

Recognizing Women's Contributions to Engineering and Technology

SME, WESTEC, Los Angeles, CA, 06-03-14-06

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Abstract: *The article presents women's noteworthy contributions to science, technology, and specifically to manufacturing. The role of women in creating a balanced workplace environment is also discussed.*

Many inventions which are still in use today were made by women: the non-reflective glass, the windshield wiper, noise-less trains, liquid paper, the ubiquitous square-bottom supermarket brown bag, and reducing air and noise pollution methods, to name just a few. Yet, when you look at lists on categories such as inventors, scientists, engineers, Nobel Prizes winners you see mostly men's names. A few such lists were examined by the author.

In the list of famous scientists, in physical sciences only one woman, Marie Curie. [1]: Archimedes, Aristotle, Niels Bohn, Nicholas Copernicus, Marie Curie, Charles Darwin, Leonardo da Vinci, Rene Descartes, Thomas Alva Edison, Albert Einstein, Ben Franklin, Galilei Galileo, Isaac Newton, Max Planck, Wilhelm Conrad Rontgen, Carl Sagan, Nikola Tesla.

In a list of 43 famous engineers there are only five women.[2]: Bonnie Dunbar - NASA astronaut, Beulah Louise Henry ("the lady Edison" for the many inventions), Grace Murray Hopper, a computer engineer, Judith Resnik - Challenger astronaut, electrical engineer, Katherine Stinson - the first female graduate of N.C. State University's College of Engineering.

In a long list of 209 only the following are women [3]: Emile Berliner, Katherine Blodgett, Bette Nesmith Graham, Erna Schneider Hoover, Margaret Knight, Stephanie Kwolek, Hedy Lamarr, Olivia Poole. A list of women inventors is given on-line at [4].

In a list of 14 inventors who also won the Nobel Prize there is only one woman, Gertrude Belle Elion [5].

One of the highest honor that can be given to an engineer is to be elected to the National Academy of Engineering or NAE. There are just a few women in NAE. To date, 2,330 male engineers have been elected to the NAE since 1964 compared to the only 37 women engineers that have been elected. The first woman engineer elected to the NAE was Lillian Gilbreth in 1965. In 1973, Grace Hopper became the second woman engineer elected. Mildred Dresselhaus was the third woman engineer elected in 1974. Betsy Ancker-Johnson was the fourth woman engineer elected to the NAE in 1975.

Women have contributed significantly in many areas of science and technology. Yet, many female inventors throughout history have been forgotten completely, concealed or ignored even though products and technologies they devised are used every day. The most interesting case, since this presentation is made in Southern California, is that of Hedy Lamarr. People

recall her as a sexy movie star of the 1930s and 1940s. Hardly anybody recalls that she invented a remote-controlled, jam-proof radio communications system for the U.S. military that was patented during World War II. Three categories can be looked when considering this issue of female inventors having been forgotten throughout history: legal, economic, and social. [6]

Legal rights of married women in the early-nineteenth century were virtually non-existent. Women's inventions were issued to men, women patents were recorded in a man's name. While the legal status may have deterred or obscured inventions by women, economic considerations fostered it. In the section written in a book about "women and technological change," Deborah J. Warner, stated that the major thing that motivated women inventors to participate at the 1876 Centennial Exposition in Philadelphia was to make money [7]. Social reason include the fact that for many century it was believed that the woman's place was in the home that it was un-lady like to work go to college or work with men, for a long time women did not have the right to vote, nor to study in high education institutions, especially in "hard fields" of science and technology.

In an article in The Washington Post, Heather Salerno presents women as "mothers of invention." She mentions some of the many female inventors throughout history who have been forgotten completely, concealed or ignored even though products and technologies they devised are used every day. [8]

