





WOMEN OF INVENTION

LIFE-CHANGING IDEAS BY REMARKABLE WOMEN








CHARLOTTE MONTAGUE



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CHARTWELL
BOOKS


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Key: Technology Science Engineering Medicine Transport & Communications

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INTRODUCTION

Machines, drugs, hair treatments, ice cream makers, aircraft, central heating systems, home security systems … women have invented things in a staggering variety of fields, often working in obscurity or with little chance of having their names attached to their discoveries, let alone gaining recognition or actually making any money from them. Who knows how many women inventors remain unacknowledged or unknown? For so long in the eighteenth and nineteenth centuries, the system would not even allow female ingenuity to be rewarded by the granting of a patent in a woman's name. Instead, the certificate was issued in the name of her husband or some other male.

Madam C.J. Walker's beauty and hair products made her one of the most successful African American business owners ever.

If the woman happened to be African American, she had no chance at all. Black female inventors had to resort to selling the rights to their creations to white men for negligible amounts of money. Often those men went on to profit greatly from the ingenuity of another person's mind. There was also the prospect, if a product was invented and marketed by a black woman, that racially prejudiced white women would be reluctant to purchase it. Madam C.J. Walker was an exception, and led the way for female African American entrepreneurs across America.

Those have not been the only difficulties for women inventors, however. Problems created by the gender politics of the eighteenth, nineteenth, and twentieth centuries can be added. If a woman was interested in a scientific career in the nineteenth or twentieth centuries, for instance, it was impossible on some occasions to be admitted by a university and even once there she would often be prohibited from attending lectures. It is shocking to learn of the reluctance on the part of some eminent scientists to allow women into their lecture theaters or laboratories.

In the workplace too, women inventors experienced startling difficulties until very recently. When Patsy Sherman, inventor of Scotchgard, was working at the huge multinational 3M in the early 1950s, women were banned from entering the textile mill where products were tested. So, even though Patsy had created the product that was being tested, she was not allowed to be present. She was left outside pacing nervously up and down awaiting the results.

In some ways World War II provided opportunities for many women in the scientific and technological fields. Men were going off to fight overseas, leaving gaps in the staffing of the workplace. Many women jumped at the chance to work in the scientific arena and many retained their jobs after the war, creating new drugs, new machines. At last, they began to change the place of women in society. Hedy Lamarr proved she was

more than just a pretty Hollywood film star when she patented a highly complex frequency-hopping communication system in 1942.

It remained tough, however, and there are several instances of women missing out on recognition for their contributions to advances in human knowledge. One of the most disappointing examples is that of the English scientist Rosalind Franklin, instrumental in the discovery of the structure of the DNA molecule but who was simply airbrushed out of the story as two men, Francis Crick and James Watson, took all the glory as well as the 1962 Nobel Prize in Physiology or Medicine.

Another woman who lost out was the Chinese-born American experimental physicist Chien-Shiung Wu who was not even named as a joint winner of the 1957 Nobel Prize in Physics although she had played a fundamental role in the work that won it for her colleagues, Professor Tsung-Dao Lee and Professor Chen-Ning Yang. Wu had worked on the Manhattan Project and in later years became known as "the First Lady of Physics."

Despite all of these problems, hindrances, prejudices, and disappointments, women have proved every bit as ingenious as their male counterparts and perhaps even more so, as they have had to work harder to gain any recognition at all. Some like Marie Curie have become world famous, others such as Frances Gabe, inventor of the self-cleaning house, have died in obscurity.

The women in this book come from all walks of life. Needless to say, there are examples of domestic, culinary, homeware, and fashion inventions by women, as those are the areas to which most women were restricted. By contrast there are aeronautical engineers such as Beatrice "Tilly" Shilling, the English woman whose solution during World War II to a problem with fighter aircraft engines helped the RAF win the Battle of Britain. Spectacularly talented women such as the French flier, sportswoman, and nurse, Marie Marvingt, have amazed us with their ingenuity, courage, and sheer determination. But then there are also entrepreneurs such as the Canadian-American Martha Matilda Harper, who came from nothing to establish an international empire of franchised hair salons. There are also women whose work has changed the world and saved countless lives, women like Virginia Apgar, creator of the Apgar score by which the health of newborn babies is measured and monitored.

As this book proves without a doubt, invention is far from a male preserve, and we should be endlessly grateful for the efforts of all the women assembled within these pages to be original and innovative, often with the odds totally stacked against them. You don't need to be a specific gender to be a great inventor, all you need according to Beulah Louise Henry is "time, space and freedom." Or as Patsy Sherman once said, "Girls should follow their dreams. They can do anything anybody else can do."

Maya Burhanpurkar is a science prodigy with a great future ahead of her.

RANDI ALTSCHUL

THE WORLD'S FIRST DISPOSABLE CELL PHONE INVENTION: THE PHONE-CARD-PHONE

Often we think of throwing our cell phones against the wall in frustration when we lose signal in mid-conversation. With the phone invented in 1999 by Randi Altschul, you could actually do just that. It was the world's first disposable cell phone.

Randice-Lisa "Randi" Altschul was no stranger to new ideas. Born in 1960, she was a toy designer who had made a fortune by the age of 26 from inventing toys and games. Her invention of the Phone-Card-Phone shows that you do not need to be an expert in a field of technology to create something new and innovative in that area. Altschul had a unique approach, she said:

> *The greatest asset I have over everyone else in that business, is my toy mentality. An engineer's mentality is to make something last, to make it durable. A toy's lifespan is about an hour; then the kid throws it away. You get it, you play with it, and—boom—it's gone.*

The phone was made from recycled paper products and its body was the size of a credit card, only three times thicker. It used an elongated flexible circuit that was part of the phone's body, the ultra-thin circuitry was created by applying metallic conductive inks to the paper.

Altschul saw her disposable phone as invaluable to parents who wanted their children to be able to call them at any time to ensure their safety. Sadly, other telephone companies knew a good idea when they saw one and began to market their own disposable small phones. Undeterred, Randi Altschul continues to invent and is working on other ideas, one of which is a disposable laptop computer. She is unashamed in her ambition, saying:

> *I'm going cheap and dumb. In monetary terms, I want to be the next Bill Gates.*

The Phone-Card-Phone is a real cell phone which makes outgoing calls only. It has 60 minutes of calling time and a hands-free attachment.

