"Amazing Grace" Hopper

The Woman Who Brought the Navy into the Digital Age

by Kathleen Broome Williams

Rear Admiral Grace M. Hopper, USN

In 1983 Grace Murray Hopper, then seventy-six years old, was made an admiral in the US Navy by special presidential appointment. Four years later, the Navy named its new computer center in San Diego for her, and in 1996, four years after her death, it christened its newest Arleigh Burke class destroyer USS *Hopper* (DDG 70). The recipient of numerous medals, awards, and honorary degrees, Grace Hopper was esteemed both for her giant intellect and for her unceasing energy. As befits a leader instrumental in creating a whole new discipline, her message to everyone was, above all, to innovate and never to be tied to the old or customary way of doing things. Although she never went to sea during her decades of service to the Navy, her computer expertise and managerial skills made her a pivotal figure in the Navy's path to the computer age.

Although you may not be aware of it, every time you turn on your computer you owe a huge debt to Grace Hopper. In the 1940s and 50s, she and her fellow pioneers, with support from the US Navy, created the new field of computing that is so ubiquitous today.

A Yale-trained mathematician, Hopper joined the Navy in December 1943, keen on serving the war effort directly. At thirty-seven, she already had a successful teaching career at Vassar College, but at that time women were only permitted to join the Reserves. Nevertheless, in June 1944, as a newly commissioned lieutenant (junior grade), Hopper was sent to Harvard University's Computation Project—then operating under the Bureau of Ships—to work on the Mark I computer.

Even as a very young child, Hopper was inquisitive and fearless. She was especially driven to find out how things worked, even if this meant taking apart all the alarm clocks in her home and other antics that her patient parents chose to indulge and gently guide her towards more productive endeavors. Thus, both by temperament and by life experience, Grace Hopper was uniquely suited to seize the opportunities for innovative work that would so suddenly be presented to her.

During World War II, the vast expansion of the US Navy and the accompanying upsurge in data management needs accelerated the development of modern digital computers, although most were not operational until after the conflict ended. Harvard's Mark I computer—a.k.a. the Harvard Calculator—was an exception. Developed by doctoral student Howard Aiken, the Mark I was the first functional, large-scale, automatically sequenced, general purpose, digital computer to be produced in America, making it one of the few computers ready early enough to play a significant role in the war. Desperate for gunnery and ballistics calculations, the Navy leased the Mark I for the duration of the war. It was the Mark I that introduced Hopper to the emerging world of computing. It was at Harvard that the newly commissioned Lt. Grace Hopper was assigned to the US Navy Bureau of Ships Computation Project to work on the Mark I in 1944, introducing her to the emerging world of computing and sparking a fascination that was to absorb the rest of her life.

With the war raging, there was no time for training; Hopper learned on the job how to write the codes that put the Mark I to work, becoming one of the first-ever computer programmers. Operating around the clock, the Mark I churned out essential data for all sorts of ordnance projects, making complex calculations for naval guns, acoustic and magnetic mines, self-propelled

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Capt. Grace M. Hopper takes the oath of office from Secretary of the Navy John Lehman, during White House ceremonies promoting her from the rank of Captain to Commodore, 15 December 1983. President Ronald Reagan looks on.

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Grace Hopper teaching a COBOL class, 1961

rockets, and even the atomic bomb. In addition to being one of only three programmers for the Mark I and writing its first manual of operations, Hopper was also instrumental in the development of its successors, the Mark II and the Mark III, which were used by the Navy after the war. Reflecting on the significance of military sponsorship of science, Hopper often maintained that there would not have been a computer industry at all without that early Navy support.

Entering the computing field on the ground floor, Hopper influenced the US Navy's ability to wage a modern, math-dependent war. With this head start in the discipline, she continued to make invaluable contributions to computer development for the next forty-four years. In the earliest days of computing, there was no distinction between a computer's hardware and its software—between the machine itself and what it was instructed to do. Indeed, these terms had not even been coined. Yet from the beginning, Hopper had been relatively uninterested in hardware, focusing instead on methods to speed the writing of coding instructions for individual programs. It was in this field—in what became known as programming—that she made her major contributions, both to the Navy and to commercial computing.

When World War II ended, Hopper wanted to transfer to the regular Navy, but at age thirty-eight, she was over the cutoff age and had to satisfy herself with staying in the Naval Reserve. Still, the new field in which the Navy had trained her opened exciting postwar opportunities in the civilian sector, as computing steadily became an accepted academic discipline and also began to be adopted by commercial ventures such as banks and insurance companies. Relatively few men had the same training and experience as Hopper; later, she loved to point out that, in the 1940s, all the computer people in the country could fit into one small room.

Initially, Hopper remained at Harvard working with Aiken in his computation lab, but in 1949 she joined the firm responsible for creating one of the first successful commercial computers, the UNIVAC. Hopper remained with the UNIVAC division through its various acquisitions and mergers that eventually created Sperry Rand, later to become UNYSIS. It was during these years that she produced her most innovative work. She retired from the company in 1971.

