Editor's Introduction

Great Lives from History: Inventors and Inventions concentrates on those whose inventions have raised the human standard of living in demonstrable ways. Emphasis is placed not only on the inventors' biographies but also on the stories behind their inventions: the forces and circumstances motivating them and the impact that their in-ventive genius and resulting inventions have had on humankind. Inventors were chosen based on whether their inventions have had an impact on the world in one or more of the following ways:

- by changing the way people work and play, contributing to the improvement of life;
- by altering culture and society for the better;
- by saving lives and extending longevity;
- by helping to eliminate boring, hard work;
- by teaching important principles and creativity;
- by advancing science and technology; and
- by standing the test of time, being used by many people over generations.

Inventions range from tangible physical devices to mechanical and chemical processes and beyond. Here you will find entries on some of the people who changed the world in major ways for all time (Thomas Alva Edison, Alexander Graham Bell, and Steve Jobs) and others who made it more delicious, better looking, or just more fun (Melitta Bentz, Madame C.J. Walker, and Lonnie Johnson). Each essay sheds light on the inventive process, the hard work, the numerous dead ends, and the successes that the inventors encountered.

Inventors and their inventions provide a window on history that parallels the story of human progress and corresponds to the cultural revolutions that have impacted the world. Although inventions are not distributed evenly over time, they have for the most part developed systematically as dictated by human needs or desires for improvement. Early inventions centered around the necessities of life, particularly farming, housing, and clothing.

After the Middle Ages, the emphasis shifted to literacy and numerical skills. Johannes Gutenberg's invention of the metal movable-type printing press was the foundation for the "learning revolution," as books became cheap and were made available to the general public. During the 1700s, the focus on inventions moved to devices and processes that increased the ease and efficiency with which human tasks could be accomplished. The invention of the steam engine fueled the Industrial Revolution.

In the latter part of the nineteenth century, electricity was harnessed for practical usage. Invention of devices that could use electricity in the everyday world sparked the "communication revolution." In the twentieth century, more and more inventions were made using a systematic scientific approach in industrial research laboratories, research universities, and government laboratories. Inventions that include microelectronics, computers, telecommunications, robotics, and synthetic materials unleashed the "digital revolution" that led to the emergence of the World Wide Web, as inventors and their inventions concentrated increasingly on global connectedness. And in the twenty-first century, as advances in artificial intelligence, biomedicine, and other cutting-edge fields come at a breakneck speed, there are truly no limits and anything is possible. Included in *Great Lives from History: Inventors and Inventions* are the important inventors whose inventions span a diverse range of disciplines and who helped to spearhead and develop the learning, industrial, communication, and digital revolutions that dramatically changed and shaped the world.

Great Lives from History: Inventors and Inventions includes inventors from all time periods of human history, ancient to modern, and from all parts of the world, including many from thinly represented areas of the world. During ancient times, inventive prominence was centered in China, Egypt, and the Euphrates River Valley, then moved to Greece and Rome, then to the Islamic world, later to Europe, and finally to America. The oldest known wheel can be traced to Mesopotamia and is believed to date back more than 5,000 years ago. The invention of the papermaking process is attributed to Cai Lun in

China around 105 CE. Roger Bacon, an English medieval inventor, was one of the first Europeans to formulate the scientific method based on experimentation around 1250. Italian Leonardo da Vinci developed designs for the first flying machines in 1492. The first refracting telescope was assembled by Hans Lippershey in Holland in 1608.

The Industrial Revolution and the modern world emerged in large part as a result of post-Renaissance engineering, such as the invention of the first steam engine by Englishman Thomas Savery, around 1698. The development of steam power eventually revolutionized transportation, trade, and manufacturing, which in turn drove markets for other technologies. In 1793 Eli Whitney's cotton gin transformed the American South both economically and socially, making the United States the world's major supplier of cotton by the middle of the nineteenth century, which served to establish a growing but shameful foundation for slavery. A number of European and American inventors were involved with the invention and improvement of the sewing machine between 1790 and 1840. In 1857, Sir Henry Bessemer patented the process for making steel in England. The telephone was patented in 1876 in the United States by Alexander Graham Bell. As it is known today, the electric light was invented simultaneously in 1879 by Thomas Alva Edison in the United States and Joseph Wilson Swan in England.

One of the most impactful inventions of the past century and a half was the automobile. The automobile that was being produced by around 1900 evolved from a series of automotive inventions made by Nicolas-Joseph Cugnot and Étienne Lenoir in France, Nikolaus August Otto, Gottlieb Daimler, and Carl Benz in Germany, and Ransom Eli Olds, Henry Ford, and others in the United States. Like so many inventions before it, the automobile transformed the world not only economically but also socially. Home and work became geographically divided, teenagers took to the road and achieved a sometimes-ill-advised independence, and Ford's assembly line transformed labor.