BETSY ANCKER-JOHNSON

CHANGING ATTITUDES TO WOMEN IN SCIENCE
INVENTION: THE GIGACYCLE RANGE SIGNAL GENERATOR

Born in 1927 in St. Louis, Missouri, Betsy Ancker was encouraged by her mother to pursue whatever was of most interest to her. She chose physics, enrolling at Wellesley College, the famous women's college in Boston, from which she graduated in 1949 with a bachelor's degree. She moved on to the University of Tübingen, in Baden-Württemberg, Germany, where she gained a PhD in physics in 1953. In 1958, she married Hal Johnson and they had four children.

In 1956 she became a Senior Research Physicist for Sylvania Electric Products at their Microwave Physics Laboratory in Palo Alto, California, and began to specialize in plasma which she described as a fourth state of matter after liquids, solids, and gases. She wrote a number of papers on the subject of plasma and her work led to the finding that solid-state plasmas can be used as microwave sources of radiation.

In the 1960s she worked at Boeing Research Laboratories in Seattle, where she discovered that if a low-density plasma is established in a piece of semi-conductor material in the presence of a high-intensity electric field and low-intensity parallel magnetic field, high frequency signals well into the gigacycle range can be generated. Her Gigacycle Range Signal Generator transmits repeating and non-repeating electronic signals used commonly in microwaves, arbitrary waveforms, and pitch.

In 1973, Ancker-Johnson became Assistant Secretary for Science and Technology at the US Department of Commerce and two years later, she became just the fourth woman elected to the National Academy of Engineering. She was the first woman ever to occupy the position of vice-president in the automotive industry when she took on the role of Vice President of General Motors' Environmental Activity Staff in 1979.

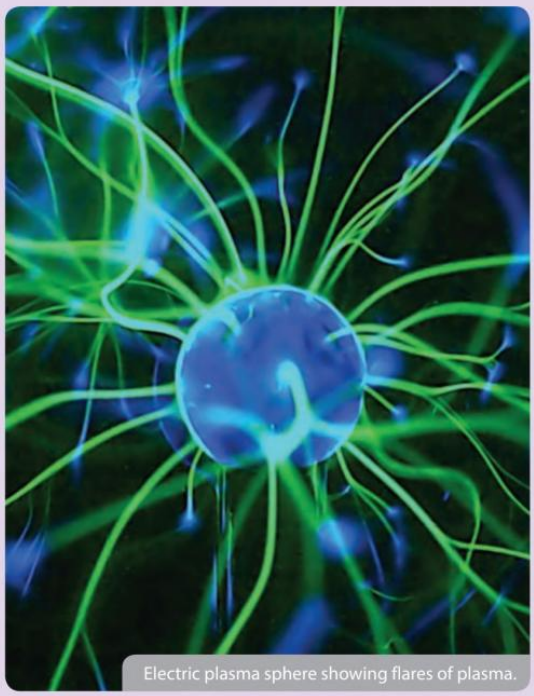
Betsy Ancker-Johnson was 90 years old in 2017, she has published over seventy scientific papers and patents. She is one of a generation of women who helped inspire a reassessment of attitudes to women in science and industry.

WHAT IS PLASMA?

The term "plasma," meaning "moldable substance," was coined in the 1920s by the Nobel Prize-winning American chemist Irving Langmuir. It is one of the four fundamental states of matter, the others being solid, liquid, and gas, although it does not exist naturally on earth and can only be created artificially from neutral gases.

A plasma is an ionized gas into which enough energy is provided to free electrons from atoms or molecules, and to allow both ions and electrons to coexist. To the best of our knowledge, plasmas are the most common state of matter in our universe.

Gases can be transformed into plasmas in a variety of ways, but all of them involve pumping the gas with energy. For instance, a spark in a gas will create a plasma and a hot gas passing through a big spark will make that gas a plasma that can be of use. Thus, plasma torches can be used in industry to cut metals. The sun, by the way, is nothing more than a huge ball of plasma.

