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Grace Brewster Murray Hopper (1906-1992) was a computer pioneer and naval officer. She earned a master's degree (1930) and a Ph.D. (1934) in mathematics from Yale. Hopper is best known for her trailblazing contributions to computer programming, software development, and the design and implementation of programming languages. A maverick and an innovator, she enjoyed long and influential careers in the U.S. Navy and the computer industry.

Early Life and Education

The daughter of Walter Fletcher Murray (Yale B.A. 1894, Phi Beta Kappa) and Mary Campbell Van Horne, Grace Brewster Murray was born in 1906 in New York City. Her father owned an insurance company. In 1928, she graduated Phi Beta Kappa from Vassar College with degrees in mathematics and physics. After receiving her master's degree in mathematics from Yale, Hopper began teaching mathematics at Vassar while pursuing her doctorate. She completed her Ph.D. in mathematics from Yale in 1934. During a one-year sabbatical from Vassar, Hopper studied with the famous mathematician Richard Courant at New York University.

Service in the Navy

After the bombing of Pearl Harbor and the United States' entry into World War II, Hopper decided to join the war effort. She was initially rejected because of her age and diminutive size, but she persisted and eventually received a waiver to join the U.S. Naval Reserve (Women's Reserve). In December 1943, she took a leave of absence from Vassar, where she was an associate professor, and completed sixty days of intensive training at the Midshipmen's School for Women at Smith College in Northampton, Massachusetts.

After receiving her commission (lieutenant junior grade), Hopper was assigned to the Bureau of Ships Computation Project at Harvard University. There, she joined a team working on the IBM Automatic Sequence Controlled Calculator, better known as the MARK I, the first electromechanical computer in the United States. Under the guidance of Howard Aiken, who had developed the MARK I, Hopper and her colleagues worked on top-secret calculations essential to the war effort—computing rocket trajectories, creating range tables for new anti-aircraft guns, and calibrating minesweepers. One of the first three "coders" (now known as programmers), Hopper also wrote the 561-page user manual for the MARK I.

After the war ended, Hopper turned down a full professorship at Vassar to

continue her work with computers. In 1946, she left active service when the Navy declined her request for a regular commission due to her age, but she remained a naval reservist. From 1946 to 1949, she continued to work on the MARK II and MARK III computers under Navy contracts. At the end of her three-year term as a research fellow, she left Harvard because there were no permanent positions for women.

A Programming Pioneer

In 1949, Hopper joined the Eckert-Mauchly Computer Corporation in Philadelphia as a senior mathematician. The company, which was soon acquired by Remington Rand and then Sperry Rand, had built the first electronic computer (ENIAC) under army contracts. In the early 1950s Eckert-Mauchly was developing the Universal Automatic Computer (UNIVAC I), the first commercial electronic computer. While working on the UNIVAC I and II, Hopper pioneered the idea of automatic programming and explored new ways to use the computer to code. In 1952 she developed the first compiler called A-0, which translated mathematical code into machine-readable code—an important step toward creating modern programming languages.

In 1953, Hopper proposed the idea of writing programs in words, rather than symbols, but she was told her idea would not work. Nevertheless, she continued working on an English-language compiler, and in 1956 her team was running FLOW-MATIC, the first programming language to use word commands. Unlike FORTRAN or MATH-MATIC, which used mathematical symbols, FLOW-MATIC used regular English words and was designed for data processing purposes. She also demonstrated how programs could be written in word-based languages other than English.

Hopper's project of creating word-based languages helped expand the community of computer users. Making computers accessible to people without an engineering or math background was especially important at a time when computer companies were marketing their products to the private sector. By developing programs that used word commands rather than symbols, Hopper believed that more people would feel comfortable using computers, particularly for business applications such as payroll. In a 1980 interview Hopper explained, "What I was after in beginning English language [programming] was to bring another whole group of people able to use the computer easily…I kept calling for more user-friendly languages. Most of the stuff we get from academicians, computer science people, is in no way adapted to people."[i]

As the number of computer languages proliferated, the need for a standardized business language increased. In 1959, Hopper took part in the Conference on Data Systems Languages (CODASYL), the goal of which was to develop a common business language that could be used across industries and sectors. The finished product was COBOL, short for "common business-oriented language." Although many people contributed to this effort, Hopper is widely recognized for her work designing COBOL, developing compilers for

it, and encouraging its broad adoption. By the 1970s, COBOL was the "most extensively used computer language" in the world.[ii]

Throughout her career in the computer industry, Hopper remained a Navy reservist. In 1966, age restrictions forced her to retire from the Navy as a commander. She later called it "the saddest day of my life."[iii] Just months later, however, she was recalled to active service to help standardize the Navy's multiple computer languages and programs. She retired from UNIVAC, a division of Sperry Rand, in 1971.

Nicknamed "Amazing Grace" by her subordinates, Hopper remained on active duty for nineteen years. She retired from the Navy as a rear admiral at the age of 79—the oldest serving officer in the U.S. armed forces. That same year she went to work as a senior consultant in public relations at the Digital Equipment Corporation, where she worked until her death in 1992. Hopper was buried with full military honors in Arlington National Cemetery.