The great economic and social transformations of the twentieth century were grounded in the development of electricity in the nineteenth century. After innovators like Arthur James Arnot and Edison set the stage for the electric grid, night lighting extended productivity and telecommunications boomed. Well before Bell's invention of the telephone, English mathematician Charles Babbage laid the groundwork for the computer age by inventing the "difference machine" in the early nineteenth century, spending his life and fortune to develop this prototype of the digital computer. In 1946, the first fully electronic digital computer was invented by John Pres-per Eckert and John William Mauchly in the United States. With the invention of the World Wide Web protocol and language by Englishman Timothy Berners-Lee in 1990, the internet emerged and eventually evolved into the dominant communications medium throughout the world.

In numerous instances, the names of the originators of many inventions are hard to find or have unfortunately been lost over time. The inventors of the first wheel, the first plow, the first compass, or the first smelting furnace, as well as the inventors of many other very important early inventions, remain unknown. Some inventions have involved the interaction and contributions of many people during their formulation, development, improvement, perfection, and implementation. Some have involved coinventors. In several such cases, the leading inventor is discussed in detail in this work, while the coinventor is discussed in the entry dealing with the main inventor. In some instances, there has been overlap of ideas and rival claims for the same invention. For example, Lenoir, Benz, Daimler, and Otto all have legitimate claims associated with the invention of the automobile that is powered by an internal combustion engine. Likewise, Ernst Alexanderson, Philo Farnsworth, and Vladimir Zworykin all have claims related to the invention of the television. These stories are captured and the claims sorted out as well as possible in *Great Lives from History: Inventors and Inventions*.

Many of the inventors in these pages have been Nobel Prize winners. Several, including Alexander Graham Bell, George Washington Carver, Thomas Alva Edison, Nikola Tesla, and Alfred Nobel, have also been inducted into the National Inventors Hall of Fame, a nonprofit organization in the United

States dedicated to recognizing, honoring, and encouraging invention and creativity. Special effort has been made to include female inventors, inventors from groups traditionally underrepresented in science, technology, engineering, and mathematics (STEM), and inventors who are often overlooked and almost never found in history books. Many of these inventors overcame great odds that were associated with discrimination and poverty to make important contributions through their remarkable creative abilities.

It is important to note, however, that vision and inventiveness, while admirable, do not indicate that a person is deserving of unquestioning admiration: when an inventor included here has held views or committed acts deserving of censure (such as Eugène Schueller's cooperation with the Nazis), no attempt has been made to obfuscate those facts.

Another important note: some inventors made useful inventions but otherwise left little trace in history. Thousands of inventors—too many to cover in depth within these four volumes—have made a broad range of useful and sometimes vital contributions to the progress of humankind. An appendix to this work, a "Biographical Directory of Inventors," is therefore included in Volume 4. It offers not only a summation of the 457 inventors covered in the essays but hundreds of others as well.

Great Lives from History: Inventors and Inventions is written to engage high school students and to be wide-ranging, relevant, and interesting enough to appeal to undergraduates and to anyone fascinated by the history of technology—as well as to anyone curious about the stories behind the objects we use in our everyday lives. It is a tribute to human ingenuity and inventiveness that engenders an understanding of the conditions that can lead to useful inventions, as well as providing the necessary guidelines and role models to assist and inspire future inventors. A central theme included in every essay throughout this work is a concentration on the process of invention by means of a sidebar that highlights one of the inventor's most important inventions. This process involves the fermentation of ideas, attempts to implement the ideas, and the ultimate culmination of ideas that led to practical inventions and applications. The editors hope that the personal stories of the world's greatest inventors contained in this work will generate exciting and inspiring insights into the inventive process. Annotated bibliographic entries for each essay in a "Further Reading" section, as well as cross-references to other inventors of interest, will help readers to further their research interests and their own inventive pursuits.

Thanks are due to the many contributing authors for their diligence, expertise, literary skill, and cooperation in writing the essays for these four volumes. Thanks are also owed to our readers, whom we will leave with one piece of advice from Albert Einstein: "The important thing is not to stop questioning. Curiosity has its own reason for existing." If we have done our jobs adequately, the vision, creativity, and persistence of the inventors in these pages will inspire you to even greater heights of curiosity.

