Zuse, Konrad

1910–95

German Inventor

Konrad Zuse is popularly recognized in Germany as the inventor of the computer. He built a mechanical device, which he called Z1, in the living room of his parents' apartment in Berlin. The construction of the Z1, the first programmable binary computing machine in the world, began in 1936 and finished in 1938.

As part of his civil engineering studies at the Technical University Berlin–Charlottenburg, Zuse learned to perform repetitive static calculations—for example, those needed to determine the stress on materials of structures such as bridges. Static calculations were performed by filling out forms on which all necessary formulas had been preprinted. Zuse started considering the possibility of automating this task. The engineer had to fill in the data and follow the prescribed computational path—surely a machine could do this work.

With his parents' financial help, he began to build the automaton which until that point had only existed in his imagination. Some friends assisted by working for him; others gave him small amounts of money so that he could finish what would become the Z1. This might be the most important difference between Zuse and other computer inventors working at the time: While in the United States, scientists such as **John Atanasoff** (1903–95) and **Howard Aiken** (1900–73) had the resources of universities or companies at their disposal, Zuse was working alone. The entire design of the machine was his own work.

Ignorant of the internal structure of any type of calculator built at the time, Zuse started from scratch and developed an entirely new kind of mechanical construction. Whereas contemporary desktop calculators were based in the decimal system and used rotating mechanical components, Zuse decided to use the **binary system** and metallic plates that could move in only one direction—that is, they could only shift position. These plates were all that was needed for a binary machine, but some other obstacles had to be surmounted. It was not only necessary to design the complete logical description of the machine and then wire it accordingly; the mechanical components posed an additional formidable challenge since every movement of one logical gate had to be coupled with the movement of the other gates. Linear shifts of the components had to be transformed to linear shifts in different layers of the machine, or shifts in perpendicular directions. From today's perspective, the mechanical design of the machine was much more challenging than the logical structure. Nobody except Zuse understood exactly how the machine worked, although many of his friends helped in cutting the hundreds of metallic plates needed for the apparatus.

The Z1 was operational in 1938. It was demonstrated to several people, computing the determinant of a 3 by 3 matrix. The mechanical Z1 proved that the logical structure of the machine was sound; now an electronic or electrical realization, using telephone relays, could be contemplated. Helmut Schreyer, an electronic engineer and friend of Zuse, suggested the

Konrad Zuse, German engineer and inventor. (Courtesy of the Computer Museum History Center)

use of **vacuum tubes**. Schreyer, in fact, adopted this as a Ph.D. project and developed some vacuum-tube circuits for the electronic machine. Zuse himself was not convinced that vacuum tubes should be used. They promised extremely fast calculations, but he thought that vacuum-tube machines could not be made to perform as reliably as relays or even mechanical components. Zuse had already been contemplating the possible uses for his machine, and his goal was the development of a programmable replacement for mechanical desktop calculators, for use at large or medium-sized companies. Clearly, the machines had to be both resilient and fault-tolerant.

Nevertheless, Schreyer and Zuse showed some of the electronic circuits to a small group at the university in 1938. When asked how many vacuum tubes would be needed for a computing machine, they replied that 2000 tubes and several thousand other components would be necessary. The most complex vacuum circuits at the time used no more that some hundred tubes. The university audience left in disbelief—surely the power necessary to keep the machine working would be excessive. A few years later, the ENIAC would show to the world that vacuum-tube machines were indeed expensive, but entirely feasible.

The start of World War II had immediate consequences for Zuse; he was called to serve in the army. With the help of Kurt Pannke, a constructor of mechanical calculators, Zuse tried to obtain a transfer to Berlin in order to continue his work on the next computing machine. Helmut Schreyer, who worked as an engineer at the university, also tried to obtain Zuse's discharge. He offered the military command to build an automatic air defense machine that could be operational in two years: By way of reply, he received a sardonic reminder that the war would be won in much less time. Ultimately, Zuse was transferred to the Henschel airplane factory, to make the calculations needed for the stability of the "flying bombs" (now called *cruise missiles*) being built in Berlin.

