The Mills of the Patent Office[1]

The futile efforts of Konrad Zuse to patent the program-controlled calculating machine*

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Summary Konrad Zuse, who was able to demonstrate the functionality of the first program-controlled computer in 1941, had been trying to obtain a basic patent since 1936, which had touched all computers. Until the end of the war, the Patent Office's requirements for the correct drafting of a patent application had to be met, but since 1953 he had to deal with numerous objections. The proceedings ended in 1967 with the rejection of all of Zuse's claims by the Federal Patent Court.

1. Introduction

On 14 July 1967, the Federal Patent Court (Bundespatentgericht, BPG) decided to reject the appeal filed by Zuse KG against the German Patent Office's refusal to grant the patent for a "program-controlled calculating machine" on 20 September 1962. The possibility of appeal to a third instance was excluded.[1]

This concluded a patent procedure in which the inventor Konrad Zuse had been trying since 1936 to obtain a basic patent for his concept of a program-controlled calculating machine. The patent was not granted, although Zuse was able to demonstrate a functional realisation of this concept for the first time in 1941 with the "Z3" and although the Z3 is considered to be the first functional computer ever, even if it does not have all the features of the computer concept associated with the name John von Neumann.

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* Revised version of "Die Ermittlung des 'Standes der Technikes' und der 'Erfindungshohe' beim Patentverfahren Z391. Dokumentation nach den Zuse-Papieren", *GMD-Studien*, No. 59, St. Augustin 1981. I would like to thank Prof. F.L. Bauer for carefully reviewing the text and for numerous detailed discussions. I thank Prof. R. Rojas for the inclusion of the work in this volume and for the careful conversion into a clear typeface. Of course, I remain solely responsible for all remaining errors and ambiguities.

1 Decision of the Federal Patent Court of 14.7.1967, Zuse Papers (ZuP) 005/009. The citations follow the numbering by the GMD (Gesellschaft fiir Mathematik und Datenverarbeitung, St. Augustin). The citations are based on the copies of the original Zuse documents arranged by the GMD. The copies of the GMD are now in the archives of the Heinz Nixdorf MuseumsForum Paderborn, whereby the numbering is unchanged. The original documents are in the possession of the Zuse family. *[η1]*

η1 Translation note: When Petzold wrote this article, Zuse's original papers were in Zuse's house in Huenfeld with the family, but for many years now they are in the archives of the Deutsches Museum in Munich.

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1 Published in German as the chapter "*Die Mühlen des Patentamts*" in Raul Rojas' very illuminating book "*Die Rechenmaschinen von Konrad Zuse*", Springer, Heidelberg, 1998.

Konrad Zuse's priority as the inventor of "the" computer is widely recognised today. Brian Randell from England is quoted as representative of many others: "This computer, since it was operational in 1941, is believed to have been the world's first general purpose program-controlled computer."[2] On the other hand, the IBM chronicler Emerson W. Pugh expressed doubts: "His computing device is said to have been operational in 1941. Because it was destroyed during the war, however, there are numerous unanswered questions. [...] Zuse's machine is credited as a 'first' by many historians. It is a rather limited first, however, since the device was too small to do useful work."[3] The sensible path from a scientific point of view is the differentiated view, which breaks down "the" computer as a closed overall machine into essential aspects and principles, in which the priorities are clearer.[4]

With regard to the important honours which the computer pioneer Zuse had in the meantime received, the Federal Patent Court stated: "At the time of filing the application, it may have been meritorious to take up and pursue the idea of actually developing and executing a functional machine according to the published descriptions of program-controlled calculating machines. However, such a circumstance, which may well give rise to public recognition and honours, does not yet give the task the character of an invention in the sense of the Patent Law, for which a patent could be granted."[5]

To justify this, the BPG referred to the fictitious "skilled person" required by the self-understanding of Patent Law, who in 1941 "sets himself the task of building a machine approximately according to Couffignal's dissertation (held against Zuse, H.P.)". Because Couffignal did not say anything about "how he wanted to display the commands from the programme carrier in the form of a punched tape", the opposing party cited numerous

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2 Randell, B., *The Origins of Digital Computers*, 3rd ed. The German-language authors hold Zuse's priority resolutely high. Only de Beauclair, W., *Rechnen mit Maschinen*, Braunschweig, 1968, pass. and Zemanek, H., *Weltmacht Computer,* Esslingen, Miinchen, 1991, p. 102 should be mentioned.

3 Pugh, E.W., *Building IBM. Shaping an Industry and its Technology,* Cambridge, Mass., London, 1995, p. 343. The fact that the acknowledged experts William Aspray and Martin Campbell-Kelly do not mention the central works of Zuse and the Z3 at all in their account of the history of the computer and exhaust the question of priority with the mention of Aiken's Mark I, "the first fully automatic computer to come into operation", shows that ignorance has also maintained its place. Campbell-Kelly, M., W. Aspray, *Computer - A History of the Information Machine,* New York, 1996, p. 75.