—The Editors

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A

Abbas ibn Firnas

Spanish Arabic engineer

A Renaissance figure at the height of the Islamic golden age in Moorish Spain, ibn Firnas is most remembered for his revolutionary design of a glider, the first manually manipulated flying machine, and for executing the first recorded controlled flight.

Born: 810 c.e.; Izn-Rand Onda, al-Andalus (now Ronda, Andalucia, Spain)
Died: 887 c.e.; Córdoba, Spain
Also known as: Abbas Qasim ibn Firnas (full name); Armen Firman
Primary fields: Aeronautics and aerospace technology; astronomy; mathematics
Primary invention: Glider

EARLY LIFE

That anything is known of Abbas ibn Firnas (AH-bahs IHB-n FUR-nahz) is remarkable. Much in the archival records and libraries of the Islamic empire that evolved in the Iberian Peninsula across nearly seven centuries was systematically destroyed in the fifteenth century as part of the fierce religious wars that marked the closing century of the Muslim presence in Europe. Ibn Firnas was born in 810 in Izn-Rand Onda in al-Andalus, just over a century after nomadic Muslim invaders, specifically the Umayyad (modern-day Sunni Muslims), had begun to occupy what is contemporary Spain and Portugal after a fierce seven-year war. In the decades before ibn Firnas was born, tensions between East and West had largely severed the Muslim empire into two de facto independent cultural centers—one based far to the east around Baghdad, the other around the courts of Córdoba. With its military occupation under control by mid-century, the caliphate of Córdoba, under Abd al-Rahman II (who assumed the throne in 852), began an ambitious agenda that envisioned establishing the court as the leading cultural and scientific center of the civilized world, rivaling Baghdad, by attracting with huge sums of money the best Muslim minds and undertaking an ambitious program of public building and funding scientific and artistic endeavors.

It was to that court that ibn Firnas journeyed in his late thirties, most likely in his capacity as an accomplished musician and noted poet. It is conjecture, of course, but given the wide-ranging projects that ibn Firnas undertook upon arriving at the court and the scope of his scientific endeavors (he was proficient in chemistry, physics, astronomy, mathematics, and geology), his early education in the sciences must have been considerable or he was undoubtedly the most accomplished autodidact before Leonardo da Vinci.

LIFE'S WORK

Public records of ibn Firnas's achievements after establishing his presence at the court in Córdoba are

20th century statue of Ibn Firnas outside Baghdad International Airport. Photo by Zaltmatchbtw, via Wikimedia Commons.

far more reliable. In addition to his study of flight, ibn Firnas distinguished himself in the realms of astronomy and geology. In an era when clocks were used not to measure the hour so much as to measure astronomical movements and particularly the Sun's position, ibn Firnas designed a kind of grand water clock that drew on a steady stream of running water to create an accurate system of measuring the Sun's movement by relying on a waterwheel and chain drive.

Given the enormous geological riches of the Iberian Peninsula, specifically its crystal quartz reserves, the potential economic boom was frustrated because the Córdoba court had to rely on exporting the crystals, principally to Egypt, known at the time for its techniques of cutting crystals. Ibn Firnas devised a revolutionary system for cutting crystal that virtually eliminated the inconvenience and the expenses of exporting the rock. In addition, he experimented with ways to convert the abundant sand and stone of the region into crude optical glass.

Distracted by the often-elaborate theorizing about the workings of the planets and the movement of the stars, ibn Firnas devised a precursor to the modern planetarium, an elaborate hanging system of interlocked rings that displayed (with the help of a hand-turned crank) planetary motions with remarkably accurate scale (this nearly seven centuries before Nicolaus Copernicus). That device gave theoretical astronomers the opportunity to test early hypotheses about the relationship between orbit and planet size and the effects of stars on heavy planet motion. Later, ibn Firnas devised a similar surrounding experimental environment that re-created with apparently mesmerizing effect the meteorological phenomena of clouds, thunder, and lightning (through cleverly concealed devices) and gave audiences breathtaking images of stars.

It was flight, however, that drew ibn Firnas in his later years. Ibn Firnas witnessed an attempt at flight

The Glider

Because experimental notes and laboratory logs that might detail Abbas ibn Firnas's speculative process in designing his flight mechanism have never been recovered, contemporary aeronautic design engineers, interested in explicating how ibn Firnas achieved controlled flight for an extended period of time, begin with ibn Firnas's observation of a botched flight in 852. That flight device lacked any way for the pilot-rider to actually control the arc and trajectory of the flight and made inevitable a difficult and potentially life-threatening landing. Indeed, eyewitness accounts describe it as a breathtaking free fall rather than a flight. Ibn Firnas's glider, on the other hand, permitted him to change altitude and even bank and change the direction of his flight path.