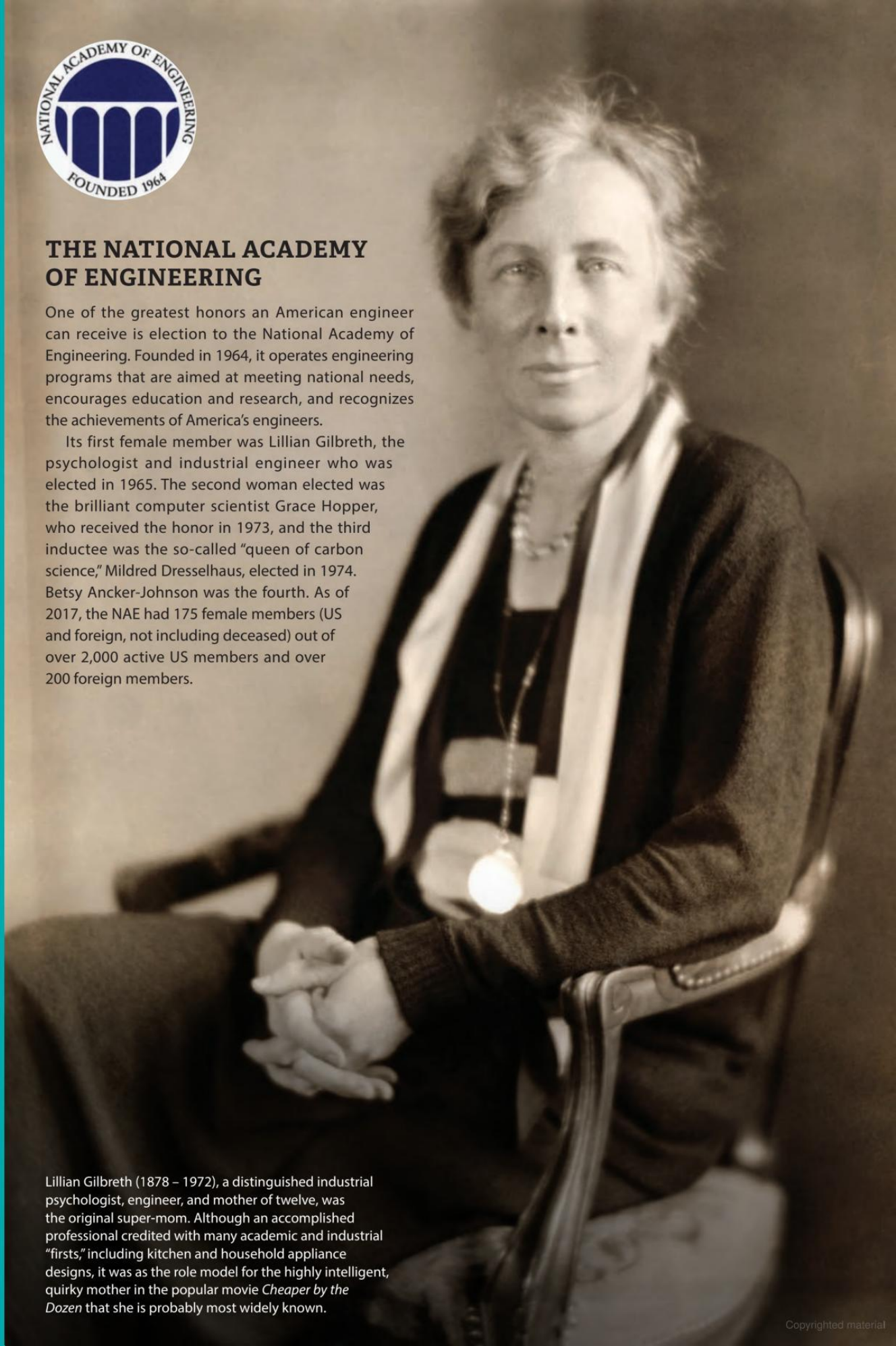


Electric plasma sphere showing flares of plasma.

THE NATIONAL ACADEMY OF ENGINEERING

One of the greatest honors an American engineer can receive is election to the National Academy of Engineering. Founded in 1964, it operates engineering programs that are aimed at meeting national needs, encourages education and research, and recognizes the achievements of America's engineers.

Its first female member was Lillian Gilbreth, the psychologist and industrial engineer who was elected in 1965. The second woman elected was the brilliant computer scientist Grace Hopper, who received the honor in 1973, and the third inductee was the so-called "queen of carbon science," Mildred Dresselhaus, elected in 1974. Betsy Ancker-Johnson was the fourth. As of 2017, the NAE had 175 female members (US and foreign, not including deceased) out of over 2,000 active US members and over 200 foreign members.



Lillian Gilbreth (1878 – 1972), a distinguished industrial psychologist, engineer, and mother of twelve, was the original super-mom. Although an accomplished professional credited with many academic and industrial "firsts," including kitchen and household appliance designs, it was as the role model for the highly intelligent, quirky mother in the popular movie *Cheaper by the Dozen* that she is probably most widely known.

MARY ANDERSON

A CLEAR VISION OF THE WAY AHEAD
INVENTION: THE WINDSHIELD WIPER

Back at the start of the twentieth century, rain on the windshield of a moving vehicle was just something you had to live with. The only way to deal with it was to stop the car every now and then and wipe the glass with a cloth. It took a woman named Mary Anderson to do something about that problem.

Born in Greene County, Alabama, in 1866, the year after the end of the American Civil War, she moved in 1889 with her widowed mother and sister to Birmingham, Alabama, where she built and managed an apartment building. By 1893 she was living in Fresno, California, where she ran a cattle ranch and vineyard until 1898.

THE FIRST WINDSHIELD WIPER

In the winter of 1902, while on a visit to New York City, she took a ride in a trolley car. It was a frosty day and she noticed that the trolley car driver had to drive with both his front windows open to the elements, otherwise the sleet that was falling would have obscured his view. She also noted how drivers had to stop their cars at the side of the road to wipe away the sleet and ice.

A solution to this inconvenient problem occurred to her and when she returned to Alabama where she was living again, she employed a designer to work on a hand-operated device that would keep a windshield clear. It consisted of a lever inside the vehicle's cab that controlled a rubber blade mounted on the outside of the vehicle. When the lever was operated, a spring-loaded arm would move back and forward across the glass. A counterweight ensured that the blade's rubber was in contact with the windshield as it swept across. She hired a local company to produce a working model and in 1903, was granted a 17-year patent for her windshield wiper.

DANGEROUS DISTRACTION

Mary attempted to make some money from her invention by trying to sell it to a Canadian company but, seeing no future in it, they replied to her: "we do not consider it to be of such commercial value as would warrant our undertaking its sale." In fact, many thought that the wiper would be a dangerous distraction for drivers and, anyway, many cars were built without windshield wipers at the time.

Her patent eventually expired in 1920 and as cars became increasingly popular, they began to enjoy the added bonus of windshield wipers along the lines of the one Mary Anderson invented. In 1922, wipers became standard equipment on Cadillacs.

It is interesting to know that the first automatic windshield wipers were also invented by a woman—Charlotte "Lotta" Bridgwood. Her Electric Storm Windshield Wiper used rollers instead of blades but, unfortunately, like Mary's invention, it was not a commercial success.

Windshield wipers are essential for a clear view of the way ahead.

VIRGINIA APGAR

TRANSFORMING THE FACE OF MEDICINE

INVENTION: THE APGAR SCORE

Pediatricians assess the health of newborn babies using the five criteria of the Apgar score: Appearance, Pulse, Grimace, Activity, and Respiration.

The American obstetrical anesthesiologist Virginia Apgar was born in Westfield, New Jersey, in 1909, into a family that she said "never sat down." She learned to play violin as a child and developed an early interest in science and medicine possibly as a result of her father being an amateur astronomer and inventor.

Deciding to pursue a career in medicine, she graduated from Mount Holyoke College in 1929, majoring in zoology. At college, she was remembered for her relentless energy. She played for seven sports teams, wrote for the college newspaper, acted in drama productions, and played violin in the college orchestra. You might have thought she would not have much time left for studies, but despite all these extra-curricular activities, her academic work remained exceptional.

