Heinz Billing

Born April 7, 1914, Salzwedel, Germany; an inventor[1]*, of magnetic drum storage and built the first working electronic computer in Germany; searched for gravity waves and became unsurpassed in not finding them.*

Education: doctoral degree, University of Göttingen, 1938.

Professional Experience: Aerodynamic Test Centre, Göttingen (Aerodynamische Versuchsanstalt, AVA) 1938-1946; German Air Force, 1938-1941; Institute für Instrumentenkunde (Institute for Scientific Instruments), Kaiser-Wilhelm-Gesellschaft (later Max-Planck-Gesellschaft), 1946-1949, and again in 1950-1972; Commonwealth Scientific and Industrial Organization, Sydney, Australia, 1949-1950; Max Planck Institute, Garching, Germany, 1972-1982.

Honors and Awards: honorary professorship in computing, Erlangen University, 1967; Konrad Zuse Prize, 1987.

Heinz Billing was born on April *7, 1914* in Salzwedel, a small town some *30* miles north of Wolfsburg, where Volkswagen automobiles are made. He went to school at Salzwedel, graduated from high school ("Abitur"-examination) at *18* and, after studies at Göttingen (a famous university town south of Hanover) and Munich, he received his doctorate in physics at the age of *24.* His thesis under Walter Gerlach was on *Light Interference with Canal Rays.*

He began his career June 1, 1938, at the Aerodynamic Test Centre at Göttingen *(Aerodynamische Versuchsanstalt,* AVA) connected with Ludwig Prandt], the famous director of the *Kaiser-Wilhelm-Institut für Strömungsforschung* (fluid mechanics). By October 1, 1938, he was drafted to the Air Force, where he worked in weather forecasting. He was released from these duties in May *1941* to do research in aeronautical acoustics.

Magnetic Sound Recording

In those days German engineering was well known for excellent results with magnetic sound recording, first on steel wire and then on tape. Telefunken's "Magnetophon" was introduced at the 1935 radio exhibition in Berlin *(Funkausstellung)* and remained a well-known trademark until the Fifties.

The goal was to apply this technology to the problem of reducing propeller noise for better communications in the aircraft cockpit.

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[1] See also Howard Aiken and Andrew Booth.

Billing tried to design a rotating magnetic audiotape which would neutralize the sound of the propeller by feeding the inverse signal into the headphones during its next rotation. The contraption didn't work, as the propellers were not inclined to sound the same each time around.

Göttingen was spared British bombardment, perhaps in order to capture its research centers and their scientists intact.

In 1945-1946 Billing wrote an AVA report on “Modern Aeronautical Acoustics” (in “Naturforschung und Medizin in Deutschland 1939-1946,” the German edition of the “FIAT Review of German Science”). By November 1, 1946, he moved to the *Institut für Instrumentenkunde* (Institute for Scientific Instruments) of the Kaiser-Wilhelm-Gesellschaft, later Max-Planck-Gesellschaft, which was also housed on the site of the AVA. Billing did research in high frequency engineering, in the amplification of brain currents, and with Geiger counters.

The First German Magnetic Drum Storage

But then his special knowledge of magnetic storage technology became very helpful to Billing.

At that time the earliest use of computers was strongly biased towards what we would call today “scientific applications.” Newly invented, non-mechanical computation devices were used for mathematical algorithms and pure number crunching rather than for data storage. The processors were designed with electromagnetic relays, and decisions were made by switching electrical currents within the machine. Then fast and silent electronic vacuum tubes were used to do this task. But how could the machine be made to remember its digits, to freeze the electric current and store the results for later use? Even the ENIAC, the legendary first “Electronic Numerical Integrator and Computer,” doing nearly one thousand operations per second back in 1945 (.001 MIPS in today's notation), had just a minimal data storage of only 20 figures; only some 2,000 tubes of the total 18,000 were for storage purposes.

In the summer of 1947 Heinz Billing and Konrad Zuse were present at a meeting of Alan Turing and J. R. Womersley from Britain with the German computer pioneer Alwin Walther from Darmstadt. Womersley spoke in vague terms about data storage by transmitting the data back to the sender, who then could choose to send it on another trip or to use it. In fact in England a mercury-delay line storage for 16 binary numbers had been built, keeping 30-digit binary figures “on the move” for 1 millisecond at a time—an expensive, insecure, and volatile system. Billing had no knowledge of this technology and misunderstood Womersley's remark, interpreting it along his own lines of thinking.

With his background in electro-acoustics he took a rotating cylinder and attached magnetic tape to it. Later the magnetic surface was directly sprayed on to it to avoid seams. This became the very first magnetic storage system for computers; rotating at 3,000 cycles per minute, it sounded like a whistling monster. The average access time from one half-rotation was a mere 10 milliseconds! On this first drum storage the read-and-write heads were firmly mounted about half a millimeter over the magnetic surface. Only later the heads were modified to ride on self-made air cushions and used new technologies that increased the storage density such as the non-return-zero system. A later version of Billing's drum can be seen today at the Deutsches Museum in Munich—although it is now mercifully silent.

Heinz Billing emphasizes that Joachim Lehmann, independently working in Dresden, had the same idea, but was a few months late—not too late, however, for a life-long friendship. Both Billing and Lehmann were of course unaware of similar developments of Andrew Donald Booth at Birkbeck College, London, and Howard Aiken on the Harvard Mark III computer, both of whom started in 1947 as well.