Zuse started working for the "special section F" at the Henschel factory in 1940. During this time he developed two machines that could automatically measure some parameters of missile wings, transform the analog measurement into a digital number, and compute a formula based on these values. This could well have been the first analog–digital converter built for subsequent digital calculations. In 1940, he also built the machine Z2, which used an integer processor built out of relays but had a mechanical memory. The machine helped Zuse convince the German Airspace Research Office (DLV in German) to partially finance development of Z3, which would be built using only relays. The Z3 was operational in 1941: It had the same logical design as the Z1, but with electrical components.

Zuse continued working for the Henschel factory, but started his own business in 1941. The Zuse Ingenieurbüro und Apparatebau, Berlin was the first company founded with the sole purpose of developing computers. The success with the Z3 brought Zuse a contract with the DLV to develop a still larger computer, the Z4. This machine had a very similar design to the Z3, but would have 1024 memory words instead of only 64. The machine was built and was almost ready in 1945, when Berlin was occupied by Russian troops. Zuse flew with the Z4 to southern Germany, where he was later stationed. Some British and U.S. military experts interviewed Zuse and inspected the machine after the war, but Zuse was not among the scientists who finished their careers working for the Allies.

After the war, Zuse continued working on two main projects: the development of an algorithmic language, which he called the ***Plankalkül*** (calculus of programs); and starting his company again. The Plankalkül can be considered to be the first high-level programming language conceived at the time, although no compiler or interpreter was ever written for it. Zuse's company was revived after Eduard Stiefel, from the Technical University of Zürich, saw the refurbished Z4 in operation and decided to rent it for his university. The Z4 was installed in Zürich in 1950 and was the first commercial computer in operation, some months before the first UNIVAC was delivered in the United States.

Zuse's company (with the new name Zuse KG) flourished after the war and many other machines were built. They were all numbered progressively according to their introduction (i.e., Z5, Z11, Z22, Z23, etc.). The dominance of the U.S. computer industry in Europe, as

well as the late adoption of a fully electronic design, brought the Zuse KG in financial difficulties. The company was sold in 1962 to Brown Boveri and Co., and later to **Siemens**. Production of the Zuse series of computers was eventually stopped.

In retrospect it can be said that Konrad Zuse's greatest achievement was the development of a family of fully digital **floating-point** programmable machines, which were built in almost total intellectual isolation from 1936 to 1945. His dream was to create a small computer for business and scientific applications, and he worked singlemindedly for many years to achieve this objective. Zuse's machines were undoubtedly smaller than the early U.S. computers, especially the **Harvard Mark I** and the **ENIAC**. However, from the point of view of modern computer architecture, they were more elegant and "canonical." A floating-point **microprocessor** built today using a few thousand transistors would probably have a structure similar to that of the Z3.

Zuse's patent application of 1941 for the computing machine Z3 was ultimately refused in 1967 by a German judge, who declared it to lack "inventiveness." The long delay between application and decision was due initially to the war and its aftermath. Then when the patent application was finally reconsidered in the 1950s, the established computer companies fought against it with every means available to them. The result was a protracted and costly legal battle that Zuse eventually lost.

Zuse always considered himself the true inventor of the computer, and his public statements on this subject demonstrated some bitterness about his lack of recognition abroad. In the United States, his name was almost totally unknown during the 1960s and 1970s, except in the academic communinty. It was not until the 1980s and 1990s that more information about his work became available for the general public in countries other than Germany.

BIOGRAPHY

Konrad Zuse. Born 22 June 1910 in Berlin, Germany. Studied at the Braunsberg High School in Braunsberg and later at the Technische Hochschule Berlin–Charlottenburg, 1927–34; civil engineering degree, 1935. Z1 computer completed, 1938. Served in German army, 1940. Founded company, Zuse Ingenieurbüro und Apparatebau, Berlin (later called Zuse KG), and completed Z3 computer, 1941. Z4 installed at University of Zurich, 1954. Recipient of many honors and prizes from international associations and universities as well as from the German government. Zuse KG liquidated in 1962. Died 18 December 1995 in Hühnfeld, Germany.

SELECTED WRITINGS

Zuse, Konrad. *The Computer: My Life.* Berlin: Springer-Verlag, 1993.

FURTHER READING

Rojas, Raúl. "Konrad Zuse's Legacy: The Architecture of the Z1 and Z3." *Annals of the History of Computing,* Vol. 19, No. 2, 1977, pp. 5–16.

—*Raúl Rojas*