Because eyewitness accounts describe ibn Firnas's device as "winglike," contemporary engineers assume that ibn Firnas studied the gliding flight of birds to design his glider. Given the extended period of his flight—nearly ten minutes—it is conjectured that his wing-style device, most likely strapped to his shoulders, must have been in the range of eight feet across, as wing length is crucial to achieving ascent. Generally, the wider the wing angle, the greater the lift. Ibn Firnas's device did not have a motor, nor did the wings flap. Thus, aeronautical engineers conclude that ibn Firnas essentially created not a flying machine but a glider. Some species of birds can glide for extended periods of time. That power comes not from the wings but from taking advantage of thermals—sharp, upward movements of air heated by the Sun as the day progresses. (Ibn Firnas took his flight late in the day.) Thermals rise off the Earth in layers that in turn save the birds tremendous amounts of energy and permit extended hovering. Birds actually float down on thermals. In this, ibn Firnas chose a high elevation and a valley slope to assist his gliding; such topography creates strong updrafts.

The problem came in ibn Firnas's landing. A glider must end its flight slowly. To land, a bird slows its wing beats and slowly lifts its wings at the shoulders even as gravity begins to pull it downward. It has to twist its tail to increase the surface area of the wing, which in turn generates more lift and slows down the landing like a brake, preventing the bird from dropping too fast. It is basically a controlled stall maneuver. Then the tail is spread open and lowered to execute a clean landing. A bird actually lands on its tail. Ibn Firnas's device had no tail apparatus, and thus his landing was quite difficult and indeed resulted in significant back injuries that prevented ibn Firnas from continuing his flight experiments. Accounts of his attempt, however, circulated throughout Europe centuries after his death, and his legendary experiment figured in later attempts at single-pilot glider flight conducted most prominently by Roger Bacon and Leonardo da Vinci.

Pasachoff, Naomi. *Alexander Graham Bell: Making Con*nections. New York: Oxford University Press, 1996. Concentrates more on his work as an educator and inventor than on his personal life. Illustrations.
Shulman, Seth. *The Telephone Gambit: Chasing Alexander Graham Bell's Secret*. New York: W. W. Norton, 2008. Examines the race to build the first telephone and uncovers potential bombshells. Provides evidence of Bell's stealing Elisha Gray's research.

See also: Alexander Bain; Georg von Békésy; Emile Berliner; Martin Cooper; Glenn H. Curtiss; Thomas Alva Edison; Elisha Gray; Hermann von Helmholtz; Joseph Henry; Heinrich Hertz; Peter Cooper Hewitt; David Edward Hughes; Miller Reese Hutchison; Bob Kahn; Lewis Howard Latimer; Guglielmo Marconi; Samuel F. B. Morse; John Augustus Roebling; Frank J. Sprague; Alessandro Volta; Eli Whitney.

Melitta Bentz

German inventor

Melitta Bentz is responsible for creating the world's first paper coffee filters, an idea she got after tiring of finding grounds in her morning coffee. The filters not only improved coffee's taste, but simplified its preparation and eliminated waste. The eponymous company she founded is still operated by her descendants.

Born: January 31, 1873; Dresden, Germany
Died: June 29, 1950; Porta Westfalica, West Germany
Also known as: Amalie Auguste Melitta Liebscher (birthname); Amalie Auguste Melitta Bentz (full married name)
Primary field: Consumer products
Primary invention: Paper coffee filters

EARLY LIFE

Amalie Auguste Melitta Liebscher was born on January 31, 1873, in Dresden, Germany, to Karl and Brigitte (Reinhardt) Liebscher. Her grandparents were the proprietors of a brewery, and her father was a publisher and bookseller. On May 10, 1899, she wed Johannes Emil Hugo Bentz. The son of a schoolteacher, he supported Melitta and their children—sons, Willy and Horst, and daughter, Herta—as the manager of a Dresden department store.

Bentz. Photo via Wikimedia Commons. [Public domain.]

As was usual in that era, Bentz spent her days as a homemaker, raising her children and managing the household tasks. While there may have been multiple frustrations inherent in that lifestyle, one in particular has been recorded in the annals of history: she began each day with a cup of coffee, and every morning she grew irritated by the presence of grounds in her cup, which not only affected the mouthfeel and taste of the brew but necessitated a frustrating process to clean the family's copper pot and cups.

LIFE'S WORK

Bentz knew there must be a way to make her coffee taste better and her mornings run smoother. She began tinkering with various methods. Porcelain percolators often resulted in burnt coffee—and still left grounds floating in her cup, and the fabric filters then available did little to mitigate the situation.