Heather Salerono's list is long: HYPATIA (370-415 A.D.) [studies in mathematics, philosophy, and astronomy]; SYBILLA MASTERS (died 1720) [created a new way for cleaning and curing corn]; MARY DIXON KIES (early 19th century) [devised a method of weaving straw with silk]; LADY AUGUSTA ADA BYRON, COUNTESS OF LOVELACE (1815-1852) [the world's first computer programmer; originated the concept of using binary numbers]; ELLEN EGLIN (late 19th century) [innovative in the clothes washing field, creating new and improved powders, wringers and machines]; MARGARET KNIGHT (1838-1914) [designed a machine that folded and glued the rectangular-bottom brown paper bags familiar today]; MARY WALTON (late 19th century) [developed air and noise anti-pollution devices]; BEULAH LOUISE HENRY (born 1887) ["Lady Edison" - a large number of inventions and wide spectrum of ideas such as a hair curler, a football inflating device, a bobbin-less sewing machine, numerous contributions to typewriters and the toy industry]; KATHERINE BLODGETT (1898-1979) [developed "invisible" nonreflecting glass]; MARJORIE JOYNER (1896-1994) [was granted a patent for a permanent wave machine]; HEDY LAMARR (born 1913) [co-invented a remote-controlled, anti-jamming communications system, a major contribution to U.S. defense technology]; RUTH HANDLER (born 1917) [created Barbie, the world's most famous doll, and breast prosthesis]; GERTRUDE BELLE ELION (born 1918) [discoveries of medicines that fight leukemia, gout and herpes and a drug that suppresses the immune system, helping the body to accept transplanted tissue; cancer drugs and kidney transplants]; RACHEL FULLER BROWN (1898-1980) [received a patent for Nystatin, the first fungus-fighting drug, antifungal antibiotic]; EDITH M. FLANIGEN (born 1929) [petroleum research - discoveries to convert crude oil to gasoline, in water purification and in environmental cleanup]; ERNA SCHNEIDER HOOVER (born 1926) [created a computerized telephone switching system]; MARY SPAETH (born 1940) [invented the tunable dye laser,

which can be manipulated to produce light of different wavelengths and, hence, different colors]; STEPHANIE LOUISE KWOLEK (born 1923) [experimented with a variety of strong fibers and discovered liquid crystalline polymers resulting in the product Kevlar, whose fibers are stronger than steel and is used to make bulletproof vests, fiber-optic cables, outdoor clothing, radial tires and airplane fuselages] [8]

One of the forgotten women who contributed to science is LEAVITT, HENRIETTA SWAN Astronomer (1868 - 1921). [9] She was one of the "computers" (in the shape of humans to do repetitive tasks) who worked at the Harvard College Observatory at the beginning of the 20th century. She was hearing impaired but this did not deter her from her studies. She volunteered at Harvard College observatory in 1893 at the age of 25 where she worked on the accurate measurements of the brightness of stars. Her most important work was the discovery of the period-luminosity relation of Cepheid variable stars. "It is worthy of notice", she observed, that "the brighter variables have the longer periods." Cepheids are stars that fade and brighten in a regular fashion. This relation is one of the fundamental building blocks in the yardstick by which astronomers measure distances to galaxies and far-away objects. Interestingly, in 1925 after her death the Swedish mathematician Gösta Mittag-Leffler wrote to her saying he was seriously inclined to nominate her for the Nobel Prize. Unfortunately Nobel prizes are not awarded posthumously. Who knows what might have happened had she lived longer. Her work was that important. [9] Recently a book was written about her: "Miss Leavitt Stars: The Untold Story of the Woman Who Discovered How to Measure the Universe," by George Johnson, Great Discoveries.

Probably the best know women in the history of science and technology are: Marie Curie [10] (1867-1934; Poland/France – Chemist), Emily Noether (1882-1935; Germany – mathematician), Lillian Moller Gilbreth (1878-1972; US – the birth of Ergonomics), and Grace Murray Hopper (1906-1992; US – a computer inventor and programmer; Mark computer, COBOL language). The reader can look on-line at the biographies and contributions to science and technology of Marie Curie [10] Emily Noter [11], Lillian Gilbreth [12], and Gace Hopper[13]. Below the discoveries of somewhat less known Lise Meitner, some women who made direct contributions to manufacturing, to materials sicene and engineering, and some contemporary women inventors will be briefly presented.

Lise Meitner (1878 - 1968) [14] was an Austrian physicist who studied radioactivity and nuclear physics. In 1905 she obtained a PhD in physics from the University of Vienna, the first woman to do so at that university. She collaborated with the chemist Otto Hahn for 30 years, studying radioactivity .In 1918, they discovered the element protactinium. In 1923, she discovered the radiation-less transition known as the Auger effect, which is named for Pierre Victor Auger, a French scientist who discovered the effect two years later. In 1926, she became the first female full professor in Germany at the University of Berlin. With the discovery of the neutron in the early 1930s, speculation arose in the scientific community that it might be possible to create elements heavier than uranium (atomic number 92) in the laboratory. A scientific race commenced between Ernest Rutherford in Britain, Irene Joliot-Curie in France, Enrico Fermi in Italy, and the Meitner-Hahn team in Berlin. After Nazi Germany annexed Austria in 1938, Meitner fled Germany for Sweden. Hahn and Meitner met clandestinely in Copenhagen in November to plan a new round of experiments; in this regard they subsequently

exchanged a series of letters. The experiments which provided the evidence for nuclear fission were done at Hahn's laboratory in Berlin. Meitner was the first person to realize that the nucleus of an atom could be split into smaller parts. Uranium had split to form barium and krypton accompanied by the ejection of several neutrons and a large amount of energy, (the latter two products accounting for the loss in mass). In 1938 Meitner did the prediction calculations for a fissile nucleus. Hahn later claimed that his chemistry had been solely responsible for the discovery. Meitner refused an offer to work on the project at Los Alamos, declaring that *"I will have nothing to do with a bomb!"* 1944, Hahn received a solo Nobel Prize for Chemistry for the discovery of nuclear fission. In the opinion of many scientists, Meitner should have shared the prize. Several books were written about her and her discoveries. [14]

