

# Grace Brewster Murray Hopper

*Born December 17, 1906, New York City; died January 1, 1992, Arlington, Va.; Rear Admiral, US Navy; developer of programming technology for the Harvard Mark I<sup>1</sup> and the Univac I, early protagonist of high-level languages, and leader in the development of compilers for, and the use of, Cobol.*



*Education:* Hartridge School, Plainfield, NJ., 1924; BA, Phi Beta Kappa, Vassar College, 1928; MA, Yale University, 1930; PhD, Yale University, 1934; Sigma Xi, 1934; Vassar faculty fellow, New York University, 1941-1942.

*Military Record:* apprentice seaman and midshipman USNR, midshipman, School-W, Northampton, Mass., 1944; Lieutenant junior grade), 1944; Lieutenant, 1946; Lieutenant Commander, 1952; Commander, 1957; retired with rank of Commander, 1966; recalled to active duty, 1967; Captain, 1973; Commodore, 1983; Rank of Commodore renamed as Rear Admiral, 1985.

*Professional Experience:* instructor to associate professor, Department of Mathematics, Vassar College, 1931-1943; assistant professor of mathematics, Barnard College, 1943; mathematical officer, US Navy, Bureau of Ordnance, 1944-1946; research fellow in engineering sciences and applied physics, Computation Laboratory, Harvard University, 1946-1949; senior mathematician, Eckert-Mauchly Computer Corp., 1949-1952; systems engineer, director of Automatic Programming Development, Univac Division of the Sperry Corp., 1952-1964; visiting lecturer to adjunct professor, Moore School of Electrical Engineering, University of Pennsylvania, 1959; staff scientist, systems programming, Univac Division of Sperry Corp. (on military leave 1967-1971), 1964-1971; active duty, US Navy, serving in the Information Systems Division as OP-91 IF, 1967-1977; professorial lecturer in management sciences, George Washington University, 1971-1978; active duty, US Navy, serving as NAVDACOOH, 1977-1986; senior consultant, Digital Equipment Corporation, 1986-1991.

*Honors and Awards:* Naval Ordnance Development Award, 1946; fellow, Institute of Electrical and Electronics Engineers, 1962; fellow, American Association for the Advancement of Science, 1963; Society of Women Engineers, SWE Achievement Award, 1964; Institute of Electrical and Electronics Engineers, Philadelphia Section Achievement Award, 1968; Connelly Memorial Award, Miami Valley Computer Association, 1968; Data Processing Management Association, Computer Science "Man of the Year" Award, 1969; Upsilon Pi Epsilon, honorary member, Texas A&M, Alpha Chapter, 1970; American Mothers Committee, Science Achievement Award, 1970; Harry Goode Memorial Award, American Federation of Information Processing Societies, 1970; honorary doctor of engineering, Newark College of Engineering, Newark, New Jersey, 1972; Wilbur Lucius Cross Medal, Yale University, New Haven, Conn., 1972; fellow, Association of Computer Programmers and Analysts, 1972; Epsilon Delta Pi, honorary member, SUNY Potsdam Chapter, Potsdam, N.Y., 1973; honorary doctor of science, C. W.

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<sup>1</sup> Known within IBM as the Automatic Sequence Controlled Calculator (ASCC).

