Computer prehistory and history in central Europe

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ABSTRACT

An excursion is made into the history and prehistory of computers with special attention to Central Europe. Three historic periods are examined. The period of programmed automata is rich in the development of programmed clocks and musical instruments beginning in the 14th century and continuing through the 18th century. The period of programmed weaving to punched cards ranges from the Jacquard loom to the Hollerith card. It can be noted that the Jacquard card and the Hollerith card are the same width. Predecessors of Jacquard can be found in Austria as early as 1680 or 1690. The Hollerith card was used in census of 1890 in Austria, a fact not as well known as its use in the United States census of 1890. The story of Otto Schaeffer, the engineer who produced the equipment for the Austrian census, is a fascinating one. The third period is the period of programmed calculation. The computer is the product of two streams of development, calculating devices and programmed calculation, and contributions from Central Europe are prominent in both streams. Among the names which must be included are those of Petzval, Boltzman, Goedel, Morgenstern and Von Neumann. Attention is called to two contributions from the author's laboratories, namely, the 1954 fully transistorized computer, "Mailufterl," and the "Vienna Definition Language."

INTRODUCTION

New ideas are rarely really new ideas. Mostly, they are just another step on a long road from ancient times into the future; often an idea becomes known as a new idea, because at this moment the idea was suddenly supported by a possibility of technical realization or industrial exploitation. We tend to underestimate the skill and wit of our ancestors. Most ideas, furthermore, are only a part in a set of ideas which all together makes a scientific field or a technical application a flourishing subject. One "new" idea, in other words, depends very much on many other flanking ideas.

Nothing, therefore, can be understood without a knowledge of the relevant history, and any object, natural or artifact, carries elements and traces of its history. Understanding the present and judging the future of any science or technology, institution or company is only possible on the basis of knowing the past.

So the modernistic view that history is uninteresting except for historians or that history today proceeds so fast that it is not worth looking into the past, is totally wrong.

The impression of speed or acceleration, by the way, is a function of specialization. You might have heard the bon mot about the difference between the universalist and the specialist which says that the universalist knows nothing about everything while the specialist knows everything about nothing. That sounds symmetric—but only until you consider time. Because then the zero knowledge of the universalist holds forever, while the total knowledge of the specialist lasts for zero time. Rephrased less extremely, one could say that the less specialized the longer the truth lasts and acceleration is proportional to specialization.

Computers require a lot of specialization and abstraction, and we all should compensate for that by carefully cultivating our personal universality and by intentionally rehumanizing our technology and profession. This principle encourages an excursion into the history and even prehistory of computers with special attention to Central Europe.

Thus the paper is organized into three sections of different length:

(1) the period of programmed automata,
(2) the period of punched card development, and
(3) the history of programmed calculation.

PROGRAMMED EARLY AUTOMATA

Time is a steady flow without steps, but in order to indicate or measure it, steadily working or analog devices are less accurate than digital ones. This basic principle is very true of the computer, but it was first discovered for clocks and watches and implemented in the forms of the pendulum and the balance wheel. Once the step function is introduced, it takes a small step to use programs and to add programmed devices. The
stroke of the full hour and of the quarter soon is followed by automatically moved figures or by chimes.

Music, of course, is typically digital, quantized in frequency, time and even in amplitude—from pp to ff. The musical notes and the score are digital programs, their realization in automatic musical instruments is well within the spirit of music, and the classic composers like Bach, Haydn, Mozart and Beethoven have written for automatic music machines.

In Northern Germany and in the Netherlands we find the oldest chimes, dating back to the 14th century. In Southern Germany, particularly in Augsburg, automata of very fine artistry have been produced during the 16th and 17th centuries. Museums in Dresden and Vienna are exceptionally rich, but one must also see the Swiss treasures in Neuchâtel, Lelocle, La-Chaux-de-Fonds and Auberson. It would be my pleasure to show many of those automata and to explain their history and their mechanisms, but I want to cover a much broader field and I must, therefore, restrict myself to a few hints. A couple of pictures, however, of the most beautiful automata in existence, both in the province of Upper Austria. They were made around 1740, and there are good indications that the invention was made between 1680 and 1690. Wooden bars are glued on a closed loop strip of linen, and the bars operate the weaving device. The name, by the way, does not seem to be derived from Brössel (crumbs), but from the diminutive form of Ambrosius, probably the family name of the inventor. It is interesting to note that Jacquard punched cards are of the same width as today's computer punched cards: certain measures change little over long times. There is the nice story that Mr. Watson answered the question of Mr. Hollerith what format he should choose for the punched card by opening his wallet and producing a dollar bill (of that time). But in all probability, Hollerith chose the size of the bill in order to be able to make use of certain sorting devices already in use for dollar bills, or much simpler: he started from a jacquard punched card in his development and found no reason to change the width.

