Episode 31 - Mary Cartwright

Mary Cartwright was born in Northamptonshire, England on December 17th, 1900. She was the second youngest of four children in a fairly affluent family. Two older brothers died in action in WWI and she was then sent to her uncle's home at age 11 to attend the reputable Learnington High School.

There she was guided by some very talented female mathematicians that helped her immensely and ended up shaping her future. In 1919, Cartwright began attending St. Hugh's College at Oxford University to study mathematics, but found it difficult getting into lectures that she was required to take as many male students returning from World War I were filling all the seats.

She asked friends who were able to get into the lectures for copies of their notes and attempted to study the coursework on her own. She was very disappointed when she only earned a second degree in mathematics in 1921 even though very few first degrees were given out that year.

After this disappointment, Cartwright considered changing her academic major to her first initial choice, history, but said ironically that she thought mathematics would be easier. So she decided to stick with it.

Soon after she attended a party made up from some professors in the field and one of the professors suggested to her that she attend one of Godfrey H Hardy's classes, a geometry teacher that was greatly admired at the school. Cartwright did so and she was enraptured by his lectures.

They inspired her to continue on with the subject and she graduated in 1923 with a first degree in mathematics. It was only a year prior that the school began allowing women to take final degrees.

Cartwright always retained a great love for history as well. Many of her mathematical publishings included a historical perspective that added a unique element to her work.

During the next four years, Cartwright taught mathematics, first at the Alice Ottley School in Worcester and then in the Wycombe Abbey School in Buckinghamshire. She began to feel overwhelmed by her administrative duties and felt she couldn't give her all to teaching with all the responsibilities on her plate. On top of that, the school had a highly regulated curriculum that didn't allow for any deviation.

Since she had no room to experiment or explore, Cartwright began to feel disconnected with her career. She felt compelled to return to mathematics research. In January of 1928, she was able to join Hardy's group of research students at Oxford.

One evening Hardy gave a list of problems in his seminar, one of which referred to an application of Abel's method of summation. He was amazed when Cartwright perfectly solved the problem using contour integration.

In October of 1930, Cartwright continued on with work in the Theory of Functions at Girton College, Cambridge. During this time she attended many of Littlewood's seminars, who was an esteemed mathematician whose work was in the field of mathematical analysis.

She caught Littlewood's attention when she obtained the right order of magnitude for the maximum modulus of multivalent functions, a problem that Littlewood had presented in his Theory of Functions class.

Cartwright impressed Littlewood with the creativity she had when adapting Alfer's [sp?] Distortion Theorem to such a different situation.

During the 1930s Cartwright's mathematics took off and she published several papers on integral functions, biomorphic functions, and analytic functions with essential singularities.

The results of her work focused on what came to be known as Cartwright's Theorem and considered very significant in various branches of mathematics. Her impeccable proof was published in 1935 in Germany's Records of Mathematics.

Cartwright's highly impressive work prompted Hardy and Littlewood to recommend her for an assistant lectureship in mathematics.

In 1934 she was chosen for a position in college lectureship in mathematics and a staff fellowship role. Cartwright became a part time university lecturer in mathematics in 1935.

She continued to excel in her role not only as a mathematician but in settling administrative difficulties, often with dry humor. She became Director of Studies in Mathematics at Girton College in 1936. Many students at Cambridge began to recognize Cartwright because she always bicycled to and from classes and committee meetings.

In 1939 the British Department of Scientific and Industrial Research asked Cartwright to help solve some nonlinear differential equations that seemed to be at the core of the issues that scientists were having with radar technology. This was circle technology that was to be utilized during World War II. Although her background was in complex analysis as opposed to dynamics, she and Littlewood decided to accept the job.

They were able to discover from the Vanderbull [sp?] Equation that as power increases the periodic solutions go through a series of exponentially higher subharmonic phases until they eventually occur irregularly. This explained why the radars were producing catastrophic results.

After this experience she began to volunteer regularly with the British Red Cross from 1940 to 1944.

Cartwright came to Littlewood for assistance in helping her understand the dynamical aspects of radio research and this partnership marked the beginning of a ten year collaboration between them. The majority of Cartwright and Littlewood's collaborative work was completed in the mid-1940s and one of the primary reasons why she was elected as a fellow of the Royal Society of London in 1947.

When asked if she felt there was any prejudice with women at Cambridge or within the Royal Society, Cartwright responded that during her time she never felt as if there was. According to many of Cartwright's students and colleagues she was outstanding in her role as supervisors and gave much encouragement to undergraduates. She was also known to meticulously grade her students' work. Not just the mathematics but in the English and syntax as well, and took pride in her thoroughness in critiquing work for improvement. She never made the students feel discouraged, however, and made it a point to uplift them.

Once Cartwright finished her collaborative work with Littlewood she began to feel that her administrative duties were standing in the way of her devotion to mathematics. Despite this she was still able to publish several papers on differential equations between 1950 and 1989. She published her book titled *Integral Functions* in 1956 and it was revolutionary in its depth and accuracy.

Those who worked with Cartwright reminisced fondly that she never seemed stressed even with her extremely full schedule. During her time as mistress of Girton she constantly proved that she was eager to adapt and evolve by implementing new practices. The college deeply appreciated her contributions to the advancement of knowledge, not just in her own field of mathematics but to many of the college's concerns.

In spite of an unfortunate bicycling accident that resulted in a broken hip, Cartwright kept busy. In 1971 she began working as a visiting professor at Case Western Reserve University in Cleveland, Ohio. She then returned to Great Britain to embark on a decade-long collaboration with HPF Swinnerton-Dyer, mathematician who specialized in Number Theory. This resulted in three highly esteemed papers on Boundedness Theorems for second order differential equations.

Cartwright continued her mathematical research well into the 1980s. She also spoke out about the importance of education for females. In 1989 she published an article titled, *Moments in a Girl's Life*, in the bulletin of the Institute of Mathematics and its applications.

Mary Cartwright died at age 97 in Cambridge on April 3, 1998. Cartwright was a pioneer in many ways. She was the first woman to achieve a first class on the Oxford finals. One of the first women to be elected to the Royal Society, and the first woman to sit on its

council. Cartwright's deep affinity for mathematics was a continuous theme throughout her life and she drew enormous satisfaction from it.

When she was asked what her favorite paper that she had written was, she gave an answer that most mathematicians can relate to. "The one I was working on at the moment."