THE PROSPECTS FOR WOMEN

Apgar began her medical training at Columbia University's College of Physicians and Surgeons where she was one of just nine women in a class of ninety. Completing her MD in 1933, she began a two-year surgical internship at Columbia-Presbyterian Hospital but when she was warned by her mentor that the prospects for women surgeons during the Depression did not look good, she decided that anesthesiology might be a safer bet.

After the second year of her internship she underwent a year's training as a nurse-anesthetist and undertook further studies at the University of Wisconsin and Bellevue Hospital in New York. She went back to Presbyterian as director of a new Division of Anesthesia that was being established in the Department of Surgery. For the next eleven years she worked tirelessly transforming the

anesthesia service at Presbyterian into one staffed by physicians rather than nurses. She also became a highly respected teacher in the division's education program.

EVALUATING NEWBORNS

In 1949, Apgar was made a full Professor of Anesthesiology at Columbia University's College of Physicians and Surgeons, the first woman to hold that rank at the university. Around this time, she began to become interested in the effects of maternal anesthesia on newborn babies, seeking to lower neonatal mortality rates which remained disturbingly high.

By 1952, she had developed a scoring system that was designed to evaluate the health status of newborn babies. It was based on measurement of their heart rate, respiration, movement, irritability, and color at one minute and then five minutes after they had been born.

Her name was borrowed as an acronym for the five simple criteria—**A**ppearance, **P**ulse, **G**rimace, **A**ctivity, and **R**espiration. These five are marked on a scale from 0 to 2. These are then added up to give a score out of 10. A low score obviously indicates that a baby needs medical attention but does not necessarily indicate a long-term problem.

The Apgar evaluation became standard practice, and is now used to evaluate the health and well-being of newborn babies around the world. Virginia Apgar died in 1974 at age 65.

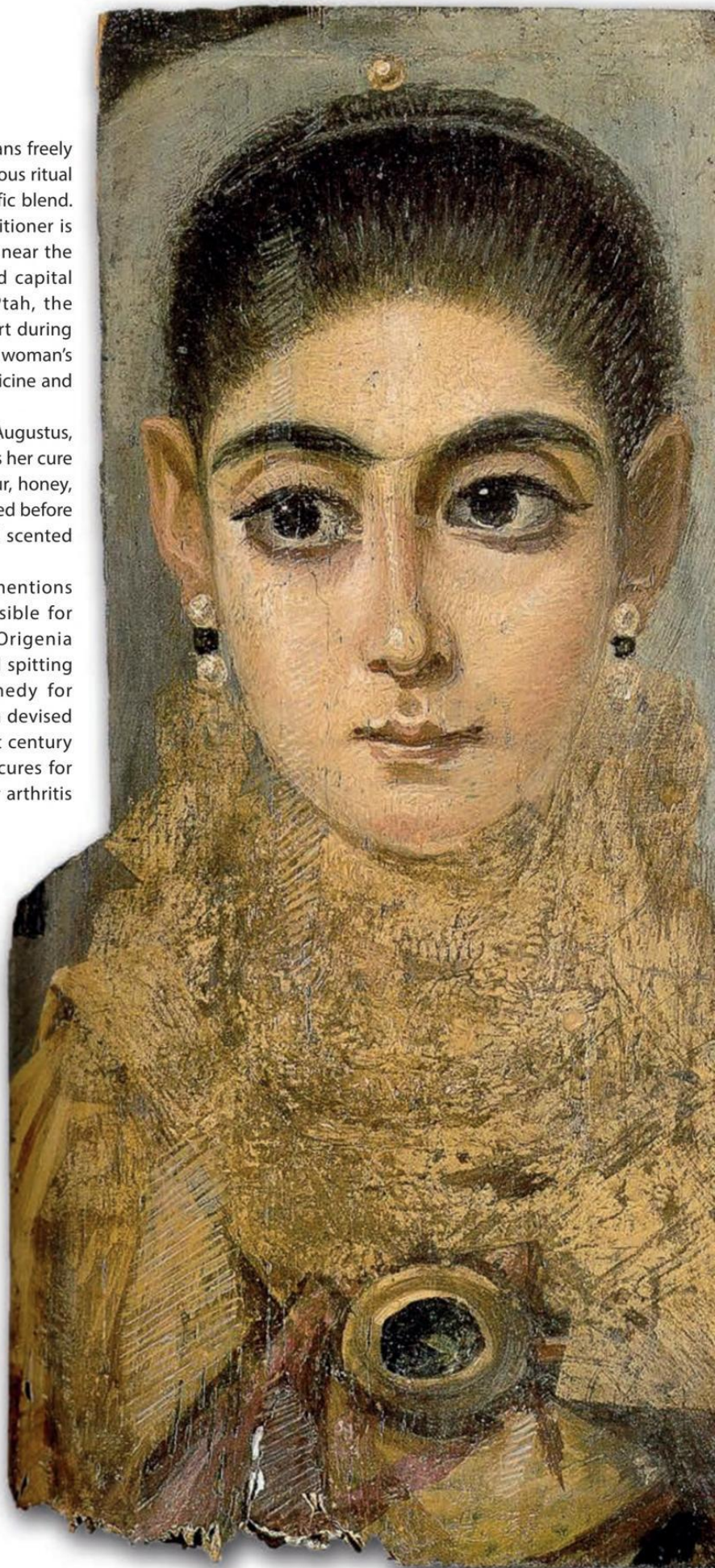
Virginia Apgar listening to a newborn baby's heartbeat, 1966.

ANCIENT WOMEN OF MEDICINE

In Ancient Egypt in 2700 BC, physicians freely mixed together the practices of religious ritual and medicine in an inventive scientific blend. The first ever woman medical practitioner is identified in a hieroglyphic carving near the step pyramid of Saqqara in the old capital city of Memphis. She was Merit-Ptah, the Chief Physician of the Pharaoh's court during the Second Dynasty. Hers is the first woman's name in history associated with medicine and science.

Octavia, sister of Roman Emperor Augustus, created many useful remedies such as her cure for toothache which used barley, flour, honey, and vinegar, mixed with salt, and baked before being pulverized with charcoal and scented with spikenard flowers.