Everybody knows that punched card equipment was introduced by Hermann Hollerith for the US census of 1890. Much fewer people know that the idea very probably comes from John Shaw Billings, a medical doctor of the US army assigned to the census office. He triggered Hollerith to construct census machines after the Jacquard loom idea; you will find this story in Herman Goldstine's book "The Computer from Pascal to von Neumann". Even less people know that there was one country where the census of 1890 was also done on Hollerith machines, and that country was Austria.

Again, it was not an engineer who triggered the enterprise, it was an economist of reputation, Professor Inama-Sternegg, head of the Austrian census office. How he had heard of the American development we can only guess, but Hermann Hollerith was on his honeymoon trip in Vienna at the right time, and it is probable that Inama got the idea by Hollerith's visit in the Vienna census office.

The engineer who made Inama's intention possible, who cooperated with Hollerith, introduced and produced equipment and maintained it, and who finally
made a very big step forward, deserves a section of this paper. I dug up this man, so to speak, (who had been practically totally forgotten in Austria) during three years of a fascinating research. Here, I can give only a short version of my findings.

OTTO SCHAEFFLER

(Theodor Heinrich) Otto (Hermann) Schaeffler was not a native Austrian. Like many famous Viennese—Beethoven, Brahms, Maelzel—he came from abroad. He was born on October 15, 1838 to a Wurttemberg pastor family in Unterheimbach, east of Heilbronn, Germany. His parents sent him to the priest seminary of Blaubeuren near Ulm, but the boy wanted to become a mechanic. So he left the seminary at the age of 15 and entered a mechanics shop in Stuttgart. His aptitude for this profession was confirmed immediately. He received an award of second class in the first year and an award of first class in the second year, the latter for designing an electro-motor. In 1855, he traveled to Vienna and continued to learn in mechanics shops for four years. He then went in 1863 to London for another four years. He settled in Vienna for the remainder of his life.

He understood how to grasp opportunity. When the Austrian Post Administration in 1867 bought (for 40,000 Austrian Gulders) the patent rights for the Hughes printing telegraph, which, in the following year, was internationally accepted at the Second International Post Congress in Vienna, Schaeffler cooperated with the American inventor so successfully that he could start local production of Hughes telegraphs. He soon exported them to Serbia and Roumania, to Italy and Switzerland and even to Japan. Schaeffler established his own factory and in an advertisement of 1871 offered all kinds of telegraph equipment, railway-signalling systems and physical measurement apparatus. The main customer was the Post Administration which in 1871 closed their own Central Telegraph Workshop (founded by the German inventor and Telegraph officer Steinheil in 1850) and turned to private suppliers. Schaeffler succeeded in getting the main contract, installed a contract workshop in the Post Administration building and ran the business of Post Telegraph and Telephone supply and maintenance until 1896. His successors continued this work until 1913.

He supported the projects of the Post engineers. He let them publish; he let them earn all the glamour he produced and he sold. So there is little trace of his work in the technical literature; I had never heard his name during my studies and I had a lot of work to collect the facts about him. The result is fascinating.

At the Vienna World Exhibition of 1873 and at the Paris World Exhibition of 1878, Schaeffler showed, apart from his Morse and Hughes telegraph equipment and his railway signalling systems, a stock exchange printer of his own invention. His exhibit was one of the best at both events; he received gold medals and France made him Chevalier de la Legion d’Honneur and Officier de l’Academie.

In 1874, Schaeffler invented another printing telegraph, a quadruple system like the Baudot, but mechanically more sophisticated. The Hughes telegraph had two synchronously rotating fingers, one in the sender and one in the receiver. By a piano-like keyboard the operator selected a letter and thereby made contact with the rotating finger in the corresponding direction. Since the receiving finger was in the same direction at this moment, the receiver could print the correct letter. The Baudot and the Schaeffler printing telegraphs use a five-bit binary code. But while the Baudot operator must learn the code and apply it to a five-key board, Schaeffler had a Hughes-like piano keyboard for 26 letters (or signs and numerics) plus letter blank and sign blank; below the keyboard there are gliding bars like in a tele-typewriter of our days which produce the code. Schaeffler’s code is a reflected binary code! What F. Gray patented in 1953 for PCM, Schaeffler had applied in his telegraph in 1874, and for a similar reason: reliability. He had contact fingers sensing on five cams consecutively all combinations; the right one triggers printing. If the fingers are to make a minimal number of movements, the solution is the reflected binary code. For Schaeffler, this idea was a minor one. More exactly, the code is described in a letter by the Austrian Post employee, J. N. Teufelhart, inserted there as a footnote and telling that Schaeffler found the code by combining wooden bars with the different combinations until he had the best solution. Another Post employee, Alexander Wilhelm Lambert of Linz, claims to have shown this code to Schaeffler as early as 1872, but this claim is not clear and cannot be checked.