4 Paul Ceruzzi made this point in his lecture at a colloquium organised at the Deutsches Museum to mark the fiftieth anniversary of the first attested demonstration of the Z3. Ceruzzi, P. E., "The early work of Konrad Zuse in the context of the invention of the digital computer: 1935-1950", Deutsches Museum, *Scientific Yearbook 1992/93,* München, 1993, pp. 170-186.

5 Resolution of the BPG of 14.7.1967.

publications and patent specifications in which punched tape played a role, so that the BPG came to the conclusion that in 1941 the "average expert" was familiar with the construction of program-controlled calculating machines "from numerous prototypes". For the fictitious "expert", who knew the technical literature published worldwide, it did not matter that Babbage's cited writings had already been published in London in 1864, Ludgate's in Dublin in 1909, that difficulties arose in the course of the patent proceedings in the 1950s in obtaining Couffignal's writings and that the cited patent specifications included American, Italian and English ones. Even the problems that the war of 1941 brought for a single German inventor could not disturb this "expert". The procedure for the construction of a machine corresponding to Zuse's concept arose "within the framework of his normal activity", the BPG ruled, and thus did not require "any creative intuition beyond the knowledge that could be learned".

The assessment of Zuse's patent application ended with the statement: "The novelty and progressiveness of the subject-matter claimed in the main application are not doubtful, but no patent can be granted on it for lack of inventive step." The reason given for the rejection of the claim for patenting Zuse's calculating device for floating-point numbers, for which, in the opinion of the BPG, no "inventive inspiration" was required, must have been perceived as disappointing for the inventor and downright provocative for many for whom the patent-law view was not a matter of course.

The decision of the patent court cannot be criticised here from a patent law point of view. Instead, the objections and delimitations and thus the "state of the art" of 1941, which was determined with great effort, are to be documented, at the same time showing the material basis on which the patent was twice refused. Despite the diversity of the technical aspects presented, it becomes apparent how selectively a patent procedure reflects a historical fact and how little it can ultimately do justice to the broader interest of those interested in history.

The rejection of a patent is based on a decision that starts from juristic categories. A patent is granted if the invention is recognised as an achievement for which an "inventive step" was necessary to go beyond the "state of the art" in solving a technical "problem". The "novelty", the "progress" and the "inventive step" of the application must also be taken into account. For German patent law, the "state of the art" is formed by "everything that has been published in the last hundred years

is already described in such a way or is already so obviously used domestically that its use by other experts appears possible."[6]

In order to determine the "state of the art", it is therefore necessary to study writings, not actually existing and functioning machines. For the inventor and designer Zuse, however, the actual built machine had been in the foreground.[7] He repeatedly invited the patent office's processing committee to inspect his machine in order to demonstrate the justification of his patent claims, but the committee never responded.

In patent law, the examination of the "novelty" and the "progress" of an invention is based on a separate comparison of the invention with each of the individual prior publications. In contrast, for the assessment "inventive step", the individual prior publications are combined "mosaically" to form the "state of the art". Patent law starts from the "state of the art" determined in this way and asks whether an "inventive step" was necessary for the invention. The inventor is contrasted with the aforementioned "average skilled person" who knows how to use the "state of the art" in a skilled manner and can also develop novel things, but cannot produce anything for which an "inventive step" is necessary. For German patent law, this "average skilled person" is one of the "legal concepts which need to be filled in", such as the concepts of "good morals" or the "diligence of a prudent businessman". "Such a term is not to be filled in by a simple logical subsumption, but by a legal-political evaluation oriented to the purpose."[8]

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[6] Bernhardt, W., *Lehrbuch des deutschen Patentrechts*, 3rd Au:fl., Miinchen 1973, § 7.

[7] It is possible that the reconstruction of the Z3, which was destroyed during the war, was created in 1961/62 at Zuse KG in connection with the patent proceedings. It has been publicly shown in many places and has been in the Deutsches Museum in Munich since 1968. However, there does not seem to be any concrete proof of this connection. However, the fact that in 1956, when the important patent on the magnetic drum memory was granted to Gerhard Dirks, who was very successful in the patent business, the patent office could be convinced with a reconstruction of a drum memory according to the state of the art of 1943, speaks in favour of this. This success had impressed Zuse. Zuse, K., *Der Computer - mein Lebenswerk*, (revised new edition of the first volume with the same title, Munich, 1970) Berlin, 1984, p. 99f. Cf. on Dirk's patents: Zellmer, R., *Die Entstehung der deutschen Computerindustrie*, Dissertation, Koln 1990, pass. This reconstruction is also in the Deutsches Museum today.

[8] Bernhardt, op. cit., p. 49.

2. The applications from 1936

A list of Zuse's patent applications from the period 1936 to 1947 was compiled in 1959 by Zuse KG, Bad Hersfeld.[9] The applications can be divided into two groups:

1. Individual mechanisms that had partial functions as their object; these include the mechanical switching elements and the surface scanning method for measuring the wing; these patents were granted in 1953/54.
2. The comprehensive applications with which the calculating machine should be registered as a whole; these include:
   - Z23139, "Verfahren zur selbsttätigen Durchführung von Rechnungen", notified on 11.4.1936, was not published, withdrawn in August 1940.
   - Z23624, "Rechenmaschine-Rechenanlage", registered on 24.12.1936, not published, withdrawn in February 1943.
   - Z26476, "Rechenvorrichtung", applied for on 16.6.1941, published on 4.12.1952, later file number Z391.
   - Z28780, "Device for deriving result data by means of basic operations of the propositional calculus" = "(Logistic) calculating device", applied for on 11.10.1944, published on 12.3.1953, later Z394.[10]

The two patent applications that were not revoked were rejected by the Federal Patent Court in the second instance in 1967.

