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Women in Engineering: Pioneers and Trailblazers. by Margaret E. Layne, P.E.

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REVIEW

This book presents an anthology of the early history of women working as engineers in the USA, identifying factors that hindered and supported their professional progress in a world that was, and to a large extent still is, dominated by men. It is a coherent collection of material from a wide range of sources – academic papers, presentations, reports and popular articles, the result of extensive research in a field lacking in archived records. In her preface, Layne points out that there have been many books about American women scientists with one or two including women engineers, but that in books about engineers, women have been largely invisible. Here, some chapters present perspectives on different issues and how they have changed over time; others focus on particular engineers.

Margaret Ingels (Chapter 4), the first woman to graduate from the University of Kentucky's College of Engineering in 1916, chose "Petticoats and Slide Rules" as the title of her talk to the Western Society of Engineering in 1952.

> *'I planned to pay tribute to all the women engineers who pre-date the "blue jeans" era. I thought at the time that the petticoat age of women engineers probably began during the days of cotton garments adorned with Hamburg ruffles. To my surprise, research proved that women entered the engineering profession during the multi-petticoat era; but we do not go back to hoop skirts and bustles!' (p.85)*

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She then introduces a procession of women engineers whom she identifies as "trailblazers", beginning with Edith Julia Griswold who studied law at New York University and civil, mechanical and electrical engineering outside the university system. She opened an office in New York in 1886 and was eventually (and perhaps grudgingly) acknowledged as an engineer and patent lawyer by *Who's Who in Engineering* in 1925 (Leonard, 1925).

In America in the 19th century, engineering moved gradually from a trade where entry was by on-the-job apprenticeship, rather than formal education, to a profession requiring a degree to practice. Membership criteria were set out by the newly formed professional societies (e.g. the first one, the American Society of Civil Engineers, was founded in 1852). They included a degree from an accredited university course, but most such courses did not admit women. Griswold's career path illustrates one woman's determination to succeed despite this formidable barrier.

Although by the turn of the century some universities were admitting women, many of the earliest women engineers did not receive formal education.
Nor was it easy for women to be elected to the professional societies. The first woman to achieve the grade of full member of the American Society of Civil Engineers was Elsie Eaves in 1927. In 1942 there were just three women members of the American Institute of Electrical Engineers. Lillian Gilbreth, well known for her work with her husband in founding the discipline of scientific management, and for continuing their joint work for 50 years after his death, was only elected to the National Academy of Engineering in 1965.

While marriage, in general, signaled the end of a woman's career in any field in the first half of the 20th century, a supportive husband who was influential in the same sphere could, in some cases, contribute to its continuation. Another example of this is Ellen Swallow Richards, a distinguished water engineer at MIT who is regarded as the founder of ecology and environmental engineering. The significance of the work of both Gilbreth and Richards is described by Martha Moore Trescott (Chapter 5), who discusses the influence of women on the intellectual development of engineering.

Both World Wars contributed to the increased activity of women in engineering. Faced with the absence of men who had joined the armed forces, employers in key industries were compelled to take on women to sustain the war effort. For the first time in WWI, and then again in WWII, shop floors and design offices were staffed by women in non-traditional spheres such as aeronautics, shipbuilding, munitions and refrigeration. Contrary to popular expectations, many demonstrated exceptional skills as engineers. At the end of each war, despite social pressures to return to their homes to look after their returning menfolk and families, many of the women sought to continue and develop their new expertise, often re-enforcing it by choosing formal studies. In England, the number of women working as engineers was great enough for some of them to found the Women's Engineering Society in 1919 after the end of WWI. Women engineers in the USA set up their sister organisation, the Society of Women Engineers, in 1952 after the end of WWII and the Korean War.

One type of war work for around 200 women was ballistics computation, which eventually led to the development of the first American computer, ENIAC (Electronic Numerical Integrator and Computer). Although the credit for this work is mainly attributed to two male engineers, they could not have done it without their vast female task force. Until 1945, a "computer" was a human, usually female; after that point, this body of women was supplanted by a machine and women became

"operators", now called programmers. Chapter 11 by Jennifer S Light (1999) provides a detailed account and gender analysis of the involvement of women and the consequences of feminisation in this new discipline of computer science. Chapter 9 recounts the career path of Edith Clarke, an electrical engineer who worked on mathematical methods for power systems analysis, seeking to reduce the laboriousness of the calculations. The work eventually became machine-based with ENIAC becoming operational in the year in which she retired.

In Chapter 2, Amy Sue Bix (2004) provides a history of women's participation in engineering education in the USA: '*From 'Engineeresses' to 'Girl Engineers' to 'Good Engineers'.* Her recent (2014) book *Girls Coming to Tech!,* reviewed in the last issue of GST (Kumar, 2014), gives slightly more recent figures. Back in 1950, women were less than 1% of engineering students; by 2010/2011 they took 18.4% of engineering bachelors degrees, 22.6% of masters degrees and 21.8% of engineering doctorates.

These percentages however do not represent the proportion of women in the engineering workforce since a significant number of graduates do not go on to pursue an engineering career. In the opening chapter of the book, Tietjen and Reynolds (1999) set out issues identified by the National Academy of Engineering 1999 Summit on Women in Engineering (SWE). These relate to transition points in women's lives which need to be addressed to increase the number of women entering the engineering workforce and advancing an engineering career. They include work/life balance, networks and support including mentoring, career preparation in the college curriculum, valuing diversity, and environmental factors such as isolation, exclusion from networks and lack of role models and mentors. Universities,employers and peer networks such as SWE need to work together to find ways that these barriers can be overcome for young women engineers in the 21st century.

The history, development and implementation of such initiatives are explored in an accompanying volume: *Women in Engineering: A Professional Life* (Layne, 2009).

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