Roman medical writer Galen mentions several women who were responsible for medical discoveries. The Greek Origenia invented remedies for diarrhea and spitting blood; Eugereasia created a remedy for inflammation of the kidneys; Xanita devised a cure for cold and fever; and a first century woman doctor, Antiochis, devised cures for diseases of the spleen as well as for arthritis and sciatica.



This mummy portrait of a young woman from Faiyum, Ancient Egypt, circa 120 – 130 AD, is exhibited in the Louvre, Paris. Portraits like this were painted on wooden boards to cover the faces of the mummified bodies of the dead. Due to the hot dry Egyptian climate, the paintings are frequently very well preserved, often retaining their brilliant original colors.

RUTH ARNON

SUPPRESSING MULTIPLE SCLEROSIS

INVENTION: COPAXONE

Kadeena Cox suffers from multiple sclerosis but won gold medals in both athletics and cycling at the Rio 2016 Paralympics.

The Israeli scientist and immunologist, Ruth Arnon, was born in Tel Aviv, Israel, in 1933. Taking her inspiration from her studious father Alexander who had degrees in electrical engineering and mathematics, Ruth resolved from an early age to study.

While in kindergarten she could already read and count and she went straight into second grade when she entered elementary school. Thanks to her mother's powers of persuasion, at the age of 13 she was enrolled at the Herzliya Hebrew Gymnasium, Tel Aviv, and by 15 she had decided that she wanted to work in the science of medicine.

She went to the Hebrew University of Jerusalem to study chemistry, spending her summers doing military training as many young Israelis did. After graduating in 1955 with an MSc degree, she served two years as an officer in the Israeli Defense Force. Around this time, she married an engineer named Uriel Arnon who was studying chemical engineering at the Technion, the Israel Institute of Technology in Haifa.

THE FIRST SYNTHETIC ANTIGEN

In 1957, she became a doctoral student at the Weizmann Institute of Science in Rehovot, Israel, where she was mentored by the Israeli immunologist Michael Sela. The two worked closely, publishing papers jointly in scientific journals and from 1975 to 1985 Sela was President of the Institute, while Ruth Arnon was Deputy President from 1988 to 1993.

It was while they were working together that they succeeded in synthesizing for the first time in the laboratory a substance that stimulated the body's immune system, creating the first synthetic antigen. An antigen is a molecule that is capable of inducing an immune response on the part of the host organism.

THE MIRACLE DRUG

With the help of another doctoral student, Dvora Teitelbaum, they discovered that their synthetic material could suppress multiple sclerosis in animals. The research and trialing of this material went on for the next thirty years until approval was granted for the resultant drug glatiramer acetate, also known by its trade name Copaxone. This miracle drug has become a major part of the fight against MS and is so effective that it helps sufferers lead an almost normal existence.

Copaxone was not Ruth Arnon's only success. She has also invented a synthetic influenza vaccine that is administered nasally. It will, it is expected, prove effective against a wide variety of flu virus for several years. In 2017 Professor Arnon was appointed co-chair of the UK-Israel Science Council, alongside Professor Lord Robert Winston.

DOROTHY ARZNER

LIGHTS, SOUND, ACTION!

INVENTION: THE BOOM MICROPHONE

A soundman holds a boom microphone above the heads of the actors on a film set as the camera and lighting rig rolls backward on tracks.

When she was young, a career in films never really entered the head of the inventor of the boom microphone, Hollywood director Dorothy Arzner (1897 – 1979). Indeed, she had harbored ambitions of becoming a doctor, and spent two years as a pre-med student and two years in the ambulance corps overseas. She had however, been close to the world of celebrities. She was raised in Los Angeles, where she worked as a waitress in her parents' restaurant frequented by movie stars such as Charlie Chaplin.

Film poster for *The Wild Party*, best known as Clara Bow's first talkie.

BLOOD AND SAND

Medicine lost out to the world of celluloid after Dorothy visited her first film studio, where she realized at once that she wanted to be a film director. She started in the film business as a typist for director William C. de Mille, at Famous Players-Lasky Corporation which later became Paramount Pictures, but was soon writing scripts and editing films. Her first editing job was on Rudolph Valentino's classic silent movie *Blood and Sand*, one of the biggest films of 1922.

After having worked on more than fifty films at Paramount, Arzner threatened in 1927 to move to the rival Columbia Studios unless she was allowed to direct her own movies. Paramount yielded and she was given *Fashions for Women*, a silent social comedy about a cigarette girl who falls in love with a count. A box office hit, it led to Arzner being offered more films to direct.

TALKING PICTURES ARRIVE

With the major success of the first talkie, Al Jolson's *The Jazz Singer* in 1927, silent movie stars were forced into the world of sound. Dorothy Arzner made history when she became the first woman to direct a sound picture, *Manhattan Cocktail* (1928), a mainly silent film which included some sound sequences.

One of the biggest names forced into the talkies was Paramount's top silent star Clara Bow. The personification of the 1920s sex symbol, "The It Girl," as she was known, was a huge box office draw. In 1929, Dorothy Arzner was given the onerous responsibility of directing the first film in which Clara Bow would speak, *The Wild Party*. It was also to be the first fully synchronized sound picture directed by a woman.

CLARA BOW'S STAGE FRIGHT

Things did not go well. Clara Bow had a thick Brooklyn accent that the silence of the pre-talkie era concealed. She was terrified of the transition to sound, and found it impossible to master the technique of talking into a microphone. The stressful situation was not helped by the sudden explosion of the microphone as she uttered her very first line.

Arzner came up with an ingenious solution to alleviate Clara's fear of sound. Working with her crew she rigged-up a microphone to a fishing rod which was dangled out of shot over the actors' heads, capturing Clara's less-than-lyrical spoken tones as she moved around the set. It was the first film studio use of the boom microphone, now an essential tool in filmmaking universally.

Sadly, Arzner failed to take out a patent on her invention, and a year later Edmund H. Hansen, a sound engineer at the Fox Film Corporation filed a patent for a very similar device. Although she did get some reward when *The Wild Party* became the third-highest grossing film of 1929.

GOLDEN AGE CAMERA WOMAN

More films followed, usually featuring free-spirited, aggressive, and independent women just like Dorothy Arzner, and included collaborations with Katharine Hepburn and Joan Crawford. In 1932, she left Paramount and began working independently.