2.1 The Application Z23139

The application under file number Z23139, which Zuse filed on 11 April 1936 through a patent attorney, was entitled "Method for the automatic performance of calculations with the aid of calculating machines".[11] He made no statement about the "state of the art", which should be outlined in the description section of an application in order to measure the inventive idea. The purpose of the invention was "to enable recurring calculations of any length and any structure, consisting of elementary arithmetic operations, to be carried out automatically with the aid of calculating machines". The main claim, to which all other claims referred, concerned precisely this procedure. It was characterised by the fact "that, on the one hand, the numbers occurring in the course of the calculation

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[9] See the appendix to this paper.

[10] "Patent applications by Dipl.-Ing. Dr. K. Zuse", (period 1936-1947), ZuP 020/003 (see appendix to this article).

[11] With letterhead of patent attorney K. Wolf, 9.4.1936, filed 11.4.1936, AZ: Z23139, ZuP 005/021.

numbers are stored and are available at any time to a computing device by means of a selection mechanism, on the other hand the required operations are selected and controlled by the scanning of a calculation plan, which for each operation continuously and automatically indicates the basic type of calculation to be carried out, the numbers of the memory cells containing the respective required numbers and the numbers of the cells storing the result".

Claims 2 to 5 brought further characteristics of the "method": The calculation plan should give formula constants, commands for control and numbers for calculation to the machine in such a way that a corresponding control command for numbers switches the scanner and enables the correct forwarding of the numbers in contrast to the control command. Furthermore, the semi-logarithmic representation in the forms $y = B^a$- b and $y = B^a$- b′ with b′ = b - l as well as the binary number system (B = 2) should be used. The claim referred to semi- logarithmic number representation in number systems of any base. The binary system was indicated as the preferred case. Claims 6 to 11, on the other hand, related to the machine for the method and parts thereof. Claim 6 characterised the calculating machine "as comprising a calculating device, a distributor, a storage unit, a selector, a scanner for the calculation plan, a scanner for the output values and a punch for the result unit".

Claims 7-11 concerned the selection mechanism, the transformation from fixed to floating point, the recognition of the first non-zero digit, the binary adder and the memory circuit. The selector unit was described in the sketches as an electromechanical relay, whereas the illustration of the adder circuit suggests a mechanical design. In the description it says: "either electrically or mechanically". Zuse left the technology open and only stated the principle.

The description was divided into explanations of the calculation plan and those of the machine's mode of operation. The machine was supposed to work in 4 cycles per "operation": 2 cycles for the transfer of the two operands into the calculating device, 1 cycle for the calculation operation and 1 cycle for the transfer of the result into the storage unit. Some suggestions indicated ways in which the procedure could be refined and extended:

> "If the result is to be used in the next step of the calculation, the two cycles for 'Save result' and 'Get operand' can be omitted.
>
> If two connections are installed between the arithmetic unit and the memory, then it is possible to request and return at the same time. The work cycles can be nested within each other.
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> Several arithmetic units, memory units, distributors, scanners, punchers and so on can be installed and thus several operations can be carried out at the same time.

Fixed number storage for $\sqrt{2}$, π, *g.*
Instead of the scanner and punch for the output and result values, setting and reading devices can be used.
The calculation plan can also be saved, with the commands being fed to the control devices in time with the calculation.
The calculation plans can be stored in a fixed form if the machine is often to perform the same calculation.
All these variations fall under the basic principle."

Zuse explained why he considered the use of the binary system to be advantageous for this system: "Since the machine performs long calculations on its own, one can go beyond human habit and choose the simplest number system. Leibniz already recognised the dyadic system, the system with the base 2, as the simplest system. [...] The idea of constructing number systems and the like in the two's system is not new. [...] However, the combination of the above-described method with the binary system means an essential progress, a working community, which mutually enables the practical implementation of both methods. The numbers are 'among themselves', results can be derived over thousands of intermediate values without the need to translate a single number into the decimal system."

The "drawing up of a calculation plan" was described as a "prerequisite for every type of calculation to be carried out". In it, "the successive arithmetical operations were recorded in character and in sequence and the numbers occurring in the course of the calculation were numbered consecutively or ordered according to some other scheme [...] without first determining them in size". The calculation plan should be recorded in a form "which is suitable for controlling the individual devices, for example on a punched tape". About the processing of the calculation plan it says: "The calculation plan is now scanned by the machine section by section and gives the following information for each individual calculation operation: the numbers of the memory cells containing the operands; the basic calculation type; the numbers of the cell storing the result. The information in the calculation plan automatically triggers the necessary operations."