Edith Marie Flanigen [15] was born in Buffalo, New York (1929) and recently retired (1994), she is one of the most inventive chemists of all time. She has earned 102 U.S. patents for her innovations in the rather esoteric fields of petroleum research and product development.

After graduating as class president and valedictorian from D'Youville College in Buffalo, and after gaining an M.S. in Inorganic-Physical Chemistry from Syracuse University (1952), Flanigen began a forty-two year career in research at Union Carbide Corporation and UOP, a joint venture of Union Carbide and AlliedSignal. Her first area of expertise was the identification, extraction and purification of various silicone polymers (chemical compounds), which could then be used in chemical processes.

In 1956, Flanigen began working on "molecular sieves": crystal compounds with molecule-sized pores, that can be used to filter and separate the constituent parts of complex mixtures, and as "catalysts," substances that accelerate chemical reactions. In her career, Flanigen invented or developed over 200 different synthetic substances, the most important of which is "zeolite Y," a silicate sieve used to refine petroleum. Petroleum, or "crude oil," found in the earth, must be broken down into its parts (called "fractions") by a process called "catalytic cracking" before it can be used. Gasoline is only one of the lighter fractions of crude oil. Flanigen's zeolites are used as catalysts to optimize the conversion of crude oil to gasoline.

Flanigen's work is admittedly complex, but it has many practical benefits. First of all, her innovations have made the production of gasoline in the U.S. and around the world greater, cleaner, and safer. Secondly, her "sieves" are used in other processes, such as water purification and environmental clean-up. Finally, Flanigen's work has other commercial applications: for, she is the co-inventor of a synthetic emerald, produced and marketed by Union Carbide for a number of year. However unknown she may be to the general public, Edith Flanigen is deservedly a living legend to research chemists world-wide. [15]

Stephanie Louis Kwolek's [16] research with high performance chemical compounds for the DuPont Company led to the development of a synthetic material called Kevlar which is five times stronger than the same weight of steel. Kevlar, patented by Kwolek in 1966, does not rust nor corrode and is extremely lightweight. Many police officers owe their lives to Stephanie Kwolek, for Kevlar is the material used in bullet proof vests. Other applications of the compound include underwater cables, brake linings, space vehicles, boats, parachutes, skis, and building materials.

Kwolek was born in New Kensington, Pennsylvania in 1923. Upon graduating in 1946 from the Carnegie Institute of Technology (now Carnegie-Mellon University) with a bachelor's degree, Kwolek went to work as a chemist at the DuPont Company. She would ultimately obtain 28 patents during her 40-year tenure as a research scientist. In 1995, Kwolek was inducted into the National Inventors Hall of Fame. [16]

Some interesting and yet not well known manufacturing type contributions by women are: Mary Dixon Kies's invention for a machine and process for weaving straw with silk, in the early 19th century when bonnets were in much demand. Her invention made the hats cost-effective to produce and the New England's had business kept the area's economy strong through an economic crisis aggravated by the war of 1812. [17]

Patsy Sherman [18] was born in Minneapolis, Minnesota, in 1930. After college graduation, she joined 3M as a research chemist and was assigned to work on fluorochemical polymers. Her work was an essential part of the introduction of 3M's first stain repellent and soil release textile treatments which have grown into an entire family of products known as Scotchgard® protectors.

Sherman regards the serendipitous discovery of Scotchgard® as one of her most significant works because many experts had written that such a product was "thermodynamically impossible." That day in the lab is legendary. Sherman and her colleague, Sam Smith, were working on another project when they observed that an accidental spill on a white tennis shoe would not wash off nor would solvent remove it. The area resisted soiling. They recognized the commercial potential of its application to fabrics during manufacture and by the consumer at home. So go ahead and put your feet up... the dirt will wash off. Sherman was inducted into the Minnesota Inventors Hall of Fame in 1983. [18]

Randice-Lisa "Randi" Altschul [19] was issued a series of patents for the world's first disposable cell phone, in November of 1999. Trademarked the Phone-Card-Phone®, the device is the thickness of three credit cards and made from recycled paper products. This is a real cell phone (outgoing messages only) with 60 minutes of calling time and a hands free attachment. You can add more minutes or throw the device away after your calling time is used up. However, with the planned additional magnetic strip the cell phone would double as a credit card, swipeable for purchases with free airtime credits as a bonus. The retail price of the invention should average twenty dollars, with a two or three dollar rebate for returning the phone instead of trashing it.

