My years with Rutishauser

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Heinz Rutishauser (1918-1970), who died far too early, was one of my very best friends; among the professionals of my age class that I became aquainted with in the fifties, he ranks in one line with Klaus Samelson (1918-1980), my Munich study colleague, and with Jim Wilkinson (1919-1986).

Rutishauser gave a seminal lecture entitled „*Automatische Rechenplanfertigung bei programmgesteuerten Rechenmaschinen*“ at the GaMM meeting in Freiburg in Breisgau, at the end of March, 1951, which I missed — I was still assistent of Fritz Bopp, the University of Munich Theoretical Physicist, successor of the famous Arnold Sommerfeld. I became aware of the lecture when it was published mid-1952 as an ETH-Mitteilung. Therefore, when I met Heinz Rutishauser in February 1952 for the first time, I was absolutely ignorant about his success, and we did not talk about the subject. It just happens that we met on February 19, 1952; tomorrow it will be 50 years ago.

You may ask yourself, how our cooperation developed. It happened via Konrad Zuse and Eduard Stiefel. In 1949 — June 27, to be precise — Zuse had presented in the seminar of Wilhelm Britzlmayr (1892–1970), logician and Honorary Professor (whose regular occupation was director of a bank) at the *Ludwig-Maximilians-Universität* in Munich a report on his ’*Plankalkül*’. Britzlmayr, who found out that I was interested in the topic and who had kindred relations in Switzerland, kept me informed from time to time on the further development, and mentioned one day that in July 1949 a professor at the ETH Zürich had signed a contract to rent Zuse’s relay calculator »’Z4’, and that in August 1950 the machine was operational.

Several circumstances had led me to be interested in calculating machinery. First of all was the construction of a ‘differential analyzer’ along the line of Vannevar Bush, that Bopp had forced upon me. The second circumstance was the continuous information on progress in electronics in the field of communications engineering that I obtained from my co-assistent and almost fatherly friend Paul August Mann. Mann, a disciple of Sommerfeld, had worked during the war at the Telefunken company. In this way I did run into the work of John von Neumann and even gave in June 1950 in the Bopp seminar a colloquium talk on automatic calculating machines.

At that occasion, Hermann Jordan, assistent of Robert Sauer (1898–1970) at the Technische Hochschule München, beeame aware of my interests. He told me one day in June 1951, that his boss was about to start a special and private seminar with the aim of building an electronic calculator together with his colleague Hans Piloty (1894–1969), who was professor of telecommunications engineering in Munich. Jordan arranged to smuggle me as a guest into this seminar. I shall all my life be thankful to him.

The incentive by Paul August Mann had led me already in January 1951, following the traces of Richard Hamming, to file a patent application for a method of constructing error-detecting and error-correcting codes. This ended in a cooperation with Herbert Wüsteney (1899–1988) in the Zentrallaboratorium of the *Siemens und Halske* AG in Munich and in the construction of appropriate equipment. In February 1952 I was sent at the expense of Siemens (and with their help to obtain an exit permit from the United States Military Government) to Bern, in Switzerland, in order to discuss with the PTT their possible interest. Of course, I wanted to make use of the opportunity to see on my way back the fabulous Z4 of Konrad Zuse working at the ETH. I approached Stiefel, and I was refered by him to Rutishauser.

Thus, I met Rutishauser on the 19th of February 1952 in his office. He was very kind to the German hitherto unknown to him, and gave readily the information I asked for. In particular, he impressed me by the richness of experience he had collected, together with Ambros Speiser, in the USA during his stay from October 1948 till the end of 1949 at Harvard University and at the Institute for Advanced Studies in Princeton. Moreover, he gave me a hint of his 1951 paper on ’Automatische Rechenplanfertigung’, which became decisive for my own path through academic life. From the visit developed a deep friendship and a fruitful cooperation that has given me, younger by six years, a great amount of stimulation.

Rutishauser’s way to Stiefel

When Rutishauser started his academic studies, he could not yet know that it would lead him to computers. Born on January 30, 1918, son of the headmaster of the *thurgauische Kantonsschule* in Frauenfeld, he lost his father in 1931 and his mother in 1934. Heinz Rutishauser and his younger brother and sister found a new home at the house of their uncle. In 1936, Heinz earned his *Matura* and was — I quote from the curriculum vitae — „*befähigt zum Studium an der ETH, das er, mit Unterbrechungen durch Wehrdienst bei*

der Festungsartillerie im Gotthardgebiet, 1942 mit dem Diplom als Mathematiker abschloß". Subsequently, he was for three years assistent of professor Walter Saxer at the ETH. During this time, he also acquired the doctors degree with a dissertation '*summa cum laude*' in the field of the theory of complex functions. After the end of the war, Rutishauser became a mathematics teacher at the gymnasiums in Glarisegg and in Trogen; in 1948 he became, together with Ambros Speiser, an assistent at the newly founded 'Institut für angewandte Mathematik' of the ETH. Thus, he entered the sphere of influence of Eduard Stiefel, a topologist who had before the war written a sensational paper on homology classes and had a high reputation, but now had changed his field.