The calculation plan was to be set up in such a way that it required as few memory cells as possible. "In order to be able to construct the calculation plan according to a scheme, a number which remains the same in the calculation device for the next operation is considered as if it were stored on memory cell O." At the beginning of the calculation work, "initial values" were fed into the machine separately from the calculation plan, which could be varied during different runs. On the other hand, constants that remained the same during these variations were built into the calculation plan. The scanner "had to be able to give the data of the calculation plan to the machine both as a command for control and as numbers for calculation."

In August 1940, Zuse withdrew application Z23139, which had not been published due to lack of disclosure.[12] The inaccurate information on the "state of the art" may have played a role in this. At that time, work on the Z2 machine was finished and the Z3 was taking shape. During this time, the wing measuring machine was also being built. Zuse was therefore in a phase in which the tinkering of the previous years was finished. He was now building functioning machines, the completion of which was awaited. Practical experience led to numerous detailed developments that had not yet been thought through in 1936.

2.2 The Application Z23624

Application Z23624 of 24.12.1936 with the designation "calculating machine"[13] referred to the "main patent" Z23139. The "method" described and applied for there required a calculating machine that differed from "the usual designs" by the use of the binary system and by the representation of numbers in the semi-logarithmic notation. Thus, eight months after the "process" application, claims 6 to 11 of which had already been applied to the machine, Zuse again filed an application concerning a calculating machine particularly suitable for the process: "With its help, the 5 arithmetic operations of addition, subtraction, multiplication, division and square-rooting can be carried out, furthermore, decimal numbers can be translated into the secondary system and vice versa, without the need for special 'translators' or 'converters' for this purpose".

The method of operation was characterised as follows: "All arithmetic operations are broken down into simple additions. In the case of multiplication and division, this is done in the known manner by repeated addition of the multiplicand or the divisor supplement. Root extraction is done by the method of quadratic addition, which is known to be very similar to division." Zuse mentioned here already known translators for the conversion of decimal numbers into binary numbers and vice versa, which "for example, for the translation from the decimal system have 9 members, which indicate the value of the digits 1-9 for the respective place in the other system". With this, he gave an indication of the "state of the art". However, his machine was supposed to work with at least 20 decimal places - "in order to be able to carry out technical calculations" - and had then needed 180 such elements. Therefore, he had developed and applied for a system that managed with fewer members by "building up the number digit by digit and periodically multiplying it by 10". For this translator, 9 members representing the digits 1 to 9 in the binary system were enough.

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12 *Lebenswerk* 1970, p. 97.

13 Zuse, K., "Rechenmaschine", patent application dated 24.12.1936, AZ: Z23624, undated with accompanying letter, Goldbach to Weber-Schäfer, 9.11.1964, ZuP 006/001.

Zuse also described the binary arithmetic processes here. In the processing of numbers that are processed in semi-logarithmic representation $y = 2^{a} \cdot b$, the calculating machine was divided into two parts, so that one part processed the value *a*, the other the value *b*. The first part only had to add and subtract. While the first part only had to add and subtract, the actual arithmetic operations took place in the other part. Since the value was always between 1 and 2, only a few digits before the decimal point were necessary. Zuse first described all these devices mathematically and only then went into the technical implementation: Because all the devices consisted largely of relay circuits, he emphasised that "according to the main patent, the relays can be electrical or mechanical. In the examples, mostly electrical relays are chosen. Corresponding circuits can be constructed with mechanical relays". He then described, with the help of the sketches, how the calculations were to be realised with circuits consisting of electromechanical relays.

The application contained 16 patent claims with the main claim: "Calculating machine operating in the secondary system, characterised in that both the actual arithmetic operations such as addition, subtraction, multiplication, division and square root extraction and the conversion of decimal numbers into secondary numbers and vice versa after breakdown into individual additions are carried out on the same arithmetic device, in which the conversion is effected by digit-by-digit increase and decrease of the number with intermediate multiplication by 10". The other claims referred to the conversion of binary numbers into decimal numbers and vice versa, to the processing of numbers in semi-logarithmic representation, to the procedures for division, root extraction and multiplication, addition devices and the distributor of the calculating devices. In the whole of Z23624, the arithmetic plan was not mentioned at all.

2.3 The American Application

Also in 1936 or 1937, Zuse filed a corresponding application with the American patent office. Here he was confronted with Babbage's "Analytical Engine", which he had not previously known.[14]

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[14] *Lebenswerk* 1970, p. 97; in the Zuse papers I could not discover any documents for this application or the Babbage opposition; Babbage, Ch., *f.assages from the Life of a philosopher*, London 1864, p. 117f. The following translation of a section is contained in: Bemerkungen zur Patentanmeldung "Rechenvorrichtung", 23.12.1953, undated attachment to the letter from the Patent Office to Zuse of 14.12.1955, cf. footnote 37.
"The Analytical Engine consists of two parts:
1. from the memory into which all the variables to be processed are placed, as well as all those quantities that have arisen from the result of other operations;
2. from the *mill*, in the sense of the wheel mill, into which the quantities to be processed are always brought.