At UNIVAC in 1952, Hopper developed the first compiler—the A-0, a library of subroutines that the computer itself could assemble into a program. Quick to grasp that computers did not have to be instructed only by mathematical symbols, as conventional wisdom dictated, in 1957 Hopper completed FLOWMATIC, the first English language compiler. By 1960, FLOWMATIC became one of the main ingredients in the collaborative creation of COBOL, soon to be widely adopted as a universal computer language. This work was so significant that in 1969 the Data Processing Management Association named Hopper its first Computer Sciences Man of the Year (!) for her contribution to the development of COBOL.

In the meantime, during the eighteen years she spent as a civilian in industry, Hopper maintained her Naval Reserve status, assigned to the Fourth Naval District in the Philadelphia Navy Yard. She worked as a consultant on many classified projects, each requiring her to learn new fields of application such as flutter and fuselage analysis, electronics and radar, accounting systems, and logistical problems, including those involving explosives.

Finally, however, time caught up with her. By her own account, late in 1966 she received a letter from the Chief of Naval Personnel telling her that she had served twenty-three years, which was over twenty. "I knew that," she loved to tell interviewers. The letter also informed her that she was about to turn sixty. "I knew that too," said Hopper. The final paragraph of the letter asked her to apply for retirement, which she reluctantly did, effective 31 December 1966. Her final fitness report stated simply that Commander Hopper was "an outstanding officer in all respects and a wonderful person." "It was the saddest day of my life," recalled Hopper.[1]

Only seven months later, the Navy repented its bureaucratic efficiency and reversed the decision to let Hopper go. With the naval expansion in response to the Vietnam War and the consequent increasing demand for computerized systems, Hopper's skills were once again recognized as invaluable. On 1 August 1967, Grace Hopper was recalled to active duty with a temporary appointment for six months. She stayed nineteen years. Her first project was to develop a Tactical Data System for atomic submarines, but her most important work was in the standardization of Navy

NHHC, US NAVY

The computers of Grace Hopper's early years in the Navy were massive machines: the Mark I was 51 feet long by 8 feet high by 2 feet deep. (above) Grace Hopper demostrates a UNIVAC computer. (right) In the late 1960s, she used bundles of wire "nanoseconds" to demonstrate how designing smaller components would produce faster computers.

computer languages. She implemented a comprehensive program to standardize COBOL in the US Navy, replacing the numerous and incompatible versions of the language then in use, revolutionizing the Navy's management information systems.

From 1977 until her final retirement in 1986, Hopper was at the Naval Data Automation Command Headquarters (NAVDAC, now NAVCOMTEL-COM) in Washington, DC. In those last years, she became the Navy's foremost propagandist for its computer program as NAVDAC's representative to learned societies, industry associations, and technical symposia. She was particularly keen to speak at schools and colleges, where she encouraged young people to take up careers in computing. Often referred to as *Amazing Grace* and *Grandma COBOL* by an admiring press, Hopper gave hundreds of speeches annually, becoming a nationally recognized advocate for Navy computing and for the computer sciences she had helped to establish. She also addressed top Navy brass, whom she enjoyed chastising for their ignorance about computing.

PHOTO BY LYNN GILBERT

Capt. Grace M. Hopper in her Washington, DC, office, 1978.

John F. Lehman, who served as secretary of the navy for six years (1981 to 1987), worked with Hopper "from time to time," and was largely responsible for pushing her promotion to admiral in 1983. She was already seventy-four years old and still working when he first met her. According to Lehman, Grace Hopper was not the least bit intimidated by what he called "the natural resistance to change and inertia of every big bureaucracy." "She had a tremendously forceful and creative personality, as well as a sense of humor." He recalled that she was "very, very bright," and that she "drove the Navy into the computer age with whips and scourges."[2]

Grace Hopper retired as a rear admiral in 1986. Then seventy-nine, she was the oldest active duty officer in the US Navy and the recipient of numerous honors, including the Legion of Merit (1973), the Navy Meritorious Service Medal (1980), and the Institute of Electrical and Electronic Engineers Computer Pioneer Medal (1983). Yet these impressive-sounding accomplishments tend to obscure her most important contribution, which was "above all," in the words of a former colleague, "to make computers a part of ordinary life for ordinary people." In that pursuit she was supremely successful.[3]

Inevitably, Hopper was also the subject of several myths, not the least that she had invented the term "bug" to explain mysterious computer failures. While it is true that she found an actual moth in the Mark II, which was then pasted into the computer's logbook where it can still be seen today labeled "first actual bug found"—this greatly amused her colleagues because the term had already been in regular use for some time. There were also other tales that were widely disseminated in the press, such as that Hopper had created the computer language COBOL (it was created by committee), or that she was the first woman to achieve the rank of rear admiral (she was not). Hopper

did not start these stories, but neither does she seem to have discouraged them.