Post College of Long Island University, Greenvale, N.Y., 1973; member, National Academy of Engineering, 1973; Legion of Merit, 1973; distinguished fellow, British Computer Society, 1973; honorary doctor of laws, University of Pennsylvania, Philadelphia, 1974; Distinguished Member Award, Washington, D.C., Chapter, Association for Computing Machinery, 1976; honorary doctor of science, Pratt Institute, 1976; W. Wallace McDowell Award, Institute of Electrical and Electronic Engineers Computer Society, 1976; honorary doctor of science, Linkoping University, Sweden, 1980; IEEE Computer Society Pioneer Award, 1980; honorary doctor of science, Bucknell University, Lewisburg, Pennsylvania, 1980; honorary doctor of science, Acadia University, Wolfville, Nova Scotia, 1980; Navy Meritorious Service Medal, 1980; honorary doctor of science, Loyola University, Chicago, 1981; honorary doctor of science, University of Chicago, 1981; honorary doctor of science, Southern Illinois University, Carbondale, Ill., 1981; fellow, Institute for the Certification of Computer Professionals, 1981; honorary doctor of public service, George Washington University, Washington, D.C., 1981; honorary doctor of humane letters, Seton Hill College, Greensburg, Pa., 1982; Gold Medal, Armed Forces Communications and Electronics Association, 1982; honorary doctor of science, Marquette University, Milwaukee, 1982; dedication of the Grace Murray Hopper Center for Computer Learning, Brewster Academy, Wolfeboro, N.H., 1983; Ada August Lovelace Award, Association of Women in Computing, 1983; honorary doctor of business administration, Lake Forest College, Lake Forest, Ill., 1983; honorary doctor of science, Clarkson University, Potsdam, N.Y., 1983; Computer Pioneer Medal, Institute of Electrical and Electronic Engineers, 1983; honorary doctor of science, Hood College, Frederick, Maryland, 1983; honorary doctor of science, Russell Sage College, Troy, N.Y., 1983; Golden Plate Award, American Academy of Achievement, Coronado, Calif., 1983; honorary doctor of science, Villajulia College, Baltimore, Md., 1983; Achievement Award, American Association of University Women, 1983; Federally Employed Women Achievement Award, 1983; Distinguished Service Award, Association of Computing Machinery, 1983; Living Legacy Award, Women's International Center, San Diego, Calif., 1984; Jane Addams Award, Rockford College, Rockford, Ill., 1984; Woman of the Year Award, Young Women's Christian Association of the National Capital Area, 1984; Andrus Award, American Association of Retired Persons Annual Award, 1984; Centennial Award, Institute of Electrical and Electronics Engineers, 1984; Engineering and Science Hall of Fame, Dayton, Ohio, 1984; Samuel Eliot Morison Award for Distinguished Service, USS Constitution Museum, Boston, 1984; honorary doctor of science, University of Maryland, College Park, 1984; honorary doctor of laws, Smith College, Northampton, Mass., 1984; honorary doctor of science, St. Peter's College, Jersey City, NJ., 1984; honorary doctor of science, Worcester State College, Worcester, Mass., 1984; honorary doctor of science, Hartwick College, Oneonta, N.Y., 1984; honorary doctor of business administration, Providence College, Providence, R.I., 1984; honorary doctor of science, City College of Morris, Morristown, NJ., 1984; honorary doctor of science, Bloomsburg College, Bloomsburg, Pa., 1984; honorary doctor of science, Aurora College, Aurora, Ohio, 1985; honorary doctor of science, Wright State University, Dayton, Ohio, 1985; honorary doctor of letters, Western New England College, Springfield, Mass., 1985; INFOMART Information Processing Hall of Fame, Dallas, Texas, 1985; Award of Merit, American Consulting Engineer Council, Colorado Springs, Colo., 1985; Honorary Navy Recruiters, United States Navy Recruiting Command, 1985; Henry T. Heald Award, Illinois Institute of Technology, Chicago, 1985; honorary doctor of laws, College of William and Mary, Williamsburg, Va., 1985; honorary doctor of science, Rivier College, Nashua, N.H., 1985; honorary doctor of science,

Marist College, Poughkeepsie, N.Y., 1985; honorary doctor of science, Saint John Fisher College, Rochester, N.Y., 1985; honorary doctor of science, Syracuse University, Syracuse, N.Y., 1986; honorary doctor of humane letters, Caldwell College, Caldwell, NJ., 1986; honorary doctor of science, University of Massachusetts at Amherst, 1986; honorary doctor of military science, Northeastern University, Boston, 1986; Lifetime Achievement Award, Federation of Government Information Processing Councils, 1986; Unsung Heroine Award, Ladies Auxiliary to the Veterans of Foreign Wars, 1986; Distinguished Achievement Award, American Aging Association, 1986; Meritorious Citation, Navy Relief Society, 1986; Navy Distinguished Service Medal, 1986; honorary doctor of letters, Drexel University, Drexel, Pa., 1987; Charles Holmes Pette Medal, University of New Hampshire, Durham, 1988; The Emanuel R. Piore Award, Institute of Electrical and Electronics Engineers, 1988; National Medal of Technology, 1991; National Women's Hall of Fame, 1994 (posthumously).

Rear Admiral Grace Brewster Murray Hopper, first lady of software and first mother-teacher of all computer programmers, died in her sleep in her Arlington, Va., home on January 1, 1992. She was 85.