Rear Admiral Hopper was the recipient of more than forty honorary degrees, and many scholarships, professorships, awards, and conferences are named in her honor. In 1972 she received Yale's Wilbur Lucius Cross Medal awarded to outstanding alumni. In 1973, she became the first woman and the first American to become a Distinguished Fellow of the British Computer Society. In 1991, President George Bush awarded Hopper the National Medal of Technology "for her pioneering accomplishments in the development of computer programming languages that simplified computer technology and opened the door to a significantly larger universe of users;" she was the first woman to receive the nation's highest technology award as an individual.[iv] In 1996, the Navy commissioned the *USS Hopper*, a guided military destroyer. In 2016, Hopper posthumously received the Presidential Medal of Freedom, the nation's highest civilian honor, in recognition of her "lifelong leadership role in the field of computer science."[v]

A Gifted Teacher and Communicator

Hopper was not only a brilliant mathematician and computer scientist; she was also a gifted teacher and communicator. Although she left her faculty position at Vassar to join the Navy, teaching remained an important part of her life. In 1959, Hopper was a visiting and then adjunct lecturer at the Moore School of Electrical Engineering at the University of Pennsylvania. In the 1960s and 1970s, she taught and lectured at Penn, George Washington University, and for the U.S. Naval Reserve. Outside of academia, she organized myriad workshops and conferences to promote the understanding of computers and programming. In her remarks upon accepting the National Medal of Technology, Hopper said, "If you ask me what accomplishment I'm most proud of, the answer would be all the young people I've trained over the years; that's more important than writing the first compiler."[vi]

Hopper's talents as a teacher also helped her communicate with a wide variety of audiences—technical experts, engineers, business leaders, data processors, young people, and the general public. She helped persuade

business clients of the value of adopting new technologies, and her biographer Kurt Beyer describes her as a "spokesperson for the evolving computer industry" in the 1950s.[vii] Hopper played a similar role for the Navy. From 1977 to 1986, she was "the Navy's foremost propagandist for its computer program as…[its] representative to learned societies, industry associations, and technical symposia."[viii] In the last years of her life, she did similar public relations work for the Digital Equipment Corporation. Throughout her career, Hopper placed great value on being able to explain complex situations and problems to many different audiences. "I've come to feel that there is no use doing anything unless you can communicate," she said in a 1980 interview.[ix]

A Visionary Trailblazer

Hopper came of age at a time of unusual opportunity for women. A relatively high number of women were receiving doctorates in the 1920s and 1930s—numbers that would not be matched again until the 1980s.[x] World War II also created opportunities for women to enter the workforce in greater numbers. Nonetheless, her success in a male-dominated field and in male-dominated organizations, including the U.S. Navy, was exceptional.

An optimist as well as a visionary, Hopper celebrated the potential of computers. "I think we consistently…underestimate what we can do with computers if we really try," she once said.[xi] In a 1983 interview on "60 Minutes," host Morely Safer asked if the computer revolution was over. Hopper replied, "No, we're only at the beginning…We've got the Model-T." Until the end of her life, Rear Admiral Grace Hopper looked forward with confidence to new technologies and their problem-solving capabilities.

Further Reading

Kurt W. Beyer, *Grace Hopper and the Invention of the Information Age* (Cambridge: MIT Press, 2009).

Kathleen Broome Williams, *Grace Hopper: Admiral of the Cyber Sea* (Annapolis: Naval Institute Press, 2004).

[i] Transcript, Grace Hopper, Oral History Interview by Angeline Pantages, December 1980, 11. Computer History Museum. http://www.computerhistory.org/collections/catalog/102702026. Hereafter Pantages/Hopper Oral History.

[ii] Kurt W. Beyer, *Grace Hopper and the Invention of the Information Age* (Cambridge: MIT Press, 2009), 304, 310.

[iii] Kathleen Williams, "Improbable Warriors: Mathematicians Grace Hopper and Mina Rees in World War II," in B. Booss-Bavnbek and J. Høyrup, eds., *Mathematics and War* (Basel: Birkhäuser, 2003), 117.

[iv] "Rear Adm. Grace M. Hopper Dies; Innovator in Computers Was 85," *New York Times,* January 3, 1992,

http://www.nytimes.com/1992/01/03/us/rear-adm-grace-m-hopper-dies-innova…

[v] "President Obama Names Recipients of the Presidential Medal of Freedom," White House Press Release, November 16, 2016, https://obamawhitehouse.archives.gov/the-press-office/2016/11/16/preside….

[vi] Poor health prevented Hopper from receiving the award in person, but she prepared these remarks, which were delivered on her behalf. See Carmen Lois Mitchell, "The Contribution of Grace Murray Hopper to Computer Science and Computer Education" (Ph.D. diss., University of North Texas, 1994), 77.

[vii] Beyer, *Grace Hopper*, 11.

[viii] Williams, "Improbable Warriors," 118.

[ix] Pantages/Hopper Oral History, 26.

[x] Beyer, *Grace Hopper*, 3.

[xi] Pantages/Hopper Oral History, 48.