Following his stay in the United States, Rutishauser aimed for a 'Habilitation'. This led to the already mentioned work on '*Automatische Rechenplanfertigung*' that followed the vague traces of Zuse's *Plankalkül*, but was concrete and, compared with the '*Programmator*' of Zuse (published in 1952), more realistic.

I am not sure whether or not Rutishauser initiated me in 1952 in the preparatory work that had started in 1948/49 by Speiser for the construction of ERMETH, which even was the deeper reason for their visit to the USA. There was no reason for giving me the information, since on my side, although I knew of Piloty's aims, I was officially not entitled to know it and therefore had to keep silent.

This changed in the autumn of 1952, when, after I had finished my PhD under Bopp (1909–1987) in January 1952, I became an assistant to Robert Sauer at the Technische Hochschule München. In the meantime, the German Research Council (DFG) had given their support for the Munich application and I could speak quite openly about the PERM. In the course of the year 1953 and in the following years I met Rutishauser regularly, sometimes in Zurich, sometimes in Munich. I remember particularly one of his very first visits to my house, January 20 to 22, 1954.

From the very beginning, our discussions had been bipartite: they encompassed on the one side Numerische Mathematik that just was in the process of moulting, and on the other side the construction of computing machines, where we could concentrate, in accordance with the division of labor that was exerted in Munich and in Zurich, on the functional side. In addition, there were more and more the problems of 'Programmierungstechnik', as we called it at that time - today we say 'Informatik'.

Numerische Mathematik - the beginning of algorithmic thinking

The acquisition of the relay computer Z4, the surprise Stiefel had for the repatriated Speiser and Rutishauser, turned out to be a clever chess move: it guaranteed him in 1951 the possibility to test new numerical methods, although on a slow machine, and offered a favorable environment for a quick build-up of a new doctrine in Applied Mathematics: Numerische Mathematik that was governed by algorithmic thinking.

The spiritual uprising occured on the example of a problem almost impossible to solve with the Z4: The solution of a system of 106 linear equations on a machine that, to quote Speiser „*hatte 64 Speicherplätze für Gleitpunktzahlen und leistete 1000 Grundoperationen pro Stunde*". Thus, a direct elimination procedure was excluded. But there existed reasonable initial approximations for the problem that dealt with the reservoir of Grande Dixence. An iterative refinement method like the relaxation method of the steepest descent, advocated by Lothar Collatz and his school, turned out to be insufficient, even when used with overrelaxation.

The outsider Eduard Stiefel, with the best knowledge in Geometry as well as in Analysis, invented under the pressure of the situation the method of conjugate gradients ('cg-method'), that was also discovered independently by Magnus Hestenes. lt was still iterative, but, by producing mutually orthogonal residuals and mutually A-orthogonal ('conjugate') corrections, allowed one to produce a solution exact up to rounding-off errors in 106 steps (actually, as stated in the dissertation of Urs Hochstrasser, 90 steps produced on the Z4 calculator in Zurich an estimate of sufficient accuracy to be acceptable). The cg-method was a milestone in the development of algorithmic thinking.

In the first half of the 20th century, in Pure Mathematics at a few occasions, say with the 10th Problem of Hilbert or the word problem of Dehn and other decision problems, a resort was made to the century-old linguistic usage of 'algorithm' in the sense of 'a general, a priori determined procedure giving a solution in a finite number of steps'. While the word was barely used in Applied Mathematics, since it seemed to be connected with trivialities like 'Euclidean algorithm' or 'algorithm of multiplication', a sharpening of the concept had been made in the course of Turing's ideas on computability. Therefore, it was not astonishing that in the vicinity of Stiefel the word 'algorithm' shows up for numerical methods that terminate steadfastly. In fact, Stiefel and Hestens wrote 1952 in the summary of their joint paper: 'An iterative algorithm is given for solving a system of linear equations'. Consequently, Rutishauser in 1954 called his method for the determination of eigenvalues '*Quotienten-Differenzen-Algorithmus*'. Peter Wynn, who later was my assistent at Mainz, introduced in 1956 the '*epsilon-Algorithmus*', and in 1958 I introduced the '*g-Algorithmus*' and the 'η-*Algorithmus*', both being continued fraction algorithms, the links between the previously mentioned ones. 'Algorithm' pretty soon was a catch-phrase of numerical and nonnumerical mathematics; ALGOL stood for *algorithmic language*. James Varah stated, George Forsythe (1917-1972)

emphasized the development of algorithms more than the finding of theorems. The same holds for Heinz Rutishauser.