D

Jacques Daguerre

French physicist

Improving on the discoveries of Nicéphore Niépce and others, Daguerre perfected a photographic process that made possible the first permanent images produced by cameras.

Born: November 18, 1787; Cormeilles, near Paris, France
Died: July 10, 1851; Bry-sur-Marne, near Paris, France
Also known as: Louis-Jacques-Mandé Daguerre (full name)
Primary field: Photography
Primary invention: Daguerreotype

EARLY LIFE

Louis-Jacques-Mandé Daguerre (lwee zhahk mahn-day dah-gaihr) was the son of Louis Jacques Daguerre, an employee of the local magistrate's court in Cormeilles, and Anne Antoinette Hauterre. Shortly after the birth of a daughter, Marie Antoinette, in 1791, the family moved to Orléans, where the elder Louis worked as a clerk at the royal estates. Young Louis and his sister received little formal education; however, Louis demonstrated such a remarkable gift for drawing and sketching that he was soon apprenticed to an architect under whom he trained for three years as a draftsman.

Although Daguerre learned valuable rules of perspective and accuracy during his apprenticeship, he was determined to study art in Paris. He enjoyed drawing much more than architectural design, but his father opposed art as a career choice. In a compromise measure, Daguerre was apprenticed to a well-known Parisian stage designer, Ignace Eugéne Marie Degotti, in 1804. Working in Degotti's studio, Daguerre learned quickly and was given a major role designing several important productions.

Daguerre's irrepressible personality made him many friends in the artistic community. He enlivened parties where singing, dancing, and acrobatics were popular, sometimes even making dramatic entrances walking on his hands. He also performed in choreographed scenes in the Paris Opéra and executed tightrope acrobatics with great skill. Throughout his life, Daguerre benefited from an abundance of energy and endurance.

LIFE'S WORK

In 1807, Daguerre became an assistant to Pierre Prévost, a panorama painter, and in 1810 married Louise Georgina Smith, sister of a painter who later became Daguerre's colleague. The popularity of panoramas, immense paintings exhibited in circular

A daguerreotype of Daguerre c.?1844. Photo via Wikimedia Commons. [Public domain.]

Walt Disney

American animator, film producer, film director, businessman, and screenwriter

Disney wanted to entertain, not invent, but his expanding vision of entertainment required new technology. Disney began with simple, hands-on devices but ended as head of an innovative research facility designed to turn his visions into reality.

Born: December 5, 1901; Chicago, Illinois
Died: December 15, 1966; Burbank, California
Also known as: Walter Elias Disney (full name); Retlaw Yensid
Primary field: Entertainment
Primary invention: Audio-animatronics

EARLY LIFE

Walter Elias Disney (DIHZ-nee) was the youngest of four sons of Elias and Flora Call Disney, and had a younger sister. His father worked as a carpenter and contractor. In 1906, Elias moved the family from Chicago to a farm at Marceline, Missouri. For Walt, the farm and small town of five thousand people provided freedom and an idyllic vision of cohesive and caring community life that would influence many of his films and even the original Main Street of Disneyland. Although farming was backbreaking work for Elias and his two oldest sons, Walt was allowed to run free, learning a love for nature also evident in his films. He began drawing early and probably saw his first film in Marceline.

Elias was demanding and authoritarian. His two oldest sons fled, and, without them, Elias could not maintain the farm, which he sold in 1910. In 1911, the family moved to Kansas City, Missouri, where Walt's world was transformed, his freedom lost. Elias bought a paper route, paying some children to deliver the papers, but Walt and his brother Roy worked for free. At age nine, Walt rose before dawn, delivered papers, went to school, and delivered more papers after school, holding other jobs for spending money. This rigorous routine may have taught him his obsessive work habits, but it also created the desire for freedom and autonomy that made him resist later attempts to control his career or his studio. Walt was not a good student, but teachers encouraged his interest in drawing. When his family moved back to Chicago, Walt became a cartoonist for his high school paper and attended some art classes. Although underage, he dropped out of high school to join the Red Cross Ambulance Corps. After World War I, he returned to Kansas City.

LIFE'S WORK

Disney briefly worked for the Pesmen-Rubin Commercial Art Studio and the Kansas City Slide Company, while studying animation and unsuccessfully trying to establish his own studio. Bankrupt, he left for California, where he and his brother Roy formed Disney Brothers Studio (later Walt Disney Productions). There, Disney and Kansas City colleague Ub

Walt Disney, 1946. Photo via Wikimedia Commons. [Public domain.]