3. The 1940 design

There is a draft patent application from 1940 entitled "Rechenmaschine"[15], in which the applications from 1936 were taken up again. The document referred to the main patent Z23624 and consisted only of a detailed description. Claims were not formulated. The text did not contain any reference to the "state of the art": "The main application is limited to the problems of the actual numerical computation, whereby it remains open whether the settings on the machine required for carrying out the computations are operated by hand or also by machine organs. It is now the object of the present application to develop the principle on which the main application is based in such a way that the device carries out all the settings automatically and the control can be effected by a calculation plan (cf. application Z23139). For this purpose, the connections must be designed in such a way that the connection to a memory device is possible according to the application cited." However, the possibility of step-by-step input by hand should remain.

Zuse pointed out that the principles of the main patent could be combined in any way: one could work with or without a semi-logarithmic number representation; the translator principle could also be used for systems other than the decimal system, for example, for English currency. In order to grasp the relationships theoretically correctly, the draft application referred to the logical formulae of the propositional calculus as presented in the "Grundzügen der theoretischen Logik" (Fundamentals of Theoretical Logic) by Hilbert and Ackermann: "Through the interconnection of the conductors by relays, the voltage state of new conductors is given and one can set up a corresponding logical formula for each circuit". While this representation adhered to electrical relay circuits, Zuse, "since other constructions are possible in addition to the electrical relay principle", introduced a neutral symbolism to describe the circuits: "The relay is indicated by a circle through which the controlled carrier (conductor) passes

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Each formula whose calculation can be required by the analytical engine consists of certain algebraic operations to be carried out on given expressions and of certain other variations which depend on the numerical values assigned to these expressions. There are therefore two headings, the first to direct the type of operations to be carried out - these are called operation cards; the other, to direct the individual variables with which those cards are to operate - these last are called variable cards."

In a plan by Babbage dated 6.8.1840, it is shown that both the operation cards and the variable cards as well as other "number cards" were connected to each other in the form of a ribbon. The drawing was published by Ch. Babbage's son in 1889 in: Babbage, H. P., *Babbage's calculating engines*, London 1889.

[15] Zuse, K., "Rechenmaschine", with handwritten remark: "Nicht angemeldet, Vorläufer Z391, 1940", ZuP 005/019. *[η2]*

η2 Translation note: "Not registered, predecessor Z391, 1940"

while the controlling pole is only brought close to the circle".

Zuse distinguished between "single-step" and "multi-step" circuits. In the "multi-step" circuit, the relays respond one after the other. Zuse called this a "relay chain".

The addition took place in three phases: 1. formation of the digit sum, i.e. addition without consideration of the digit transfer, 2. digit transfer, 3. formation of the result. In the draft application of 1940, Zuse described all the subdevices using concrete circuits. The combination of the described parts into "multi-species machines" was to be achieved "by simple superimposition".

He described two combination examples in more detail: a multispecies machine for performing the operations of addition, subtraction, multiplication with decimal-binary, pound-system-binary, binary-decimal, binary-pound-system translation devices; The combination consisted of a number setting device with rows of keys, one of which had 11 keys for the pound system, an "upper distributor", a device for scanning the multiplier, a device for shifting the multiplicand, an arithmetic device with an addition mechanism, a result display with an English display and a guide mechanism. In addition, he described the principle of translation extended for the English currency. While this machine only calculated with integers, a second combination example worked in semi-logarithmic form with an additional division and root extraction device. Both examples were intended for manual operation. The design, however, contained a supplementary circuit for the master unit with which one could "run the process from the setting of the numbers in the decimal system to the converted result by oneself".

The draft, which was accompanied by 39 illustrations, was not submitted. It contained the most concrete representation of the Zuse machine up to that time and can probably also be regarded as a concept for the production programme of a planned company. The special device for measuring flintigel, for example, was a variant of this system.

4. The procedure Z26476 until 1944

16.7.1941 Zuse applied for a patent for a "calculating device" through patent attorney Kuno Wolf under file number Z26476.[16] The patent description continued the 1936 application and the 1940 design for a "calculating machine". Zuse now no longer applied for a "method", but for an apparatus that embodied this method. By this

[16] Zuse, K., "Rechenvorrichtung", application note without date; dated 1941 in the index of Zuse papers, with an obviously later handwritten note: "Z391", ZuP 005/011.

time he had completed the machine which later became known as the "Z3" and knew that his theoretical system could be successfully applied in practice. The characterising introductory sentence of the application also immediately indicated the possibilities of opposition in the later patent proceedings: "The present invention means the combination of largely known individual devices to form an aggregate which makes it possible to carry out frequently recurring calculations of any length and structure, which are composed of elementary arithmetic operations, automatically with the aid of calculating machines". The description then listed in general form the "devices" that could be combined for this "aggregate":

1. A "fully automatic calculator, e.g. a 4-species calculator". It says here explicitly: "In this way, one can use known full-automatic calculators as a calculator". However, he then described an arithmetic unit with binary semi-logarithmic technology with the corresponding relay circuits, to which the following patent claims referred.
2. Devices for storing numbers.
3. Devices for transferring numbers from the arithmetic unit to the memory unit and vice versa.
4. A device for connecting a specific memory cell to the calculator (selector).
5. Devices for controlling the system by means of punched tape (scanners).

