Vannevar E. Bush

Born March 11, 1890, Everett, Mass.; died June 28, 1974, Belmont, Mass.; inventor of the pre-World War II electromechanical differential analyzer, and wartime US scientific leader whose conception of "Memex" foreshadowed personal computers; instrumental in the development of the atomic bomb.

Education: BS, MS, Tufts College, 1913; DEng, electrical engineering, MIT and Harvard University, 1916.

Professional Experience: General Electric, 1913; electrical inspector, New York Navy Yard, 1919; MIT, associate professor of electric power transmission, 1919-1932, first vice president and dean of engineering, 1932-1939; president, Carnegie Institution, 1939-1955.

Honors and Awards: member, National Academy of Sciences, 1934; honorary Knight of the British Empire (KBE), 1948.

Between 1927 and 1943 Bush developed a series of electromechanical analog computers which greatly facilitated the solution of complex mathematical problems. Notably in 1931, with Frank D. Gage, Harold L. Hazen, King E. Gould, and Samuel H. Caldwell, Bush completed the Differential Analyzer. It could solve sixth-order differential equations and three simultaneous second-order differential equations.

Bush's 1936 paper, entitled "Instrumental Analysis," given as the American Mathematical Society's Gibbs Lecture that year, was an excellent survey of both analog and digital calculating devices. It included several references to Charles Babbage's work and in particular to the collection of papers published by Babbage's son (1889). The section on digital devices concluded with a discussion of how it might be possible to devise a programmable master controller that would turn a set of existing IBM punched-card machines into, effectively, what Bush described as "a close approach to Babbage's large conception."[1]

It turns out that Bush did not stop at speculation, but went on to set up a project, the Rapid Arithmetical Machine, of which astonishingly little is known. Bush himself in his later years had either forgotten which seems unlikely, or consciously downplayed the significance of this work. Indeed, in his autobiography, *Pieces of the Action* (1970), he wrote, "Who invented the computer? I can write at once that I did not; in fact I had little to do with that whole development." In 1936 the Rockefeller Foundation awarded a major grant to MIT, which resulted in the famous Rockefeller differential analyzer of World War II.

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[1] In many ways, of course, this is exactly what Aiken, starting in 1937, convinced IBM to do, thus starting a project that led to the successful completion in 1944 of the first US program-controlled calculator, the Harvard Mark I.

Immediately after he delivered his 1936 paper, Vannevar Bush apparently started to work on the design of an electronic digital computer. There is evidence that he documented these ideas in a series of memoranda written during 1937 and 1938 but, despite extensive searches, these have not been found.[1] What we know of them comes from later MIT reports by W.H. Radford (1938, 1939) and from some letters and one 1940 memorandum by Bush.

The proposed machine was to be completely automatic, able to read data on perforated paper tape, to store the data in internal registers, to perform any of the four basic arithmetic operations, and to print the results of its calculations. It was to be controlled by a program represented on perforated tape. Each row of holes would consist of several fields that together constituted one instruction. Each field could contain but a single punched hole, whose position indicated directly which operation was to be performed, say, or which storage reservoir was to provide the operand. There was apparently no thought of having numerically coded addresses, nor of providing means of conditional branching.

Support was obtained from the National Cash Register Co., and later resulted in the full-time employment of first Radford and then W. P. Overbeck on the project. Radford's work concentrated on the design of the basic electronic units. Various units were built and demonstrated successfully, including a scale-of-four counter and a stepping ring—the means proposed for storing each decimal digit. Bush's 1940 memorandum reviewing progress-to-date contains estimates that the machine would be able to multiply two six-decimal digit numbers in about 0.2 seconds, assuming a basic pulse rate of 10,000 per second.

Overbeck took over in late 1939 and spent the next year or so devising special-purpose tubes in an attempt to reduce the number of vacuum tubes needed. Work on the project came to an abrupt and premature end in early 1942, when Overbeck was claimed for work on the atomic bomb project. About the same time, Bush left MIT to become president of the Carnegie Institute.

During the war Bush headed the National Defense Research Committee (NDRQ and its successor, the Office of Scientific Research and Development (OSRD). This office directed the work of some 30,000 scientists and engineers, working on everything from radar, proximity fuses, and amphibious vehicles, to the atom bomb.

The shortened title “Diff. Analyzer,” inferring the construction of a Bush-type machine, included in the proposal to the NRDC for the funding of ENIAC by Brainerd (for Mauchly and Eckert) has been attributed to sensitivity to potential opposition to the project by Bush's associates.” Outside the field of computation, Bush was probably best known for his leadership of the “Manhattan Project.”

Yet the Rapid Arithmetical Machine project had been forgotten. It was rediscovered during the extensive historical investigations undertaken in connection with the patent litigation between

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[1] See Randell, Brian, “The Case of the Missing Memoranda,” Ann. Hist. of Comp., Vol, 1. 1982, pp. 66-67.

Univac and Honeywell over the validity of the ENIAC patent—litigation that lasted six years and involved testimony by over 150 witnesses and 30,000 pieces of evidence, ranging from a single sheet of paper to a file cabinet-full. Bush's project played only a very small role in the evidence and the testimony, perhaps because none of the MIT people directly involved in the project testified at the trial. Indeed, the Rapid Arithmetical Machine project was not mentioned in the 319-page volume entitled Findings of Fact, Conclusions of Law and Order for Judgment that was the sole official publication resulting from the litigation.[1]

Bush had a long history of interest in the problem of information searching, and in 1945 wrote an article describing "Memex," composed of a desk which provided instant access to microphotographed books, periodicals, and documents.[2] To assist the researcher the Memex maintained a trail so that backtracking to earlier searches could be rapidly achieved .[3] This concept was basically achieved in the development of interactive computer systems at MIT in the mid-1960s.[4]

After the war Bush returned to his responsibilities at the Carnegie Institution. When he retired in 1955 he went home to Cambridge and took up duties as a member of the boards of several companies, including the MIT Corp.

When Bush died in 1974, papers such as the New York Times carried lengthy accounts of his most impressive career (see Reinhold, 1974). They detailed his many inventions, his illustrious academic career at MIT and the Carnegie Institute, and, perhaps most important, his vital wartime role as director of the National Defense Research and Development.[5]`

QUOTATIONS

"On the occasion of the first experimental atomic bomb explosion in New Mexico, someone remarked '. . . if this thing goes off, the President will have to look for a new director of the OSRD.' Bush replied 'If it does not, he will too!'"

"Who invented the computer? I can write at once that I did not, in fact I had little to do with that whole development."

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[1] Larson, E. R., "Findings of Fact, Conclusions of Law and Order for Judgment," File No. 4-67, Civ. 138, US District Court, District of Minneapolis, Fourth Division (180 USPQ 673), Oct. 19, 1973.

[2] In the Atlantic Monthly.

[3] See esp. Nyce and Kahn, 1991.

[4] See biographies of Fernando Corbató and Robert Fano.

[5] Based primarily on Owens 1987 and Randell 1982.

"Those damn digital computers!"[1]

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UPDATES

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[1] Quoted by Robert Fano in Lee, John A. N., "Time-Sharing and Interactive Computing at MIT: Part II—Project MAC," Ann. Hist. Comp., Vol. 14, No. 2, 1992.

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