Altschul thought up the invention after being tempted to toss her cell phone out of her car in frustration over a bad connection. She realized cell phones were too expensive to lose or throw away. After clearing the idea with her patent lawyer and making sure no one else had already invented a disposable cell phone, Randi Altschul together with engineer Lee Volte, patented both the disposable cell phone and the super thin technology (STTTM) needed for the Phone-Card-Phone and other intended products. [19]

Randi Atschul's invention is very important in two ways: it is in the direction that modern technology is going, i.e., miniaturization, and also it reflects a contribution that only can be

made by a woman, given the different experience that she has than a man. In an article that appears in The New York Times Business section by Teresa Riordan [20] Altschul says “The greatest asset I have over everyone else ... is my toy mentality. An engineer’s mentality is to make something last, to make it durable. A toy’s life span is about an hour, then the kid throughs it away.”

This leads us to why women are so important in the engineering field. Throughout history women brought their specific experiences, from cooking, cloth making, raising children, taking care of the elderly, the sick, the handicapped. With their vast experience and interest in cooking there is no wonder that women played an important role in alchemy searches. Today, women in industry help balance the working environment: they are better communicators, have more intuition than men, and bring a different point of view and experience. They are different than men and thus they bring their different point of view perspective to the work environment.

So far we looked at famous women or those who made a striking contribution. We must not forget though that women form an important working force in the manufacturing industry. To give just an example, today a very large number of women around the world are employed in the field of electrical and electronics manufacturing in assembling televisions, cellular telephones, computers, and other electrical devices. [21]

References:

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- [3] http://en.wikipedia.org/wiki/List_of_inventors
- [4] <http://inventors.about.com/od/womeninventors/>
- [5] http://www.invent.org/hall_of_fame/1_4_9_nobel.asp (2000-2005 National Inventors Hall of Fame Foundation, Inc.)
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Heather Salerno, “Though Unsung and Ignored, Women Have Pushed Technology's Frontiers - Mothers of Inventions,” *The Washington Post*, Wednesday, March 12 1997; Page H01.
- [9] <http://www.astr.ua.edu/4000WS/LEAVITT.html>
- [10] http://en.wikipedia.org/wiki/Marie_Curie
- [11] http://womenshistory.about.com/library/bio/blbio_emmy_noether.htm
- [12] <http://inventors.about.com/library/inventors/blGilbreth.htm>
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- [18] http://products.engineering.com/community/academia/women_eng/famous_womeneng.htm#stephanie
- [19] http://products.engineering.com/community/academia/women_eng/famous_womeneng.htm#randi
- [20] <http://www.nytimes.com/library/tech/99/11/biztech/articles/08pate.html>
- [21] <http://www.ieee-virtual-museum.org/collection/event.php?taid=&id=3456972&lid=1>

Other on-line sources

- www.ieee-virtual-museum.org/exhibit/
- <http://www.nwhp.org> The California-based National Women's History Project has set up this site to help search for information on women in many areas of endeavor. It has links to many other web pages on women in science and technology.
- <http://www.invent.org> This gives information about the National Inventors Hall of Fame in Akron and lists biographical data about those honored there, including a few women.
- http://products.engineering.com/community/academia/women_eng/famous_womeneng.htm Information on a number of famous women engineers, brief bios and achievements.
- <http://http-server.carleton.ca/~mfrize/wise/womensc.htm> Well-known Women Engineers and Scientists from around the world (Monique Frize, Carleton University); alphabetical list through K at present
- <http://www.physics.ucla.edu/~cwp/> Contributions of 20th Century Women to Physics: from the Committee on the Status of Women in Physics and the Forum on the History of Physics of the American Physical Society.
- <http://www.astr.ua.edu/4000WS/4000WS.html> 4000 years of women in science: Photographs, Biographies, and References
- http://www.inventionandtechnology.com/xml/2003/3/it_2003_3_feat_0.xml An Interview with Stephanie Kwolek by Jim Quinn , Winter 2003 Invention & Technology

Books about women inventors

- *Feminine Ingenuity: Women and Invention in America* by Anne L. Macdonald, Ballantine Books: New York, 1992.
- *Mothers and Daughters of Invention: Notes for a Revised History of Technology* by Autumn Stanley, The Scarecrow Press Inc.: New Jersey, 1993.
- *Women, Technology and Innovation*, edited by Joan Rothschild, Pergamon Press Ltd.: New York, 1982.