Her career spanned from the silent era of the 1920s to the early 1940s. In her fifteen-year career as a director (1928 – 43), Arzner made three silent movies and fourteen "talkies." She was the only woman director during the "Golden Age" of Hollywood, the first woman to be invited to join the Directors Guild of America, and a role model for women filmmakers in future years.

Dorothy Arzner died in 1979, at age 82, in La Quinta, California. She was posthumously awarded a star on the Hollywood Walk of Fame in 1986.

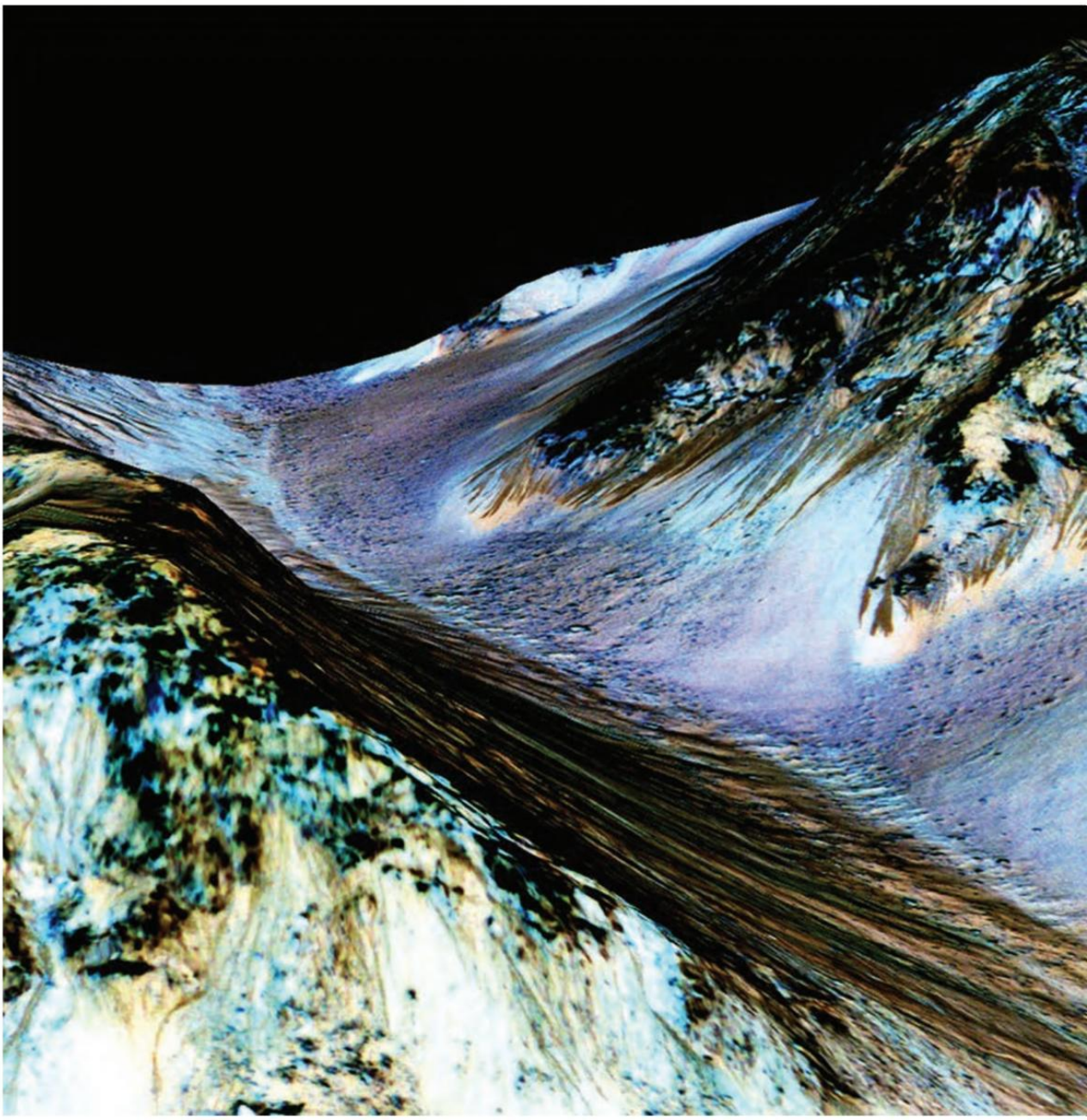
Dorothy Arzner and Clara Bow on the set of *The Wild Party* (1929).

BARBARA ASKINS

MAKING THE INVISIBLE VISIBLE

INVENTION: AUTO-RADIOGRAPHIC IMAGE ENHANCEMENT

Working for NASA at the Marshall Space Flight Center in Madison County, Alabama, physical chemist Barbara Askins (born 1939) was asked to find a way of improving astronomical and geological photographs taken from space. They often turned out fuzzy and lacked clear definition which was a problem for scientists who needed to see the fine detail. Making the invisible visible is quite an achievement, but that is what Barbara Askins did. Her invention would have a greater impact than anyone could have imagined.