Regarding the "state of the art" it was stated: "In detail, all these devices are known; furthermore, the combination of arithmetic unit and storage unit is known. [...] It is also known to control any organs of a calculating machine by means of punched tape or punched cards." The text did not indicate which publications were referred to. Zuse saw the actual invention in the specific combination of the known parts: "What is new is the combination of the elements in such a way that commands are given to the entire system from a scanner, in that the numbers of the memory cells are given to the selector unit, the information about the number of the memory cells is given to the memory unit, and the number of the memory cells is given to the memory unit. The formula to be calculated or read and the type of arithmetic operation is given to the arithmetic unit. With such a combination it is possible, in contrast to existing devices, to calculate any formula which is composed of elementary operations". It was not until 1955 that Babbage's work was also cited in Germany!

In 1936, Zuse had realised a new method with known elements, but in 1941 the process was simplified by the "aggregate", which was composed of a new combination of known partial devices. In 1941, he distinguished between a "basic form" of the aggregate, which "can be built up out of common means", and the solution practically implemented in the "Z3", which is particularly advantageous with "innovations" or "new combinations [...]". At that time, he saw as the

logical step in terms of technical development, to use one of the sophisticated four-species of calculating machines - whereby "machine" in the case of the machines available at the time referred to the multiplication and division of two numbers, which could be carried out without any intermediate operations!

As in 1936, the 1941 application also detailed the calculation of a determinant as a standard example by the structural engineer Zuse. The calculation plan was again presented in full. The notation had been improved. Whereas in 1936 the 9 elements of the determinant were simply designated as consecutive numbers, in 1941 the indexed letters V_1 to V_9 were used. The designation V_i was continued for the intermediate results, so that the last V_{26} represented the result. In addition to a description of the entire machine in mathematical form, the 1941 application contained a detailed explanation of the individual assemblies, the calculation processes for the four basic arithmetic operations, and the processing and conversion of the binary and semi-logarithmic numbers.

The application cited a total of 51 patent claims. The main claim related to a "calculating device" similar to claim 6 in Z23139 of 1936, with the simple enumeration of the sub-assemblies in 1941 being more closely described by details of the operation of the "method" of 1936. Thus, claim 1 of 1941 contained the automatic result determination, the calculation plan and the number processing in the binary system. The semi-logarithmic number representation was the subject of the second claim. In 1941, this also referred to the "calculating device", which was expressed in the patent claim by the fact that "each memory cell stores all the data required to identify such a number, such as the prefix, the integer part of the logarithm of the number [...] and the factor [...] lying between 1 and the base of the number system".

In contrast to the 1940 draft, Zuse now no longer described a machine that could also be operated automatically, but was designed for manual input, but the method of automatic calculation, which had previously been apostrophised as a "calculation method", became part of the automatically operating "calculation device". The description of the machine was kept as general as possible. The calculation plan was to be recorded in any form "suitable for controlling the individual devices, for example on a punched tape". It should indicate for each individual arithmetic operation, in addition to the basic type of calculation, the numbers of the memory cells containing the operands and the number of the cell storing the result, in order to be able to control the five devices correctly.

The five devices could be built up "from common means". Even now, Zuse did not make a sharp delimitation of the "state of the art". A particularly advantageous solution to the task posed in general form he saw

in the use of certain "innovations or new combinations":

- The execution of the complete calculation in the binary system. Since longer calculations are carried out automatically, "one can go beyond human habit and choose the simplest number system." However, the idea of building calculating machines in the binary system was not new. Zuse again emphasised as decisive: "The combination of the above-described method with the secondary system, however, means an essential progress, a working community that mutually enables the practical implementation of both methods. The numbers are 'among themselves'; results can be derived over thousands of intermediate values without the need to translate a single number into the decimal system."
- The "comma marking". In the "known machines", all numbers were fixed to the decimal point, which in technical calculations often caused problems, since here "constantly changing operations between quantities such as coefficient of thermal expansion ϵ = 0, 000 012 and modulus of elasticity E = 2100 000 kp/cm^2 occur in the same formula". Fixed storage would be mostly filled with zero and very large, but only partially used. Therefore, he saw a particular advantage for the overall system in the use of the semi-logarithmic number representation.

In the 1941 application, the calculator was extended in comparison to the one described in 1936 in such a way that, after setting the operands and the type of operation, it "carries out all further settings automatically, so that the calculator can be used within the framework of the overall system described". The description was largely taken verbatim from the 1940 draft. The individual arithmetic operations were explained with the aid of circuit diagrams. The inverse conversion from the binary to the decimal system was done according to the principle already stated in Z23624. The calculator first asked if the result was undefinable. In the case of addition or multiplication by and the square root of infinity, infinity was defined as the result. Zero times infinity was displayed separately.

The main claim was: "A calculating device consisting of an actual calculating unit which automatically determines the result after setting the operands and the calculation operation to be carried out, a storage unit with several cells, wherein each cell can be connected to the calculating unit by means of a selector unit for the purpose of mutual number transmission, and a planning unit for controlling the entire system by means of a calculating plan, characterised in that the calculating plan specifies the type of operation at the calculating unit, the reading or storage commands at the storage unit and the numbers of the storage cells at the selection unit continuously and automatically in accordance with the desired sequence of operations, the calculating device operating in the secondary system and the intermediate values of the calculation being stored as secondary numbers." The semi-logarithmic

representation was not part of the main claim. It was only mentioned in the second claim. Numerous claims referred to electrical relay circuits according to which the individual subdevices were designed.