With particular delight I remember the single case when Rutishauser and I had jointly written a paper — normally we were used to working separately and to comparing results, which led us into a rather intensive exchange of letters. In this case, however, we found out at a meeting in Munich that we had discovered — up to notational details — exactly the same method. The starting point was Rutishauser's LR-transformation; our method accomplished quadratic convergence by effectively building the powers A, A^2, A^4, A^8, A^{16} and so on of a matrix A instead of being forced to use a Newton shift with doubtful global convergence. We published it under the title *Détermination des vecteurs propres d'une matrice par une méthode iterative avec convergence quadratique* in the *Comptes rendus*, Band 240, 1955 of the Paris Academy and we were very proud that the short note was accepted. (Presumably, very few people have read it with interest.)

Within certain limits, Rutishauser informed me also on some big problems he had to work on; I still remember a dam, a parallelogram-shaped plate, and a turbine ('*Sulzer Verdichter*'). In this way he gave me conducive hints for the practical organisation of big projects, that I could use in 1956/57 in calculating a strongly meshed high voltage network of the German railroad.

STANISLAUS, a Formula-programmed Relay Calculator and Rutishauser's 'Automatische Rechenplanfertigung'

My interest in Rutishauser's '*Automatischer Rechenplanfertigung*' was established by my little relay calculator for formulas of propositional logic in Polish (parenthesis-free) notation, which I had baptized with the name of the Polish saint STANISLAUS. Under the influence of the 1949 paper by Claude Shannon, *The synthesis of Two-Terminal Switching Circuits*, I had started to look for a relay realization of a device for evaluating a well-formed formula, which was to be typed in directly. This allowed a direct evaluation of a propositional formula for instantiations of the variables by 'true' or 'false'; the test for well-formedness turned out to be a byproduct of such a 'formula-programmed relay calculator for parentheses-free propositional formulas'. Around the turn of the year 1950/51, during a stay in Davos, in Switzerland, I made the wiring diagram for the relay calculator. Then I started to collect material for the construction of the device. In October 1951 I entered into a consulting contract with the Siemens company in Munich; now from time to time I could help myself from the surplus bin of the Siemens & Halske AG Central Laboratory in the Munich Hoffmannstraße, where relays and keyboards were to be found. Again and again, my former Munich logic professor Britzlmayr urged me to start with the actual construction, but I had too many other obligations. It was only in 1954 that I started, under the attentive eyes of my colleague and friend Klaus Samelson and helped by Heinz Schecher, to wire the first segments. Then, after having seen how it would work, my interest waned, and it was only after very urgent admonition from Britzlmayr that in 1956 STANISLAUS was finished. It was shown on December 3, 1956 at a colloquium in Münster and presented on January 8, 1957 to the Munich academic public; it met with the delight of Britzlmayr. Samelson and myself did not think so highly of the apparatus: in the meantime we had greater joy with the PERM computer. STANISLAUS is now exhibited in the Deutsches Museum, Munich.

Rutishauser's seminal *Habilitationsschrift* of 1951 gave the evidence that the 'Automatische Rechenplanfertigung' for a given, sufficiently flexible computing machine could be carried through with just the same machine (Andrei Ershov coined for this the expression 'programming program'). Rutishauser had no chance to do it immediately on the Z4. However, progress in building the PERM in Munich was such that we could start in 1955 programming a 'formula translator', based on the so-called 'cellar principle' of my *Formelrechner* STANISLAUS. This translation method was an essential improvement over the Rutishauser method of 1951, as it was much faster. Moreover, external circumstances had the effect that I filed in March 1957 jointly with Klaus Samelson a patent application for a formula-controlled computer with hardware realizing the cellar principle. Rutishauser, on the other hand, with the experience he had already made on the Z4, programmed a run-time organization for the ERMETH, in particular the treatment of subroutine returns — a 'last in, first out'-type organisation, i.e. the cellar principle applied to program structure. (Fortunately, the German Patent Office did not find out about this, which even could have been traced back to Turing and van der Poel.) The ERMETH, by the way, was ready about one year after the PERM.