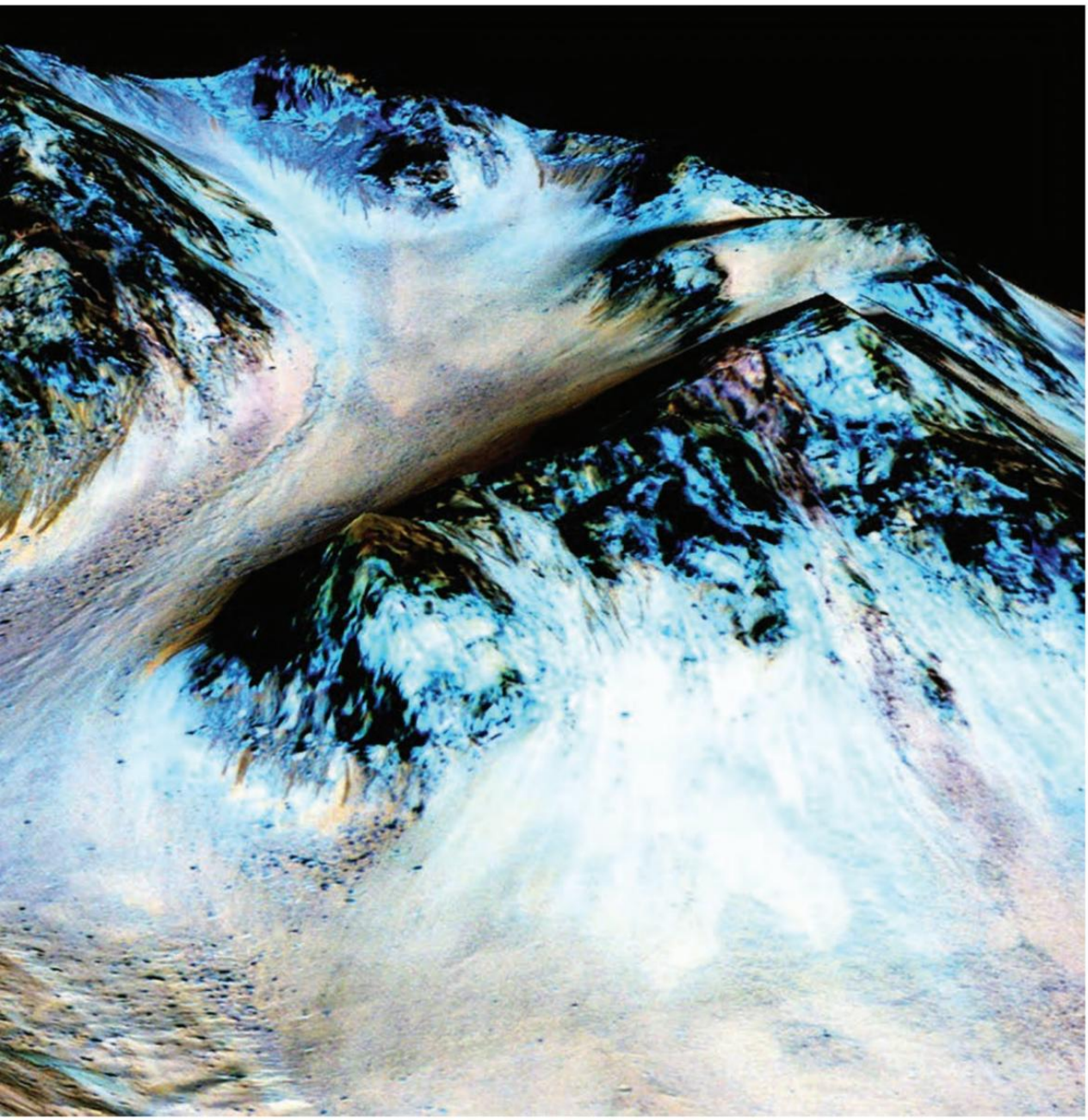


The process she developed was one in which "images on developed photographic emulsions can be significantly intensified by making the image silver radioactive and exposing a second emulsion to this radiation."

The print that resulted from this process was known as an auto-radiograph and it represented a huge increase in both density and contrast in the image. It could be used to tease data from underexposed images of space and was also useful in explaining the geology of other bodies in the solar system.

The process had a variety of other applications, including improvements in the clarity of X-ray images, allowing doctors to significantly reduce the amount of X-ray radiation used, and restoring old photographs. Askins patented her invention in 1978 and NASA employed it extensively for its research and development work.

For her invention of a new way of developing film, Barbara Askins was named National Inventor of the Year in 1978, the first women to win the award who had sole title to the patent for which she was being awarded.



The rivers of Mars. This NASA auto-radiographic enhancement image provides the strongest evidence yet that liquid water flows intermittently on present-day Mars.

HERTHA AYRTON

THE SECRET OF RIPPLES
INVENTION: MATHEMATICAL LINE DIVIDERS

Sand ripples on the beach of Budle Bay, Northumberland, England.

Hertha Marks Ayrton was an award-winning English engineer, mathematician, inventor, and physicist, best known for her groundbreaking work on electric arc lamps and sand ripples. Born Phoebe Sarah Marks in Portsmouth, England, in 1854, she was the third child of an English seamstress and a Polish watchmaker who died in 1861, leaving the family in debt. In 1863, at the age of 9, she went to live with her aunt, the writer Marion Hartog, in north-west London, and attended the school she ran with her husband.

RADICALS AND EXILES

It was at Marion Hartog's school that Sarah discovered her love of science and mathematics. She mixed with the intellectuals, radicals, and exiles who were part of the Hartogs' social circle, and adopted the name "Hertha" given to her by friend Ottilie Blind, after the Germanic Earth goddess.

Ottilie, the daughter of German writer Karl Blind, was a well-connected young lady. She introduced Hertha to Madame Barbara Bodichon, a leading women's rights activist and early benefactor of Girton College for Women at Cambridge University. A university education for women was a new idea in the nineteenth century.

Madame Bodichon provided the Girton College funds for Hertha's studies and she passed the Cambridge University Examination for Women in 1874 with honors in English and mathematics.

MATHEMATICAL LINE DIVIDERS

At Girton, she organized the college's fire brigade and sang in the college choir. Hertha also launched her career as an inventor, devising a sphygmograph, a tool for recording the pulse in arteries.

In 1884 she patented a mathematical line divider, an instrument for dividing a line into any number of equal parts, which could be used by artists and architects. The device was unveiled at the Exhibition of Women's Industries and was her first major invention.

Hertha began to teach and also began a physics course in the evening at the Finsbury Technical College in London. Her teacher was Professor William Ayrton, an electrical engineer who had studied under Lord Kelvin at the Royal Society. He was also a widower with a young daughter, and Hertha and Ayrton fell in love and were married in 1885.

ELECTRIC ARC LAMPS AND SAND RIPPLES

Hertha Ayrton is celebrated for her work on the electric arc lamp, which was widely used at the time for street lighting. Their tendency to hiss and spark dangerously and produce a far from consistent light was a constant problem. Hertha proved that if air was excluded from the arc, the hissing disappeared and the light did not flicker. In 1895 she wrote a series of articles on her discovery for the *Electrician*, and in 1899, she was the first woman ever to read her own paper "The Hissing of the Electric Arc" to the Institution of Electrical Engineers (IEE). She was elected the first female member of the IEE shortly after.