On 1 January 1992, Grace Murray Hopper died peacefully in her sleep at her home in Washington, DC. She was buried with full military honors in Arlington National Cemetery. Eight years later, in a review of a book on early modern European warfare, Steven Ross of the Naval War College, Newport, Rhode Island, wrote: "military organizations not only by their very existence but also by their effectiveness in battle act as engines of social and political change."[4] An engine of change—a perfect metaphor for Grace Hopper. ⚓

PHOTO BY MC SPECIALIST 1ST CLASS CHARLES E. WHITE, USN

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NOTES

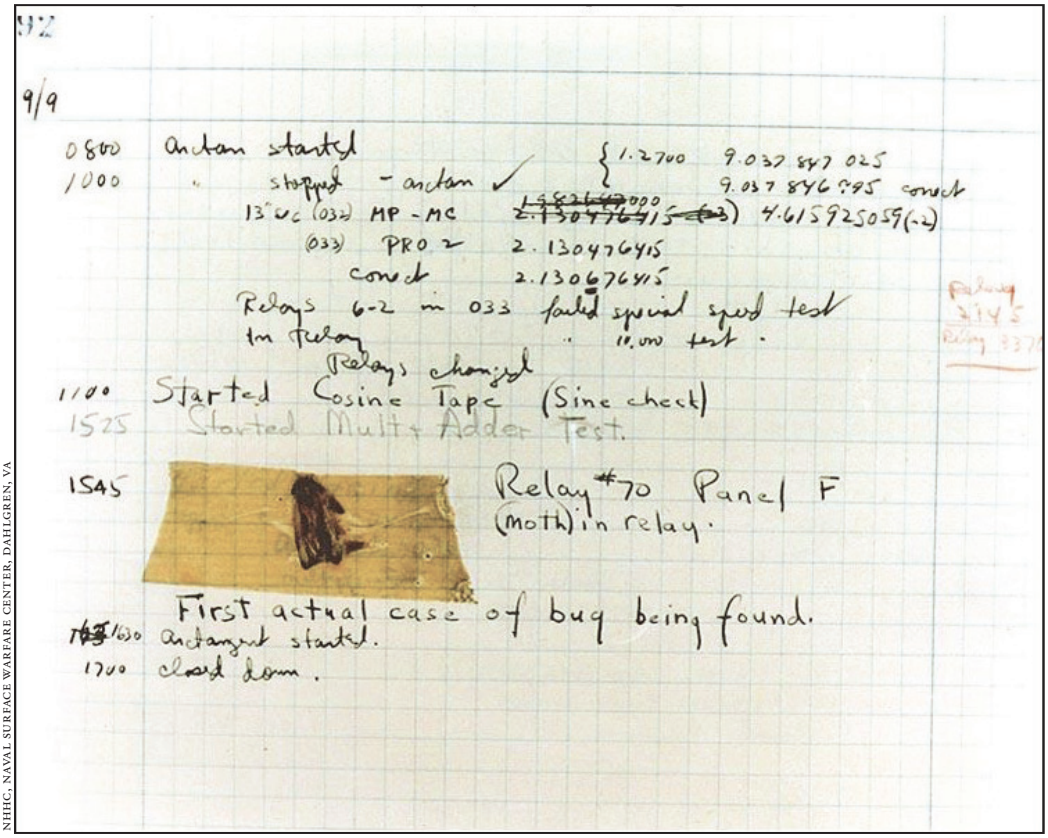
[1] Grace Hopper interview by Charles Evans, 1976, p. 1, OHI81, Charles Babbage Institute, University of Minnesota, MN; Grace Murray Hopper Officer Fitness Report, 26 February 1967, Official Military Personnel File, National Personnel Records Center, NARA, St. Louis, MO; Charlene W. Billings, Grace Hopper: Navy Admiral and Computer Pioneer (Hillside, NJ: Enslow Publishers, Inc., 1989), 87.

[2] Author's telephone interview with John F. Lehman, 26 June 1998.

[3] Ken Olsen, president and founder of Digital Equipment Corporation, quoted in Williams, Grace Hopper: Admiral of the Cyber Sea, (Annapolis, MD: Naval Institute Press, 2004), 187.

[4] The Journal of Military History, Vol. 64, No.1, January 2000, 186.

The First Computer Bug



NHHC, NAVAL SURFACE WARFARE CENTER, DAHLGREN, VA

On 9 September 1947, Lt.j.g. Grace Hopper was working on the Harvard University Mark II Aiken Relay Calculator. In the process of testing the Mark II to investigate the cause of a malfunction, a moth was found trapped between points at Relay #70, Panel F. The operators removed and taped the moth to the computer log, with the entry: "First actual case of bug being found." They put out the word that they had "debugged" the machine, thus introducing the term "debugging a computer program." In 1988, the log, with the moth still taped by the entry, was found in the Naval Surface Warfare Center Computer Museum at Dahlgren, Virginia.