# Internet Pioneers

## *Vannevar Bush*

Vannevar Bush was never directly involved with the creation or development of the Internet. He died before the creation of the World Wide Web. Yet many consider Bush to be the Godfather of our wired age often making reference to his 1945 essay, "As We May Think." In his article, Bush described a theoretical machine he called a "memex," which was to enhance human memory by allowing the user to store and retrieve documents linked by associations. This associative linking was very similar to what is known today as hypertext. Indeed, Ted Nelson who later did pioneering work with hypertext credited Bush as his main influence (Zachary, 399). Others, such as J.C.R. Licklider and Douglas Englebart have also paid homage to Bush.

Bush's innovative idea for automating human memory was obviously important in the development digital age, but even more important was his influence on the institution of science in America. His work to create a relationship between the government and the scientific establishment during WWII changed the way scientific research is carried on in the U.S. and fostered the environment in which the Internet was later created.

**Bush's Early Years**

Bush was born on March 11, 1890, in Chelsea, Massachusetts.

He had two sisters. His father was a Universalist minister. As a child, Bush was sickly and was occasionally bedridden for long stretches of time. Still, he was self-confident and sometimes got into fights with other boys. He once said, "all of [my] recent ancestors [before my father] were sea captains, and they have a way of running things without any doubt. So it may have been partly that, and partly my association with my grandfather, who was a whaling skipper. That left me with some inclination to run a show once I was in it." (Zachary, 23).

Bush did well in school where he showed an aptitude for math.

When he graduated he went off to Tufts College to study engineering. Half of his expenses were paid by a scholarship. He worked as a tutor and aid in the math department to pay the other half. Bush studied earnestly and earned a master's degree in the time it usually takes to earn a bachelor's degree. His academic success fueled his desire to do things his way not depending on others' rules. This trait would become increasingly evident later in his life.

While at Tufts Bush enjoyed his first experience as an inventor. His invention was a land surveying device he called the profile tracer. It looked something like a lawnmower. As it was pushed over land it automatically calculated elevations and drew a crude map. It allowed one man to do the work usually done by three. Bush thought it would be commercially successful, but it never caught on. He learned from this failure. He learned that to become a real engineer he needed to learn more than math and physics. He needed to learn how to effectively deal with people.

After graduation from Tufts, Bush went to work for General Electric testing electrical equipment. He was laid off after a fire broke out in his plant. He then took a position teaching math at Tufts' sister college-Clark University in Massachusetts. That was in 1914. The next year he decided to return to school himself. He was offered a large fellowship of $1,50o to pursue his doctorate under a professor named Arthur Webster. Webster wanted Bush to devote his doctoral work to the study of acoustics. Bush, who did not care to be

told what to do, declined the fellowship. Instead, he went to MIT where he earned his doctorate in engineering in less than a year ad then returned to Tufts as a assistant professor.

**World War I**

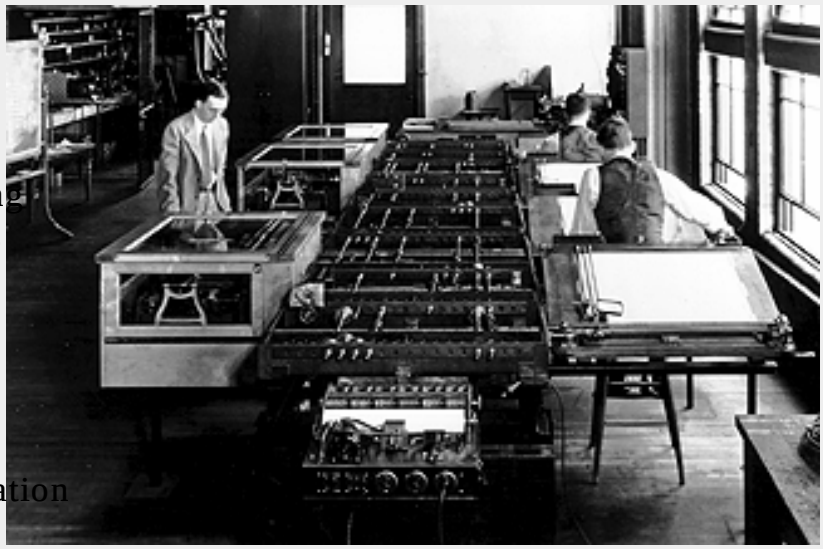
Bush had paid little attention to the war before the U.S. entered into it in 1917, but then he wanted to aid the effort. Other scientists also wanted to lend their services, but the military and government mostly declined their offers. In 1916, a group of interested scientists formed the National Research Council (NRC). The council's main purpose was to produce innovations in weaponry. One of its main tasks was to improve submarine detection.