A second specification of application Z26476[17] differed from the first one by an extension of the main claim. The internal representation in the binary system was adopted here in a new claim separate from the main claim. Accordingly, this application had 52 claims. Thus, the main claim also included the combination with the decimally operating known full automata mentioned in the description.

9.2.1942 Under file number Z26476, the patent office communicated the result of the examination, to which Zuse agreed to comment on within five months, and eliminate the deficiencies. Zuse's "calculating device" was listed as "a machine for calculating determinants". Since the Patent Office was already aware of a "fully automatic determinant machine" - that of Weygandt[18] - Zuse was asked to correct the "state of the art". The Patent Office found that the text of the application was too vague about the "computing machine operating in a secondary system", which was already the subject of his earlier application. It also found fault with the fact that "the applicant seems to see his invention primarily in the use of a calculating machine operating in the secondary system and in semi-logarithmic notation". Then the technical progress associated with the use of just such a machine would have to be demonstrated." Zuse was supposed to shorten the description and change his claims to the features of a determinant machine. The patent office "did not hold out the prospect of publishing the application".[19]

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17 Zuse, K., "Rechenvorrichtung", application without date, handwritten note: "Z26476", ZuP 006/001.

18 In the early 1930s, A. Weygandt took up the possibility of building a calculating machine with the standardised components of telephone technology. "In order to secure the right of priority", he published his conception by describing a prototype in 1933 ("Die elektromechanische Determinantenmaschine", *Zeitschrift fur Instrumentenkunde*, vol. 53, 1933, pp. 114-121). Weygandt did not use simple relays with two states, but rotary selectors. For the multiplication, he connected a mechanical multiplication table. He was awarded his Dr.-Ing. in 1938 *(Der Drehzählautomat fur die Ausrechnung von Determinanten,* Dissertation, TH, Hanover 1938). The finished machine calculated a determinant of the second order in 5 seconds. For the calculation of a determinant of the sixth order it took 1.6 hours. The determinant calculation was completely automatic. As a control unit, Weygandt used a 26-part three-armed selector called a "regulator", which also transmitted the individual digits to the arithmetic unit.

19 Reich Patent Office to Zuse, 9.2.1942, ZuP 006/001.

30.3.1942 Zuse asked his lawyer to arrange an appointment with the patent office for a demonstration of his machine. He emphasised that he did not want to register a determinant calculator, but a machine with a universal character in order to calculate "all algebraic formulas given in explicit form, insofar as they can be described at all with the help of the basic operations". Compared to the earlier application, this application is considerably extended, for example, by the calculation plan and the fully automatic process. It was precisely the fully automatic process that formed the main subject matter of the application. In contrast, the Weygandt machine referred to was a purely special device.[20]

5.11.1942 The Patent Office stated that it was of the opinion that the device applied for "allows the use of devices [...], which are pending applications". It was therefore appropriate to "suspend the priority of the present application until the earlier applications had been published or otherwise disposed of".[21]

4.3.1943 Zuse then withdrew the application for Z23624 and applied for the continuation of Z26476.[22]

19.12.1943 In the reply from the Patent Office, the subject matter of the application was now referred to as a "punch card-controlled calculating machine", and pointed out that such machines were known. The German patent specifications 688393 and 695055 were cited:

- The German patent specification 688393 contains a patent of Deutsche Hollerith "Multiplication machine with electrically monitored power drive for the number wheels of the result mechanism". It was published in 1940 and was valid from 1933 with priority in the USA in 1932.[23]

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[20] Zuse to Wolf, 30.3.1942, ZuP 006/001.

[21] Reich Patent Office to Wolf, 5.11.1942, ZuP 006/001.

[22] Wolf to Reich Patent Office, 27.3.1943, ZuP 006/001.

[23] The main claim was: "A multiplication machine with an electrically monitored power drive for the counting ribs of the result mechanism and contacts of multiple contact relays located in the circuits associated with the counting ribs for controlling the counting mechanism circuit and the shifting of positions in the case of successive multiplication machine cycles, characterised in that the exciter circuits for the exciters of the multiplication relays are so guided for controlling the counting mechanism circuits, that in the circuit of a multiplication relay excited by the radiation of a multiplier point, the winding of the control magnet of a point shifting relay associated with the multiplier point is always also connected in series with the magnet of the multiplication relay, and that the excitation of the control magnet causes the changeover to the next multiplier point to be made effective, for example by closing a contact which establishes a circuit for a changeover relay."