By the late nineteenth century, her electrical engineering work was recognized internationally and she attended the 1899 International Congress of Women in London and spoke at the Paris International Electrical Congress in 1900.

In 1901 she started work analyzing the ripple patterns that appear in sand when a wave passes over it. This had been a scientific mystery until Ayrton read "The Origin and Growth of Ripple Marks" to the Royal Society in 1904. She was awarded the Royal Society's Hughes Medal for an original discovery in 1906, the first woman to do so and one of only two women to win it to date.

LIFE-LONG INVENTOR

Sadly, William Ayrton died in 1908, but Hertha continued inventing and in 1915 during World War I, she designed the Ayrton anti-gas fan to disperse poison gas from the British trenches. During the war, 104,000 of the Ayrton fans were issued to troops on the Western Front and they were in daily use from May 1916. She also invented improved searchlights that were used in both world wars.

Hertha fully supported women's rights, taking part in protest marches and allowing arrested suffragettes to stay at her house after their release from prison. She was also a life-long inventor and owns twenty-six patents: five on mathematical line dividers, thirteen on electric arc lamps, and the rest on air propulsion.

Hertha Ayrton died in 1923, at age 69. In 2010, she was named by the Royal Society as one of the ten most influential British women in the history of science.

THE ROYAL SOCIETY

The Royal Society initially grew out of meetings of groups of physicians and natural philosophers in the middle of the seventeenth century. In 1660, the formation of a "College for the Promoting of Physico-Mathematical Experimental Learning" was announced and in 1662, it was given a Royal Charter and renamed the Royal Society of London. It met at Gresham College. In the second half of the eighteenth century, it became customary for the government of the day to refer important scientific issues to the Society and its Fellows were appointed to serve on government committees relating to scientific matters.

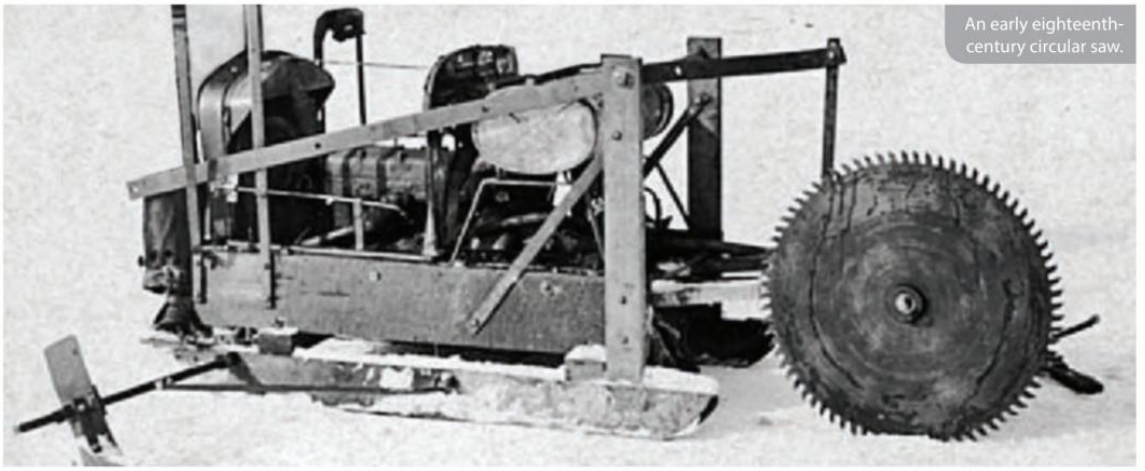
By 1739, the membership had been increased to 300 and the Royal Society had flourished under the presidency of Sir Isaac Newton who occupied that position from 1703 to 1727. The Society's normal business continued to be the demonstration of experiments and the reading of important scientific papers.

In the nineteenth century, the Society entered a period of relative decline, reflecting, perhaps, a decline in science in Britain. Charles Babbage published *Reflections on the Decline of Science in England, and on Some of its Causes*, in which he was highly critical of the Royal Society. It was decided to limit membership to fifteen a year. This was increased to seventeen in 1930 and twenty in 1937. By 1941 membership was usually between 400 and 500. The first women members were elected in 1945.

SARAH TABITHA BABBITT

SHAKE IT ON DOWN

INVENTION: THE CIRCULAR SAW



An early eighteenth-century circular saw.

Sarah "Tabitha" Babbitt was born in 1779 in Hardwick, Massachusetts, and by 1793 was living in the Harvard Shaker Village working as a weaver. This particular community worked mainly in forestry, and every day Tabitha watched men working hard sawing logs. In 1810, she came up with a tool that would make their job a lot easier.

The men used a pit saw, a long two-handled saw which they pulled from side to side, one at each end. They cut along the length of the log to create planks. The problem was that the saw only cut into the wood on its forward pull, rendering the second pull only useful for taking it back into position. It was a waste of energy, time, and manpower.

Tabitha devised an alternative by making a prototype to demonstrate its effectiveness. It consisted of a circular blade attached to her spinning wheel. She used the pedal of the spinning wheel to power it and as the blade spun, no movement was wasted. Furthermore, it cut faster and the manpower required was reduced by one.

A larger version of her original design was installed at the local sawmill and soon other sawmills were copying her invention. But as a Shaker, Tabitha did not believe in patenting her idea and, therefore, made no money from it.

Tabitha Babbitt is also credited with inventing the spinning wheel head and a process for manufacturing the type of nails known as "cut nails." When she died in 1853, she was working on a new process for manufacturing false teeth.

THE SHAKERS

The United Society of Believers in Christ's Second Appearance, commonly known as the Shakers, is a Christian sect that was founded in England in the eighteenth century. The name "Shaker" derives from the description of them as "Shaking Quakers" because of their behavior during worship when they behave ecstatically.

Best-known today for its popular styles of nineteenth-century furniture and crafts, the Shaker legacy includes many achievements in social reform, agriculture, technology, and innovation. The flat broom, the circular saw blade, the spring clothespin, chair tilter buttons, and the paper seed envelope are all among a long list of Shaker inventions.

Shaker religious exercises in the meetinghouse, New Lebanon, New York.

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