The Baudot apparatus was successful, the Schaeffler apparatus was not; the Post Administration was not interested in proliferation of telegraph systems. Schaeffler soon turned to the next subject, where he saw and obtained his next big chance: the telephone.

Graham Bell and Elisha Gray had shown their inventions in 1876 at the Philadelphia World Exhibition. Two years later the first American telephone network opened in Detroit. Vienna followed in 1881. A private company got a license for a telephone network within a 10-mile circle around St. Stephen’s Cathedral and started in December 1881 with 154 subscribers. Schaeffler constructed and built telephone stations. He supplied the exchanges for 500 subscribers in 1882, for 2,400 in 1884, to which he adds a second of the same capacity in 1890 and a third for 3,000 in 1892. In a report by J. Hopkinson, a member of the Royal Society of London, dated 1893, the Vienna network is classified as faster, better (except for some noise in the lines), and less expensive than the networks of London, Paris and Berlin. In 1895, the Post Administration bought the Vienna network (which now has 18,500 sub-
In 1880, Schaeffler married a Viennese and in 1883 became an Austrian citizen. Between 1874 and 1895, he filed 18 patents and in 1885 he fought the Bell patent with partial success. In 1884, he moved into a new factory where he employed 80 workers (plus 6 in the contract workshop at the Post Administration). He was known in Vienna as a progressive entrepreneur. He allowed no children’s work and no Sunday work, which was not a normal procedure in those days. He financed health and employment insurance for his employees and was interested when they got medals (from the trades’ union of lower Austria) for working 25 years in their profession.

In 1889, Hermann Hollerith received his patent for the punched card system. The director of the Austrian Census Office (Central Statistical Office), Professor Inama-Sternegg, an important statistical and economic scientist of his time, heard about the new machinery and wanted to apply it to the Austrian census of 1890. Schaeffler accepted the task of importing and servicing the Hollerith machines, providing for the power supply, organizing trial runs and using it for smaller tasks like cattle census and hospital statistics. In the spring of 1891, Emperor Franz Joseph I visited the Hollerith operation which processed 28 million punched cards using 12 machines during 667 days, thus carrying out almost 100 million counting steps. The emperor was very satisfied with his visit and after completion of the work, Schaeffler received a very high distinction (Ritterkreuz des Franz-Josephsordens).

Programming of punched card operations was extremely clumsy on Hollerith’s early machines. An electrician had to wire the interconnections between sensors, counters, the relays and their contacts. Schaeffler, the experienced telephone exchange specialist, saw the way for the remedy and applied exchange technology, such as plugs and plug-in cables. On May 20, 1895, he got the Austrian patent No. 463 182 for this idea. He wired the different elements around the bar to make contact on plates of metal. He used 77 counters, 100 relays, 240 punched card hole sensors, and 5 batteries which were accessible and could be programmed by connecting neighboring elements with plug in cables and groups of sensors with metal sheet forms. The programming board could be moved out and the electrician had access in case of trouble. This patent clearly was the beginning of technical programming which could be carried out by the census employees without a requirement for an electrician.

In 1896, Schaeffler came home with a big surprise for his wife. He had sold his factory to Czeija & Nissl who then used the name United Telegraph and Telephone Factories Czeija, Nissl and Company and is now merged into ITT Austria. Schaeffler had requested the term “United” in the name to indicate the succession and, in fact, the new company continued the contract with the Post Administration until 1913. Schaeffler’s big 7,800 subscriber exchange was replaced in 1898, but in remodeled form it was installed again in Prague and worked there for several years.

Before retiring, Schaeffler moved into an imposing house behind the factory he had built. Even today the guest of the present owner, who organizes chamber music concerts in Schaeffler’s ancient rooms, are excited about the place.

Schaeffler died in 1928, at the age of 90, unknown, not as rich as he was at the end of the century, but after a life full of success and satisfaction.

