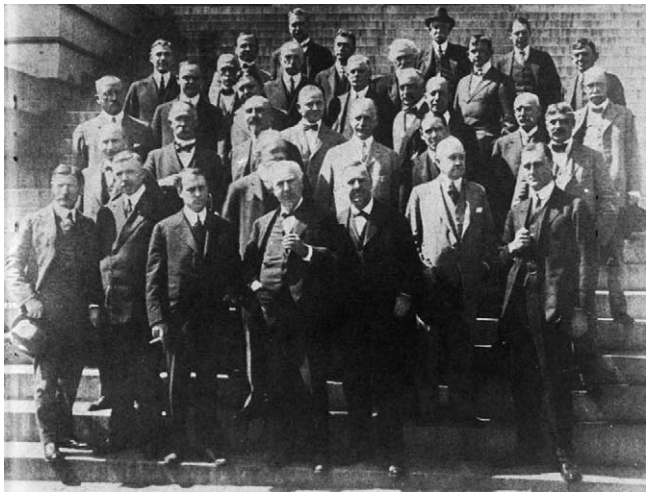


Fig. 23. The Naval Consulting Board.

"I never perfected an invention that I did not think about in terms of the service it might give others... I want to save and advance human life, not destroy it... I am proud of the fact that I have never invented weapons to kill...The dove is my emblem...

I find out what the world needs, then I proceed to invent... My main purpose in life is simply to make money so that I can afford to go on creating more inventions...

A good idea is never lost. Even though its originator or possessor may die, it will someday be reborn in the mind of another...

Genius is one percent inspiration and ninety-nine percent perspiration. As a result, a genius is often a talented person who has simply done all of his homework..."

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[3] P. Israel, Edison, The Edison Papers Project, Rutgers University.
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