

The First Computers—History and Architectures

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Preface

We are proud to present this volume to all programmers, computer scientists, historians of science and technology, and the general public interested in the details and circumstances surrounding the most important technological invention of the twentieth century — the computer. This book consists of the papers presented at the International Conference on the History of Computing, held at the Heinz Nixdorf MuseumsForum in Paderborn, Germany, in August 1998. This event was a satellite conference of the International Congress of Mathematicians, held in Berlin a week later. Using electronic communication, the contributions for this volume were discussed before, during, and after the conference. Therefore, this is a collective effort to put together an informative and readable text about the architecture of *the first computers* ever built.

While other books about the history of computing do not discuss extensively the structure of the early computers, we made a conscious effort to deal thoroughly with the architecture of these machines. It is interesting to see how modern concepts of computer architecture were being invented simultaneously in different countries. It is also fascinating to realize that, in those early times, many more architectural alternatives were competing neck and neck than in the years that followed. A thousand flowers were indeed blooming — data-flow, bit-serial, and bit-parallel architectures were all being used, as well as tubes, relays, CRTs, and even mechanical components. It was an era of *Sturm und Drang*, the years preceding the uniformity introduced by the canonical von Neumann architecture.

The title of this book is self-explanatory. As the reader is about to discover, attaching the name “world’s first computer” to any single machine would be an over-simplification. Michael R. Williams makes clear, in the first chapter in this volume, that any of these early machines could stake a claim to being a first in some sense. Speaking in the plural of the *first computers* is therefore not only a diplomatic way around any discussion about claims to priority, it is also historically correct. However, this does not mean that our authors do not strongly push their case forward. Every one of them is rightly proud of the intellectual achievement materialized in the machines they have studied as historians, rebuilt as engineers, or even designed as pioneers. And this volume has its share of all three kinds of writers. This might well be one of the strengths of this compilation.

Why study old architectures?

Some colleagues may have the impression that nothing new can be said about the first computers, that everything worth knowing has already been published somewhere else. In our opinion, this is not the case; there is still much to be learned from architectural comparisons of the early computers. A good example is the reconstruction of Colossus, a machine that remained classified for many years, and whose actual design was known to only a small circle of insiders. Thanks to Tony Sale, a working replica of Colossus now exists, and full diagrams of the machine have been drawn. However, even when a replica has been built, the internal structure of the machine has sometimes remained undocumented. This was the case with Konrad Zuse's Z1 and Z3, reconstructed for German museums by Zuse himself. Since he did not document the machines in a form accessible to others, we had the paradox in Germany of having the machines but not knowing exactly how they worked. This deficit has been corrected only in recent years by several papers that have dissected Zuse's machines.

Another example worth analyzing is the case of the Harvard Mark I computer. Every instruction supplies a source and a destination: numbers are moved from one accumulator to another, and when they arrive they are added to the contents of the accumulator (normal case). The operation can be modified using some extra bits in the opcode. This architecture can be streamlined by defining different kinds of accumulators, which perform a different operation on the numbers arriving. Thus, one accumulator could add, the other subtract, and yet another just shift a number. This is exactly the kind of architecture proposed by Alan Turing for the ACE, a computer based on the single instruction MOVE. We notice only the similarity between both machines when we study their internal organization in greater depth.

It is safe to say that there are *few* comparative architectural studies of the first computers. This volume is a first step in this direction. Moreover, we think that this book can help motivate students of computer science to look at the history of their chosen field of study. Courses on the history of computing can be made more interesting for these students, not always interested in the humanities or history in itself, by showing them that there is actually much to be learned from the successes and failures of the pioneers. Some kinds of computer architectures even reappear when the architectural constraints make a comeback. The Connection Machine, a supercomputer of the 1980s, was based on bit-serial processors, because they were cheap and could be networked in massive amounts. Reconfigurable hardware is a new buzzword among the computer science community, and the approach promises to speed up computations by an order of magnitude. Could it be that the microchips of the future will look like the ENIAC, like problem-dependent rewirable machines?

Those who do not know the past are condemned to live it anew, but the history of computing shows us that those who know the past can even put this knowledge to good use!

Structure of the book

Part I deals with questions of method and historiography. Mike Mahoney shows that computer science arose in many places simultaneously. He explains how different theoretical schools met at the crossroads leading to the fundamental concepts of the discipline. Robert Seidel then discusses the relevance of reconstructions and simulations of historical machines for the history of science. New insights can be gained from those reconstruction efforts. In the next chapter, Andreas Brennecke attempts to bring some order to the discussion about the invention of the first computers, by proposing a hierarchical scheme of increasingly flexible machines, culminating in the stored program computer. Finally, Harry Huskey, one of the pioneers at the conference, looks at the constraints imposed on computer architectures by the kind of materials and logical elements available during the first decades following World War II.

Part II of the book deals with the first American computers. John Gustafson, who led the reconstruction of Atanasoff's machine, describes the detective work that was necessary in order to recreate this invention, destroyed during the war and considered by some, including a federal judge, to be the first computer built in the U.S. He addresses the limitations of the machine but also explains how it could have been used as a calculator. I. Bernard Cohen, whose Aiken biography is the best study of a computer pioneer published up to now, contributed a chapter which sheds light on the architectural solutions adopted by Aiken and clarifies why he did not build an electronic machine. Professor Jan Van der Spiegel and his team of students performed the feat of putting the ENIAC on a single chip. Their paper provides many details about the operation of the machine and discusses its circuits in depth. Their description is the best and most comprehensive summary of ENIAC's architecture ever written. William Aspray and Paul Ceruzzi review later developments in the computer arena in their contributions and show us how the historian of computing can bring some order in this apparent chaos.

Part III looks at the other side of the Atlantic. For the first time, a single book written for the international public discusses the most important early German computers: the Z1, Z3, and Z4, as well as the electronic machines built in Göttingen. Raúl Rojas, Ambros Speiser, and Wilhelm Hopmann review all these different machines, discussing their internal operation. In his contribution Hartmut Petzold looks at the emergence of a computer industry in Germany and the role played by Konrad Zuse. Friedrich L. Bauer, a well-known German pioneer, looks again at the high-level programming language invented by Zuse, the *Plankalkül* (calculus of programs), which he considers his greatest achievement. Friedrich Kistermann and Thomas Lange analyze

the structure of two almost forgotten, yet very important machines, the DEHOMAG tabulator and the first general-purpose analog computer, built by Helmut Hoelzer in Germany. Hoelzer's analog machines were used as on-board computers during the war.

The first British computers are explained in Part IV. Tony Sale describes the reconstruction of Colossus, which we mentioned above. Brian Napper and Chris Burton analyze the architecture and reconstruction of the Manchester Mark I, the world's first stored-program computer. Frank Sumner reviews the Atlas, a real commercial spin-off of the technological developments that took place in Manchester during those years. In the final chapter of this section, Martin Campbell-Kelly, editor of Babbage's Collected Works, takes a look at the EDSAC, the computer built in Cambridge, and tells us how much can be learned from a software simulation of a historical machine.

Finally, Part V makes information available about the first Japanese computers. Seiichi Okoma reviews the general characteristics of the early Japanese machines and Eiiti Wada describes the PC-1 in more depth, a computer that is very interesting from a historical viewpoint, since it worked using majority logic. The same kind of circuits had been studied in the U.S. by McCulloch and Pitts, and also had been used by Alan Turing in his written proposal for the ACE machine. Apparently, the only hardware realization was manufactured in Japan and used for the PC-1.

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