

# the story of ENIAC crackpot notions



BY DILYS WINEGRAD

On February 14, 1946, *The New York Times* announced the unveiling of “an amazing machine which applies electronic speeds for the first time to mathematical tasks hitherto too difficult and cumbersome for solution.” “Leaders who saw the device in action for the first time,” the report continued, “heralded it as a tool with which to begin to rebuild scientific affairs on new foundations.” With these prophetic words, the world’s first large-scale electronic general-purpose digital computer, developed at the Moore School of Electrical Engineering at the University of Pennsylvania in Philadelphia, emerged from the wraps of secrecy under which it had been constructed in the last years of World War II.

The *Times* reporter went on to predict that the advent of a flexible computer would revolutionize all areas of science. A great many mathematical models that had been around for generations were suddenly practical propositions available for use by engineers and physicists. Once the new invention had been put through its paces in public, there was widespread interest in seeing how it worked. In the summer of 1946 an expert audience attended the famous Moore School Lectures, at which the speakers constituted a veritable who’s who of computing. The significance of the ideas was variously received, some participants remaining less than convinced. Nonetheless, the National Bureau of Standards was sufficiently persuaded to begin building its own computers. And Project Whirlwind at the Massachusetts Institute of Technology finally changed from analog to digital technology.

Skepticism was by no means confined to proponents of rival technologies. Banks and insurance companies, far from grasping the potential of the computer, seem to have been put off by the notion of turning decisions, even

repetitive ones, over to a machine. Adolph Matz, a Wharton School professor, predicted that “completion of the first all-electronic general-purpose computing machine [would open] the future to the development of business machines heretofore undreamed of . . . and may well also revolutionize methods and systems of dealing with everyday business transactions.” But in 1945 his ideas on applications to commercial enterprise were dismissed as “too ephemeral,” and his article, “Electronics in Accounting,” was initially rejected by the official magazine of the Association of Accountants. As John Maynard Keynes observed, “The difficulty lies not in the new ideas, but in escaping the old ones.” In this spirit, Lord Kelvin in 1887 observed that radio had no future, the telephone was described in 1876 as “only a toy”—and John Logie Baird was kicked out of an office in 1925 as a possibly dangerous lunatic for claiming to have “a machine for seeing by radio.”

In the 1940s, however, the nation had been ready for a breakthrough in computer technology. Not surprisingly, the quantum leap in computer development occurred during World War II in response to urgent military needs. During the national emergency, the Moore School’s differential analyzer—the most sophisticated computing instrument available for scientific use before the ENIAC—was in constant use working out ballistic tables. A course in the design of electromechanical instruments had also been instituted at the School. At any other time the ideas that were elaborated and put into effect at the University of Pennsylvania would have been dismissed as interesting, impractical—and certainly too expensive.

A variety of personnel had arrived at the Moore School to serve in the war effort. Large numbers of “human computers”—young women with mathematics

degrees, supplemented by other specially trained recruits—were engaged in computing the ballistic tables, and select students attended the Moore School's Engineering, Science, Management War Training course (ESMWT) at government expense. Several PhDs among them were hired to replace the Penn professors who had been called up. One of these, John W. Mauchly, who taught physics at neighboring Ursinus College, had originally signed up for a course on the theory and design of computing instruments.

The graduate student responsible for running the lab associated with the ESMWT course, John Presper Eckert, Jr., was described at the time as "undoubtedly the best electronic engineer in the Moore School." Still in his early twenties, Eckert had already secured a patent for recording sound on film. The Navy adopted a device he had developed to check the effectiveness of magnetic mine sweeping airplanes. Eckert and Mauchly found time to chat about the ideas that fascinated both.

Because his primary research interest in meteorology involved enormous amounts of statistical data, Mauchly was constantly looking for ways to speed up computation. He had already investigated the use of cold cathode tubes—much slower than vacuum tubes and with a poorer margin of safety, but with the advantage that they dissipated less power and were far more economical. For his meteorological investigations, he had constructed an analog device that he named a "harmonic analyzer."

Eckert soon decided that Mauchly's ideas on electronic computation were technically feasible. He immediately set about applying his engineering ingenuity and native genius to the problems that would have to be worked out. Encouraged by Eckert's receptivity to his

the response that greeted his proposals for developing an electronic computer. Knowing this, when the American Association for the Advancement of Science met at Penn in 1940, Mauchly had opted to deliver his paper on weather statistics to the physics section. In the audience was John Atanasoff, a professor from Iowa State University, who, together with his graduate student Clyde Berry, was at work on an electromechanical rotary dynamic storage register. Mauchly and Atanasoff discussed their mutual interests then and on subsequent occasions.

The machine Atanasoff proposed permitted a number to be added to another number that had previously been "stored" in the form of electrostatic charges. Designed to solve a single class of problems, not at electronic speeds, it had no programming. Like many ingenious inventions, it was never finished. Although not a computer in any useful sense, years later when the importance of computers had been fully recognized, this device was adjudged "prior art" by a Federal court. The decision, which denied eligibility for patent protection to the Eckert/Mauchly invention, came in the context of business interests and a rapidly expanding computer industry.