With Schaeffler’s retirement, the import and production of punched-card equipment obviously was at a provisional end; the machines of the Census Office continued to work, the population register was made a continuous service operated on Schaeffler’s punchers, counters and sorters. One or the other machine was still in existence at the end of the Second World War.

GUSTAV TAUSCHEK

A generation later, development started again, Gustav Tauschek (1899-1945) began around 1930 to develop accounting machines of a new type on punched-card basis. He used only the upper half of the standard card for a punched one-out-of-ten code, while the lower half served as written or printed document. There was a sorter running at 20,000 cards per hour; the calculating machine had 75 places for counting and printing, all four basic operations could be performed and also the total sum of the digits of a number. The throughput was at 4,000 cards per hour. Programming was done by plugboards.

Tauschek’s machines remained single models, no production was made. But Tauschek sold 169 of his 200 patents to IBM, among which there was a set for an interesting reading machine.

JOHANN NEPOMUK MAELZEL

Another Austrian (again not born there) I want to mention shortly is Johann Nepomuk Maelzel whose life story has not yet been written. I have collected almost all material and I hope to write it soon. We cannot cover here his contributions to the Music Machine of the 19th century and his success in Artificial Intelligence. Maelzel had invented the Panharmonium, the first flute organ extended by trumpets and percussions, and the first automatic trumpet player. Maelzel had pushed Beethoven to write a Battle Symphony, the first stereophonic composition for two automats, intended for Maelzel’s machines, but never performed on any. Maelzel himself convinced Beethoven to rewrite “Wellington’s Victory” for two orchestras. The cooperation ended in a lawsuit which, however, was terminated by a friendly agreement. Maelzel
bought the famous wrong Chess Player from the son of Herr von Kempelen, sold it to Eugen Beauharnais and got it back in 1817. Nine years later, he came over here to the US and performed with the Chess Player and other automata in simulating artificial intelligence. Kempelen's trick, to prove that an obviously man-driven chess player could not possibly contain a human being, was superbly staged by Maelzel. Once he was dead, the chess automaton was practically dead. That it was destroyed by fire in Philadelphia in 1854 is only the proper dramatic end of a fascinating story.

Maelzel, however, also introduced the master clock into music, and a standard for musical speed, much more efficiently than any modern standards committee. He started off by stealing the mechanical invention from D. N. Winkel, who had invented his chronometer in 1814. Maelzel not only got patents in London, Paris and Vienna, he started fabrication in all three places within two years after stealing the mechanical construction idea. Apart from his sales campaign, his main contribution was first, a good trade name, metronome, and second, the scale which made the device attractive. From the natural marks at 60 and 120 beats per minute, he derived a 16-step scale which is accepted by musicians to this day. All of that was accomplished in two years. Maelzel would give metronomes as presents to the most famous composers in London, Paris and Vienna, if they signed a declaration that they would mark future compositions by the Maelzel measure.

DIEDERICH NIKOLAUS WINKEL

D. N. Winkel (1777-1826) was very angry about Maelzel's total disregard of him as the real inventor. (It is true, however, that Maelzel made the mechanical idea a world success, which Winkel could never have achieved. This is a lesson for the engineer on the difference between a technical idea and its commercial exploitation). So Winkel decided to beat Maelzel in his (then) central field: in the field of musical machines. And Winkel built a music machine which could compose, and this is the first construction I know of to use a stochastical element. The trick is to distribute eight forms (the melody and seven variations) of a composition over two pin drums, two bars on one and two bars on the other in sequence. The stochastic element decides a stochastic path through the stored information which would repeat itself only after 5 million years, as the Paris Academy calculated.

The stochastic element is a 3" wheel where the first and third quarter of the circumference is cut out. It is started and slowed down. When it stops, a finger finds out the decision (stopped at a cut-out quarter or at a full quarter) and correspondingly commands a move or not into the adjacent variation. Weaving, Music Machines and Census have prepared as many ideas for the computer as calculating devices. Only part of the history of ideas is collected and described in publications of our days and in our language. A lot remains to be done.

But let us now turn to programmed calculation.

PROGRAMMED CALCULATION

The computer, in fact, is the product of two streams of development, namely calculating devices and programmed calculation, and it should never be forgotten that a computer can be as well man as machine.

The prehistory of calculating devices is well known, from the calculi, the reckoning-stones to the abacus, which might be an Asiatic invention but might also come from Europe. The contributions of Pascal and Leibniz are known, but the fact that a professor of theology in Tuebingen, Germany, by the name of Schickart built a four-species device already in the year in which Pascal was born, had to be rediscovered several times. No Schickart machine survived, but we have some documents from which several reconstructions have been derived. The device contains an adder with carry plus cylindric multiplication tables which permit easy adding for multiplication and substraction for division. Since transmission is done by the operator, the system is less reliable than the later desk calculators.