Bush had an idea for a device that would use magnetic fields to detect submarines. In May 1917, he traveled to Washington to meet with the director of the NRC. The director liked Bush's idea and thought it was worth pursuing. Bush convinced the director to let him handle the research personally without interference. It was important to Bush that he be in control of his project. His device proved to be successful in testing, but Navy officials, who generally viewed Bush as somewhat of a maverick, did not deploy the device correctly and it proved virtually useless in combat. Bush again learned that a successful engineer also had to be a good politician.

**Between the Wars**

In 1919, Bush left Tufts and went to MIT's electrical engineering department. By the 1930's Bush was working on analog computers. These were large mechanical devices that looked quite different than today's digital machines. They actually used large gears and other mechanical parts to solve equations. In 1931, he completed the first differential analyzer- a machine that was used to solve differential equations.

***Bush's Differential Analyzer***



Bush also worked on developing machines that would automate human thinking. Specialization in just about every field of academia was creating a glut of information. Something was needed to help sort through the growing store of accumulated knowledge. In the 1930' s microfilm, which had been around for nearly a century, was growing in popularity as a storage device, especially among librarians. Bush, a photography enthusiast, was quite interested in this resurgent technology. He proposed to build a machine for the FBI that could review 1,000 fingerprints a minute. They turned him down. But he continued to pursue his latest vision.

Bush called his device a rapid selector. It would be housed in a desk and could store huge amounts of information on microfilm. The user could rapidly select documents which would then be projected on screen. In the late 1930's, Bush oversaw the building of four rapid selectors. They were plagued with technical problems and hindered by the state of current technology, but he was among the very first to attempt to build a personal information processor, and these early experiences provided a solid base for his landmark article, "As We May Think."

Vannevar Bush Visits Langley, October 21, 1938
NASA Langley Research Center 10/25/1938 Image # EL-1999-00655

In 1937, Bush became the president of the Carnegie Institution. The institution spent $1.5 million annually on research. The presidency of the institution came with a lot of prestige. The president influenced the direction of research in the U.S. and informally advised the government on scientific matters.

**World War II**

The U.S. was not prepared for the second world war. Little was spent on military research. The military research that was done was done by military personnel and often duplicated between the different branches. The military looked down on engineers as little more than salesmen. By 1940, Bush and other American scientists felt that the country needed a new organization to conduct military research. Scientists and the government/military, as well as business would need to cooperate in the event of American involvement in the war.

On June 12, 1940, Bush met with President Roosevelt and detailed his plan for mobilizing military research. He proposed a new organization he called the National Defense Research Committee (NDRC). The committee would bring together government, military, business, and scientific leaders to coordinate military research. Roosevelt quickly agreed and thus the NDRC was created. Bush was made chairman and given a direct line to the White House. In mid-1941, The Office

of Scientific Research and Development was set up. The NDRC had been funded by presidential emergency funds and was often short on money. The OSRD was congressionally funded. The NDRC was subsumed under the OSRD as its chief operating unit. Bush became director of the OSRD.