Born in New York City on December 9, 1906, she received a BA in mathematics and physics from Vassar College in 1928, where she was elected to Phi Beta Kappa. Her graduate studies in mathematics at Yale University earned her an MA in 1930 and a PhD in 1934. She returned to Vassar where she taught mathematics from 1933 to 1943. In December of that year she joined the US Naval Reserve, attended Midshipmen's School at Northampton, Mass., and on graduation in July 1944, was commissioned a lieutenant, junior grade. She was at once assigned to the Bureau of Ordnance's Computation Project at Harvard University, where she was greeted by Naval Reserve Commander Howard Hathaway Aiken with the words, "Where the hell have you been?"

He pointed to the Harvard Mark I, said it was a computing machine, and told Lieutenant Hopper to compute the coefficients of the arc tangent series by Thursday. Thus it was that she, who later said, "I had never met a digit and I wanted nothing to do with digits," came into the computer business, becoming, in her words, "the third programmer on the world's first large-scale digital computer." (The two who preceded her, then called "coders," were Ensigns Robert Campbell and Richard Bloch.)

In addition to using the Mark I for mathematical calculations she was assigned the task of drawing together all the mimeographed notes concerning the machine into a *Manual of Operation for the Automatic Sequence Controlled Calculator*. This became a 500-page volume that both explained how to set up the machine and outlined the operating principles of computing machines. It was published in the spring of 1946 as Volume I of the *Annals of the Harvard Computation Laboratory* and has since been reprinted by the Charles Babbage Institute as Volume 8 of its *Reprint Series on the History of Computing*. Although no title page credit is given, Hopper was both the editor and a major contributor to the volume, writing both the first chapter on history and the two chapters of machine description and electromechanical circuit operation.<sup>1</sup>

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<sup>1</sup> Extracts from the manual were published in 1946 under the authorship of both Aiken and Hopper in the AIEE magazine, *Electrical Engineering*, and are reprinted in *The Origins of Digital Computers, Selected Papers*, edited by Brian Randell.

It was while working with the successor to the Mark I, the Mark II, in the summer of 1945, that the incident of what has come to be called the First Bug occurred. A large moth had caused a relay to fail. Hopper entered the moth, with Scotch tape, in the log book with the note, "First actual case of bug being found." (The log book and the moth are in the National Museum of American History, Smithsonian Institution.) It is clear from her note that she did not believe she had invented the term, which has since been traced back to at least the time of Edison, but was humorously pleased to have found a real bug that had caused a bug in the machine.<sup>1</sup>

At the end of World War II she resigned from Vassar and was appointed to the Harvard faculty as a research fellow in the Computation Laboratory. In 1949 she joined, as senior mathematician, the newly formed Eckert-Mauchly Corporation where BINAC and Univac were under construction and stayed with that firm and its successors (Remington-Rand and Sperry-Rand) until her retirement in 1971. It was in these years that her major contributions to programming were made. Inspired by John Mauchly's "Short Order Code,"<sup>2</sup> of 1949 and Betty Holberton's first Sort-Merge Generator of 1951, she developed the first compiler,<sup>3</sup> A-0 (1952), and later modified it to produce A-2 (1953). This work, and her view of what programming languages ought to be like, led her to the development of the first English-language data processing compiler, B-0 (FLOW-MATIC), completed in 1957.

Her views on programming and computing were expressed in "The Education of a Computer" first published in the *Proceedings of the ACM Conference*, May 1952.<sup>4</sup> In it she expressed the hope that "the programmer may return to being a mathematician." In this paper she anticipated artificial intelligence saying, "it is the current aim to replace, as far as possible, the human brain by an electronic digital computer." She recognized that the software would turn out to be more expensive than the hardware and foresaw that there would be the same kinds of applications in commercial programming as there were then in mathematics. The paper includes glimmerings of many tools and techniques concerning compilers that are now commonplace, including subroutines, translation of a formula, relative addressing, the linking loader, and code optimization. In it she also anticipated symbolic manipulation.

In the opinion of some who were there at the time, had Remington-Rand supported Hopper's efforts more vigorously and exploited her programming developments with the skill and force that IBM was then exploiting Fortran, she might have saved her employer from being overtaken by others in the industry.

Grace Hopper's involvement with Cobol was indirect, through her subordinates who served on the committee which developed the Cobol specifications, and through FLOWMATIC. The influence of FLOWMATIC on Cobol was enormous since it was the only English language business data processing language in use at the

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<sup>1</sup> The story appears, with a photograph of the bug, in *Ann. Hist. Comp.*, Vol. 10, No. 4, 1989, pp. 340-342. A letter in Vol. 13, No. 4, 1991, pp. 360-361, raises a question about the date of the event.