Hence, it was natural that Rutishauser, Samelson (who extended the cellar principle to storage allocation) und I did intensify more and more our cooperation in the area of what became called compiler-building. This had the consequence that we were forced to agree on language constructs, and again the lead of four years in practical programming Rutishauser had, thanks to the Z4, was his great asset. Rutishauser's reputation also had the effect that his appeal at the GaMM-meeting in 1955 to create a common programming language found the support of the GaMM president; within the 'Fachausschuss Programmieren' a working group with Zürich, Munich and later Mainz members was established that pushed the language

creation. Rutishauser was not less active than Samelson and myself: the first larger working meeting of the group that meanwhile called itself ZMD-Gruppe (D for Darmstadt: Hermann Bottenbruch) took place in autumn 1957 in Lugano, organized by Rutishauser. At that meeting it was decided, in the name and with the approval of the GaMM, to approach the US-american ACM and the British Computer Society with the proposal of a joint conference for the creation of an internationally-based programming language for scientific computation. Unfortunately, the BCS did not react; the ACM, however, under its president John Carr III was cheerful and it came to a one-week ACM-GaMM conference in May 1958 at the ETH Zürich, thanks to the support Eduard Stiefel had given. While the English working title was IAL (International Algebraic Language), the name Algorithmic Language ALGOL was already chosen in the publication, edited by A. J. Perlis and K. Samelson, in the newly founded Springer journal 'Numerische Mathematik', Vol 1 (1959).

The further course of development of ALGOL saw Heinz Rutishauser also taking part in the conference held January 11-16, 1960 with thirteen experts from the USA, Germany, Switzerland, Netherlands, England, Danmark, and France in Paris. It produced ALGOL 60, a milestone. Rutishauser's share was more than a thirteenth.

Rutishauser in the 60's

With ALGOL 60, the 60's had opened, the Golden Years of Programming had gone. Rutishauser took part in the further developments within the frame of the IFIP Working Group 2.1 ALGOL; however because of his health no longer with full activity. In particular, he did not dare to travel by airplane to the USA. He also disliked (like Samelson and myself) several *faux pas* that occured mainly in the attempts to create ALGOL 68. The fiasco of ALGOL 68 is to be blamed on others. Rutishauser prefered to concentrate on the description of standardized numerical algorithms in ALGOL 60; this led to a good part later to the LINPACK and EISPACK collection. He also wrote Volume I, Part A 'Description of ALGOL 60' of the *Handbook for Automatic Computation* (1967), published by Springer, that contained many representative examples of algorithms.

After becoming already in 1955 '*außerordentlicher Professor*', Rutishauser was in 1962 promoted to '*ordentlicher Professor*'. In 1968 he was nominated '*Leiter der Fachgruppe für Computerwissenschaften an der ETH*', the predecessor of the '*Institut für Informatik*' and later of the 'Department Informatik der ETH'. However, his health was not the best. This I became aware of already in 1955 when Rutishauser stayed in our house. In the night of Wednesday, February 16, 1955, he developed a heart problem. Fortunately, the next day it was stabilized, but he was forced to take a longer recreation stay in Klosters. He also recovered rather quickly from a heart infarction in the autumn of 1964, and he was granted a few more years. But when towards the end of the 60's a professorship was open for the Munich Leibniz Computing Center and Rutishauser was chosen by the Ludwig-Maximilians-Universität and the Bayerische Akademie der Wissenschaften, he did not accept. He let me know that his health would disallow the acceptance of this honourable offer. In 1969 he became seriously ill. He died November 10, 1970, sitting on his desk, by an acute heart failure.

Please let me finish in my native language. Im Nachruf schrieb ich damals, in tiefer Trauer: „Viele Ehrungen, die er in seinem Leben noch zu erwarten gehabt hätte, erreichen ihn nun nicht mehr. Dem bescheidenen, den Glanz der Öffentlichkeit nicht suchenden Wissenschaftler wären sie ohnehin nicht gelegen gekommen. Er arbeitete lieber in der Stille, und verlangte dabei zu allererst von sich selbst das Höchste. Er war redlich und lauter, ein aufrechter Mensch, um den besonders die trauern, die das Glück hatten, ihn zum Freund zu haben, ihm nahegekommen zu sein". In 1971, I dedicated my book ''Informatik' in memoriam to Heinz Rutishauser, where I wrote „Er gehörte zu den ersten, die die über die Numerik hinausreichenden Fähigkeiten der digitalen Rechenanlage erkannten und nutzten - und damit halfen, das Gesicht der Informatik zu formen". Heinz Rutishauser wird als einer der Begründer der Informatik unvergessen bleiben.