The NDRC and then the OSRD were originally set up to support and augment Army and Navy research, but by the end of the war the OSRD was leading military research. Many useful innovations resulted from OSRD research and development including improvements in radar, the proximity fuse, anti-submarine tactics, and various secret devices for the OSS (the precursor of the CIA). Bush was also very closely involved in the Manhattan Project which developed the first atomic bomb. Of course most of OSRD's work was top secret during the war, but Bush as its leader became something of a celebrity. Colliers magazine hailed him as the "man who may win or lose the war" (Ratcliff, 1942).

Bush's work with the NDRC and OSRD definitely helped the U.S. and its allies win the war. Bush also changed the way basic scientific research was done in the U.S. He proved that technology was key to winning a war and this created a new respect for scientists. He institutionalized the relationship between government, business, and the scientific community. Paul Ceruzzi, curator of the Smithsonian Institutions says, " Bush is responsible for the whole architecture of government support for science" (Ceruzzi in Zachary). It was this government support of research that would later foster the creation of the Internet.

**The War Ends**

By late 1944, Allied victory was inevitable. Bush began to look to the future. He believed that after the war the nation would still need permanent support for research. In March 1945, Bush drafted an article entitled, "Science-The Endless Frontier." He outlined the importance of continued support for research. He called for a National Research Foundation that "should develop and promote a national policy for scientific research and scientific education, should support basic research in nonprofit organizations, should develop scientific talent in American youth by means of scholarships and fellowships, and should by contract and otherwise support long -range research on military matters" (Bush, 28). His

dreams for were never fully realized, but in 1950 the National Science Foundation (NSF) was created. The NSF did not quite fulfill Bush's expectations. It was not as powerful as his proposal called for. Nonetheless, the marriage between science and government was secured.

**"As We May Think"**

In 1945, Bush also published an article in the Atlantic Monthly called, "As We May Think." He had written earlier drafts of this article years before he actually published it. His main purpose in writing the article was to influence "thinking regarding science in the modern world" and to "emphasize the opportunity for the application of science in a field which is largely neglected by science" (Bush in Nyce & Kahn, 81). That field was the automation or augmentation of human thought.

In the article he describes a theoretical machine called a "memex." It was an obvious extension of Bush's earlier work with the rapid selector. The memex was also to be a storage and retrieval device using microfilm. It would consist of a desk with viewing screens, a keyboard, selection buttons and levers, and microfilm storage. Information stored on the microfilm could be retrieved rapidly and projected on a screen. The machine was to extend the powers of human memory and association. Just as the human mind forms memories through associations, the user of the memex would be able to make links between documents. Bush called these associative trails and offered this example in his article:

> "The owner of the memex let us say, is interested in the origin and properties of the bow and arrow. Specifically he is studying why the short Turkish bow was apparently superior to the English long bow in the skirmishes of the Crusades. He has dozens of possibly pertinent books and articles in his memex. First he runs through an encyclopedia, finds an interesting but sketchy article, leaves it projected. Next, in a history, he finds another pertinent item, and ties the two together. Thus he goes, building a trail of many items. Occasionally he inserts a comment of his own, either linking it into the main trail or joining it by a side trail to a particular item. When it becomes evident that the elastic properties of available materials had a great deal to do with the bow, he branches off on a side trail

> which takes him through textbooks on elasticity and physical constants. He inserts a page of longhand analysis of his own. Thus he builds a trail of his interest through the maze of materials available to him." (Bush, 15).

This system is remarkably similar to modern hypertext. In fact, Ted Nelson, who coined the term "hypertext" in the 1960's, acknowledges his debt to Bush. "Bush was right," says Nelson (Nelson in Nyce and Kahn, 245).

Vannevar Bush died on June 30, 1974, years before the Internet became widely popular or the World Wide Web even existed. With the growing popularity of the Internet many now look back through its history and see Bush as a visionary. Even when Bush was alive he seemed to always be looking toward the future, or perhaps he saw the present a little differently than most others—he was fond of saying, "It is earlier than we think" (Zachary, 408).

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