<sup>2</sup> Schmitt, William E "The UNIVAC Short Code," *Ann. Hist. Comp.*, Vol. 10, No. 1, 1988, pp. 7-18.

<sup>3</sup> Hopper's concept of a compiler was slightly different from that of today. In many ways her compiler would more qualify as a macro-assembler and was closer to the English dictionary description referring to library activities.

<sup>4</sup> Reprinted with an introduction by David Gries, in *Ann. Hist. of Comp.*, Vol. 9, No. 3/4, 1988, pp. 271-281.

time that the Cobol effort started. As such, FLOWMATIC served as a model on which to build and augment with inputs from other sources.

She was an early member of the Association for Computing Machinery and served on its council. In 1957 she edited its first *Glossary of Computing Terms*, the discipline's first authoritative dictionary. For several decades she was the most requested speaker of all those on the ACM lecture circuit. Her talks, which were both educational and highly entertaining, are still remembered for the physical representations she would give to abstract concepts, such as the short piece of wire she would hold up to represent a nanosecond.<sup>1</sup> In speaking of the future she early expressed her hope that she would one day have a computer the size of a shoe box, this at a time when computers occupied several rooms.

Throughout her life she was active in the US Naval Reserve. In 1946 she was put on inactive status only to be recalled to active duty in August 1967 to help the Navy with its manifold computing problems. She was promoted successively through the ranks and after the regular retirement age of 62 was given repeated year-to-year extensions to stay on active duty until her final retirement as Rear Admiral, the rank she received as a special presidential appointment in 1983. The August 14, 1986, ceremony for the retirement of the oldest serving officer of the US Navy was held aboard the USS *Constitution*,<sup>2</sup> “Old Ironsides,” the oldest warship still in commission in the US Navy. The ceremony took place not far from the location at Harvard University of the Mark I computer on which she first worked. At her retirement she was given the Navy Distinguished Service Medal. She had honorary degrees from more than 40 colleges and universities. She received the first Computer Sciences “Man of the Year” award from the Data Processing Management Association (1969); the Harry Goode Memorial Award from AFIPS (1970); and the Wilbur Lucius Cross Medal from Yale (1972). In September 1991 she was awarded 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 award as an individual.

She always wanted to help young people and she took great pride in the fact that, in 1971, Sperry-Rand created the Grace Murray Hopper Award, which is presented annually by the ACM to a distinguished young computer professional. She considered her best biography to be *Grace Hopper, Navy Admiral & Computer Pioneer*, by Charlene W. Billings, which she hoped would encourage girls to look to careers in computing and in the Navy.

Her talent, vision, dedication, and persistence laid the foundation for computing as we know it and helped to guide it in its explosive growth. She was always a teacher, battling the entrenched attitudes of what she always called “the establishment.” She could always give a humorous twist to the presentation of her ideas. For example, she hated the phrase, “but it's never been done that way,” and, to remind visitors of this dictum, kept a ship's clock on the office wall behind her desk—it ran backwards.

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<sup>1</sup> I have met many people who remember Grace Hopper for her gift of a “nano-second,” but no one can find a sample!

<sup>2</sup> The Constitution is actually a frigate, and thus its proper designation is USE but this is rarely used today.

At the time of her death she was employed as a senior consultant at Digital Equipment Corporation, and until 18 months before her death was actively representing the company at industry forums, making presentations that focused on government issues and participating in corporate educational programs.

Admiral Hopper was sometimes called “Amazing Grace” because she recorded successful careers in academia, business, and the US Navy while making history in the computer field. Just as Admiral Hyman Rickover is considered the father of the nuclear navy, Admiral Hopper was the mother of computerized data automation in the naval service.

Grace Hopper was buried at Arlington Cemetery, Washington D.C., on January 7, 1992, in a full naval ceremony.<sup>1</sup>

## QUOTATION

“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.”

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<sup>1</sup> Edited from Weiss, 1992.

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Hopper, Grace Murray, "The Education of a Computer," *Proc. ACM Conf.*, reprinted *Ann. Hist. Comp.*, Vol. 9, No. 3-4, 1952, pp. 271-281.<sup>1</sup>

### **UPDATES**

New Portrait (MRW, 2013)

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<sup>1</sup> The reprint of this paper states that it was presented in Pittsburgh, Pa.; however, other references to the 1952 ACM conference also list Toronto as the venue.