Before the war, researchers at the Moore School had used the School's version of the differential analyzer, then the largest mechanical computing machine in the world, to study nonlinear and varying-parameter differential equations. When the Army took over operations in 1942, the Moore School became something of an extension of the BRL for the remaining war years—an early model of university/government cooperation. The human computers working on ballistics using hand-held calculators came under the supervision of Lieutenant Herman Goldstine, a young, Chicago-trained

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theoretical ideas and spurred by the serious consideration that they might be implemented, Mauchly wrote a five-page memo entitled "The Use of Vacuum Tube Devices in Calculating." Among other things, he pointed out that an electronic machine performing 1,000 multiplications per second would be able to compute complete trajectories in minutes rather than days. This memo became the basis of the report subsequently submitted by the Moore School to the Army's Ballistic Research Laboratory (BRL).

The meteorological community considered Mauchly's theories crackpot notions, which was much

mathematician stationed at the BRL.

A trajectory that could take up to 40 hours to calculate using a desktop calculator could be computed in 30 minutes or so on the differential analyzer. But, since each firing table involved hundreds of trajectories, it might still require the best part of a month to complete a table. In 1943 the Allies landed in North Africa, an event that presented the military with totally new terrain and a whole new set of problems for operating ordnance. The growing backlog of firing tables provided the final impetus for serious experimentation in the field of computers. *(continued on next page)*

Aware that the military were more likely than other government agencies to take a calculated risk in time of war, Goldstine saw a possible solution to the problems besetting them in the enthusiastic discussions of electronic digital computing going on at the Moore School. He briefed his superior at the Aberdeen Proving Ground in Maryland, and a presentation was arranged at which Penn Professor John Brainerd submitted a proposal to the head of the BRL and its chief scientist, Oswald Veblen. To forestall anticipated skepticism, Brainerd, who chaired the faculty committee that supervised the analyzer, proposed an “electronic diff. analyzer,” intentionally associating the proposed computer with the existing differential analyzer. (As a digital device, the proposed computer would solve differential equations by *differencing* rather than *differentiation*—a deliberate double entendre.) The computer described would be able to compute a trajectory in under five minutes. Unlike all previous models, it would be fully electronic.

After delivering their report the inventors continued to work around the clock to produce supporting arguments and data and to prepare answers to possible questions. A few days later, on Eckert’s 24th birthday, April 9, 1943, they presented a more detailed proposal. In May agreement was reached, and on June 5 contract No. W-670-ORD-4926 was signed by the Trustees of the University of Pennsylvania and the U.S. Army Ordnance Department with Brainerd as project supervisor, Eckert as chief engineer, Mauchly as principal consultant, and Goldstine as technical liaison. The machine was officially named the Electronic Numerical Integrator And Computer, ever after to be known as ENIAC.

Among the wonders of the “new electronic speed marvel” reported in *The New York Times* after the ENIAC’s demonstration run in February, 1946, was the absence of any moving mechanical parts associated with

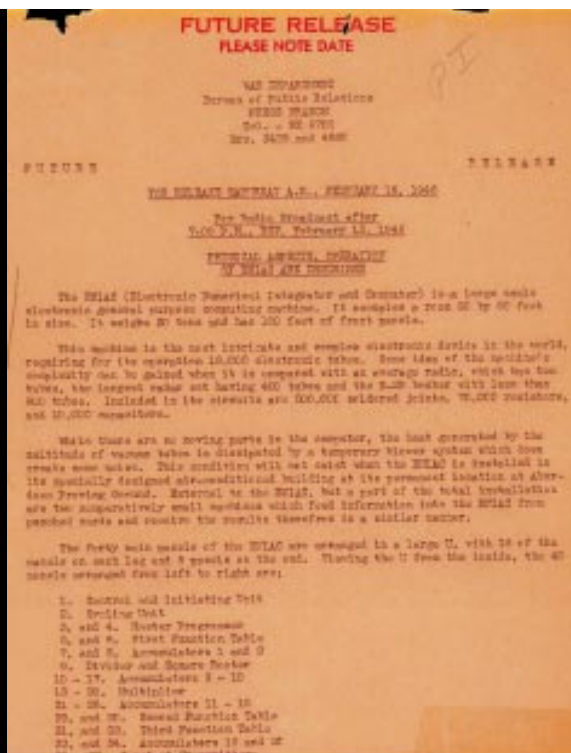
the high-speed computational aspects of the machine, which consisted of “18,000 vacuum tubes and several miles of wiring.” All prior machines had relied on such parts to perform their calculations, and these limited their compactness and reliability, not to mention the speed with which operations were executed. Astoundingly—for the time—the ENIAC could perform 5,000 additions or subtractions or 360 multiplications of two 10-digit decimal numbers in a second. In the same space of time, it could call up 1,000 values of a function from function tables that were included. Problems that would have taken months of simple hand calculation and hours, even days, with the help of the differential analyzer could now be dispatched in minutes.