First Attempts

After Billing had started his work in December 1947 on an electronic adder with magnetic drum storage, it attracted the interest of Ludwig Biermann, the famous astrophysicist who had been brought to Göttingen by Werner Heisenberg. In July 1948, Billing reported on his plans in the annual GAMM[1] meeting. (See *Zeitschrift* für *angeivandle Mathematik und Mechanik, Jahrgang*, No. 29, 1949, pp. 38-42). As an example of a practical application Billing chose the numerical Solution of the Schrödinger differential equations, a problem that was tried with desk calculators by Biermann's computing group-and found out only later that the special method that they used was in fact due to Biermann.

In the spring of 1948, Biermann visited Billing's workshop and saw, as he later reported, a glimmer of hope that the calculation time for his astrophysical computations could be reduced to a reasonable level—from years perhaps to weeks.

Sidetracked to Australia

In those economically tough times Billing was called to work for half a year in 1949 at the Commonwealth Scientific and Industrial Organization at Sydney, Australia. He might even have stayed “down under,” had it not been for its remoteness from the main technology centers in these early days before the advent of electronic mail systems.

Back to Germany

Back in Göttingen, Ludwig Biermann persuaded his senior colleague, Werner Heisenberg, to call Heinz Billing back to Germany with a plan to actually create the first German-built, fully electronic computer system. And Billing accepted for the relatively exorbitant salary of 9,660 DM-per year. He returned May 1, 1950, and found the physicists planning on having some sort of small machine quite soon.

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[1] GAMM is the “Gesellschaft fur angewandte Mathematik und Mechianik,” the Society for Applied Mathematics and Mechanics.

Therefore, in the fall of 1950, the plan was to make a series of electronic calculators: first, as a start and to gain experience, a small model, G1, paper-tape controlled but with an arithmetic unit about ten times more powerful than the mechanical desk calculators of those days. This was to be followed shortly afterwards by model G2 with a drum storage of 2,048 binary numbers, and already equipped with stored program control. All these systems would be built with vacuum tubes and drum storage. A large model, to be called G3, would come later.

Billing finished the small G1 model in 1952, using his proven drum storage technology for 26 binary coded numbers of 32 bits each, giving 10 decimal digits of precision. This idea, to save elements by encoding the whole number in binary form rather than by each decimal digit (used by Stibitz, Aiken), was first used by Konrad Zuse with his relays. It cut the number of vacuum tubes to 83 percent while retaining the same precision. (Stibitz and Aiken needed 4 bits per decimal digit, Zuse needed $\log_{10}2$ or 3.322 bits per decimal digit. The ratio 3.322:4 is 0.83.) Billing's G1 had less than 500 tubes, which made it quite reliable and robust. History tells us that the G1 worked until early 1953, logging 2,100 hours of activity, 400 of which were for service and re-runs, giving an overall availability of 80 percent—well done for a vacuum tube system. Several modified copies of the G1, called Gla, were made. One is on display in the Deutsches Museum in Munich.

The first German electronic calculators were used for scientific calculations such as predicting the paths of electrically charged particles in magnetic fields, a problem in which Ludwig Biermann was particularly interested, by using ordinary differential equations of fifth order.

The G1 already managed about two operations per second. A round of calculating the orbit of a particle took 3 to 4 hours, while doing the same job by hand with the help of mechanical machines would have taken a week of full-time work.[1]

When the Konrad Zuse Prize was first awarded in 1987, Heinz Billing received it for his creation of Germany's first electronic universal computer with stored program control, the G2.

The later and larger model already had 2,000 storage locations, and was ten times faster than the G1. It was ready in 1954 and used in 1956 to calculate the exact time of the reappearance of the asteroid Amor, which comes into view every 8 years. It was not until the tedious manual prediction proved to be off by up to two angular minutes that the virtues of electronic calculation were retroactively acknowledged by the incredulous German Astronomical Society: “In calculations of the highest precision the machine is superior to manual calculation,” they wrote in their next annual report. Little Amor had brought scientific acceptance to this new calculating wizard that silently glowed in the man-made vacuum of glass tubes.

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[1] As early as 1949 Dr. Walter Sprick had built an electronic multiplication unit connected to a Powers tabulating machine.

In 1953 Billing started to build a really large machine. The model G3 was completed in 1960 and proved to be the most powerful vacuum tube computer ever built in Germany, perhaps even the most beautiful, as Heinz Billing remembers. Even in these early days it used a microprogram, had a ferrite core memory of 2,000 binary numbers of 43 bits each with a 10-microsecond access time. A new invention, Friedrich L. Bauer's patented hardware stack, appropriately called “cellar” in Germany, was implemented, as well as microinstructions for the display of color pictures: automatically red, green, and blue filters were moved over a cathode ray tube. The resulting photo could be a full-color graph of the mathematical results. The G3 was moved with the Max Planck Institute for Astrophysics to Munich, Bavaria. It was still in service as late as November 9, 1972.

In 1967 Heinz Billing received an honorary professorship in computing at Erlangen University.

Billing Leaves the Computer Field

After transistors had been firmly established, when microelectronics arrived, after scientific computers were slowly overshadowed by commercial applications and computers were mass-produced in factories, Heinz Billing left the computer field in which he had been a pioneer for nearly 30 years.

In 1972, Billing returned to his original field of physics, at the Max Planck Institute's new location at Garching near Munich. Beginning in 1972 he became known for building the world's most sensitive instruments to measure hypothetical gravity waves.

Today, after his retirement in 1982, Professor Billing is still connected with the Max Planck Institute and has his home in the same small village, Garching, north of Munich.[1]

UPDATES

Portrait inserted, MRW, 2012.

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[1] Fritz Jörn, 1990.