Leibniz, by the way, not only described the binary system, which he got from the Chinese philosophical code connected to I-Ging, Leibniz also described the construction of a binary adder operating with metallic spheres. The case 1+1 yields zero, carry one, requires channelling one of the two spheres to the next binary place, while the redundant sphere falls through into the container which from time to time must be "poured" by hand into the "stock" above the added. Dr. Mackensen of the German Museum in Munich has built a model, restricting himself to the technical possibilities of the time of Leibniz.

But let me turn to programmed calculation. Certainly, there were many examples for it—let me tell you an Austrian story which had very practical consequences. Around 1840, there was a typical Viennese University Professor by the name of Joseph Petzval who was born in a German town in a Slovak province of the Kingdom of Hungary. He had worked in several fields of Applied Mathematics and Physics, and he had written an interesting mathematical theory of music.

At that time he had an idea how to produce high-quality lenses which would make the newly invented photography a real art and technology. But his idea would have required so many hours of calculations that a full crowd of calculators would be required which a University Professor never could afford to pay.

It was the Army who helped. One day, Petzval told his story to a Hapsburg, Archduke Ludwig, who then was the director of the Austrian artillery. Using bombardiers to calculate firing tables was already standard.
Some of these were very experienced specialists in numerical calculations. Petzval borrowed some of them and the result was first a landscape lens and later a portrait lens, manufactured by a German optician Voigtlaender who obtained a world-wide reputation based on these programmed calculations.

Petzval, to my knowledge, was the first one to use the term "thinking machine" and he used it properly. In his introduction to the paper on the programmed calculation of the lens, he says that pure mathematics is the construction of a powerful thinking machine.

A similarly powerful thinking machine is logical algebra, reinvented by engineers under the name of switching algebra. From 1895 to 1936, there is a full series of Austrian forerunners of Shannon. A contribution to the thinking tools around computers comes from Ludwig Boltzmann, the Austrian physicist who lectured on thermodynamics. His chapter on entropy contains a derivation of Shannon's formula \( H = \sum p_i \log \frac{1}{p_i} \). (It is from Boltzmann that Shannon took over the letter H for entropy.)

Austria's contribution to the theory of computation is the revolutionary paper of 1931 by Kurt Goedel, then Assistant Professor at the Vienna University, on the undecidability of axiomatic systems above a certain degree of complication. The theory of games and economic behavior comes from Budapest-born John von Neumann and Vienna-born Oskar Morgenstern. The philosophy of information processing can be based, as I have shown, on Ludwig Wittgenstein's "Tractatus Logico-Philosophicus," written while he was in the Austrian Army. All these ideas are as important for the development of information processing as the actual construction of computer models and computers.

Let me close this paper with two paragraphs on Austrian contributions to the electronic computer which was given the name "Mailüfterl" after a friendly Viennese May breeze—thus indicating its more modest parameters compared to the ambitious computers of those days called Whirlwind, Typhoon and Hurricane. But this Viennese development (which finally was, e.g., not that slow; with hearing aid transistors we could run it at a clock frequency of 130 Kilocycles per second) had several interesting features. The instruction word included van der Poel's functional bits (nine of them, in fact), could decide between binary and decimal operation, use flag-bits and attach one of 15 different conditions to any instruction.

The second development was the formal definition of syntax and semantics of PL/I, including the design of the Vienna Definition Language and an Abstract PL/I machine. The ANSI Standard for PL/I is written in this Vienna Definition Language, although there have been critical objections to this abstract method. But there is no easy way to describe a language of the size and sophistication of PL/I in English or in a half-formalized language. I think it is impossible, as a matter of fact, if one is unwilling to accept serious ambiguities. Obligation to formalization is as old as formal methods; reluctance is as human as the invention of formalisms. All is a matter of education, balance and respect for the human aspects of science and technology.

I have presented a sequence of highlights rather than a systematic paper. My excuse is that the material that exists on the subject is enough for many hours of lecturing and would require years of work to render it in a systematic form. It was not my intention to bore the reader with details. I wanted to invite him to glimpse fascinating adventure, to see not only more than the circuitry and the present status of the computer, but to understand this magnificent invention, the computer, as the result and combination of many hundred years of human efforts of many kinds. To trace these efforts back in history is as fascinating as it is useful.