At a certain stage in its development it became necessary to “freeze” the classified design in the interest of completing the project at hand. Nonetheless, as the end of the war approached, engineers at the Moore School were beginning to think intensively about developing a more sophisticated computer. From the first Mauchly had envisaged a general-purpose machine, and he continued to work towards its construction. Eckert proposed ways to overcome what he recognized as the ENIAC’s major shortcoming: The computer introduced almost every fundamental hardware concept of modern computing—with the exception of internally stored instructions.

The inventors focused on methods to increase the machine’s memory. Having experimented with acoustic delay lines earlier on, extrapolating from those developed by William Shockley at Bell Laboratories, Eckert and his engineers now investigated the possibility of developing a mercury delay line suitable for computer memory. For the time being it was not possible to implement the stored program they proposed, but the mercury delay line became an element of the next generation of computers

Scenes from the dedication. The original press release describing the ENIAC’s physical aspects and operation; J. Presper Eckert poses at the console; an invitation to the dedication ceremonies and dinner; and the development team and sponsors (identified on page 2).

Photos: John Mauchly Papers, Department of Special Collections, University of Pennsylvania Library. Documents: University of Pennsylvania Archives.



at the Moore School and elsewhere. These included the EDVAC, the second large computer developed at Penn and the first in the country to incorporate a stored memory; the EDSAC developed by Maurice Wilkes in England; and the computers designed by Mauchly and Eckert after leaving the Moore School. The concept of storing the program in the same memory unit as the data was introduced when the Institute for Advanced Studies (IAS) computer was built a few years later by a team headed by John von Neumann. While commuting between Los Alamos and the Institute for Advanced Study in the last year of the war, von Neumann had participated in the highly classified discussions at the Moore School. When it was built, the IAS computer used a so-called Williams electrostatic storage tube for the memory.

The Moore School team started work on the EDVAC in late 1944 when the Army Ordnance Department granted the ENIAC contract a supplement for an improved design. As a stored program device, the Electronic Discrete Variable Automatic Computer (EDVAC) was the true forebear of all subsequent computing devices. All of the early computers, including one called the MANIAC, acknowledged their relationship to the Moore School computers through their shared suffix. While the letter “A” had only stood for *and* in the Electronic Numeral Integrator and Computer (ENIAC), in the successor machine—and ever afterwards—it finally indicated a fully automatic device.

The ENIAC was completed too late to be utilized for its original purpose of calculating firing and ballistic tables. Instead, the first task assigned on its test run in 1945 involved the many thousands of computations connected with top-secret studies on thermonuclear reactions. While many projects had to be scrapped at the end of the war, ENIAC was not among them. The computer had proved to be significant for military

research at Los Alamos in the West as well as at the Ballistic Research Laboratory in the East. Indeed, the successful simulation of a nuclear blast resulted in the Federal government’s supporting a nascent computing technology, soon to spawn a new industry.

Today it is impossible to think of a world without computers or to imagine that the ideas from which they developed, and which we now take for granted, might have been strenuously resisted when they were first proposed. It may seem barely credible today that scientists, engineers, and businessmen five scant decades ago might not have immediately grasped the implications of the new technology. But this has been the case more often than not throughout the course of human endeavor; variations on the theme of “Who needs it?” are quickly followed by reasons why it can’t be done. Notable examples range from Nobel laureate Robert Millikan’s assurances that man could never tap the power of the atom to Harry M. Warner’s skepticism about the market for talking movies. As late as the 1950s Britain’s Astronomer Royal dismissed the notion of space travel as “utter bilge.”

With the development of the ENIAC at the University of Pennsylvania, the City of Philadelphia acquired a second site where ideas produced a revolution. Not unlike Independence Hall, the Moore School provided surroundings in which abstract theories became reality, opening paths to new technologies that have changed our ability to investigate the world and conduct every transaction imaginable in ways that continue to evolve. The first operating computer of its sort is justly famed and a reason for celebration as the events related here become remote, though hardly ancient, history.

*DILYS WINEGRAD is Director/Curator of Arthur Ross Gallery at the University of Pennsylvania.*

The University of Pennsylvania  
and  
The Ordnance Department  
United States Army  
request the honour of  
  
company at dinner  
  
and at ceremonies dedicating  
  
The Electronic Numerical Integrator and Computer  
Houston Hall, University of Pennsylvania  
3417 Spruce Street, Philadelphia  
on Friday, the fifteenth of February  
Nineteen hundred and forty-six  
at six-thirty o'clock

R. S. V. P.  
President's Office  
University of Pennsylvania  
Philadelphia 4, Penna.

Business dress  
Program on page three