- The German patent specification 695055 contains a patent of Deutsche Hollerith "Multiplication Machine". It was published in 1940 and was valid from 1929 with priority in the USA in 1928.[24]

Longer calculations could also be carried out independently with already "known devices [...]". Machines in the secondary system were also known. The British patent 410129 by Valtat was cited.[25] Another reference to Weygandt was used by the patent office to state: "Incidentally it was no longer new, for various arithmetic operations

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[24] This was a machine "in which, under the influence of actuators which are adjusted according to the factors of the task, switching connections are prepared for driving the number discs of the result mechanism, for which a force transmitter is provided which, under the influence of the actuators, becomes effective for each number disc within a certain time limit in such a way that the switching which takes place in the number disc of the result mechanism corresponds to the respective number size to be introduced into it".

[25] The British patent 410129, filed in 1932 with priority in 1931 in France, corresponds to the German patent 664012 by R. L. A. Valtat, which was filed in 1934 and granted in 1938:
"The invention relates to a calculating machine which, according to the invention, is intended to transfer a number given in the system of base 10 into a system of a substantially smaller base (preferably base 2), to carry out the operations in the latter system and to transfer the result back into the system of base 10. Machines are already known which make it possible to convert numbers of one base into numbers of another base, one base, however, being very close to the other, for example 12 and 10. These known machines serve exclusively for these conversion purposes and are consequently not computing machines proper. These older machines do not achieve the result sought by the invention, [...]. The problem posed by the invention is to create a calculating machine whose construction is as simple as possible and in which the numbers with which arithmetic operations are to be performed, and which are given in the decimal system, also appear in the decimal system in the result produced. To solve this problem, the invention assumes that a calculating machine for arithmetic operations for numbers of very low base, for example base 2 or 3, is much simpler than the usual known calculating machines. However, since the numbers of the secondary system are not common in use, it is necessary to convert physical numbers, for example those of the decimal system, into numbers of the secondary system, and then to convert the result obtained on the calculating machine in the secondary system back into a number of the decimal system. Accordingly, the invention consists in using a combination of three devices, the first of which makes it possible to convert numbers of the decimal system into numbers of the secondary system, the second constitutes a calculating machine in the secondary system and is consequently extremely simple and, above all, much simpler than the known calculating machines, and the third device makes it possible to convert the result obtained from the second device in the secondary system into numbers of the decimal system. This combination results in a calculating machine which is much simpler than those used up to now, whereby it is to be emphasised that the user receives the result sought without recognising that the calculating machine works in the secondary system".

to build automatic calculating machines [...] and to use a system other than the decimal system [...]." For the Patent Office in 1943, "the technical progress inherent in the combination of a calculating machine controlled by punched cards and operating in the secondary system was not shown", since "the combination itself [...], with regard to what is known, does not yet require an inventive step". The patent office now assumed that the novelty lay in the semi-logarithmic mode of operation. However, the corresponding advantages had to be explicitly stated first, since semi-logarithmic calculation was also generally known.

It was obviously characteristic of the difficulties that the separation between the "construction" and the "mode of operation" could no longer be maintained. The Patent Office complained: "The claims also contain to a large extent the mode of operation of the machine, which belongs in the description, and will have to be restricted to the constructional aspects. The design should then only contain what is essential for the machine." Even at this stage, the Patent Office did not rule out the granting of a patent.[26]

16.10.1944 Zuse's reply was sent to the Patent Office by the lawyer with new patent claims. It is the last document in the procedure before the Patent Office was reestablished in 1949. According to the previous correspondence with the Patent Office, it was now stated: "The present invention has the task of constructing a calculating device with which any formula of any length and structure, which is composed of elementary operations, can be automatically solved". The letter characterised "technical progress", which Zuse did not treat as a legal category: "Furthermore, the invention on the above scale entails significant technical and economic progress. There is a need in the whole industry, especially in aircraft construction, to be able to solve frequently recurring calculations of any length and structure, which consist of elementary operations, by means of calculating machines. Up to now, computational offices were necessary for this purpose, in which partial tasks were solved by means of computing machines; the correct composition and further processing of such partial solutions, however, had to be carried out by persons. With the object of the invention, in contrast to the known devices, it is possible to save this computing personnel. In addition, the automatic calculating device works faster and errors, which always occur with humans, are excluded."

Zuse rejected the opposing patents, since only multiplications could be calculated with it and not "any formula [...] composed of elementary operations". Against the cited British patent of Valtat, according to which "short multiplications and additions" could be carried out in the binary system, he argued that it was then impossible

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[26] Reich Patent Office to Wolf, 19.12.1943, ZuP 006/001.

to "solve calculations of any length and structure by itself". Valtat's machine contained neither a selection nor a planning unit. He again rejected Weygandt's machine as a special calculator.

Then he again pointed out the special advantage of the computing device in the binary system, which lay in the fact that such computing devices were "relatively simple in their construction and thus also reliable in operation". It was possible “in an advantageous manner [...] to use commercially available electrical relays [...]". He replied to the patent office: "The two features 'Self-acting computing device in the secondary system' result in a technical and economic effect which is greater than the sum of the individual effects".[27]

5. Reopening of the proceedings (1951-1956)

14.11.1951 Re-opening of the application procedure under the file number Z391. The applicant was now Zuse K.G., Neukirchen.[28]

4.12.1952 Publication of the application.[29]

2.4.1953 Objection filed by the Triumph company. The objection included a request for a partial refusal of the patent. It was justified by the fact that "as far as the wording of the main claim is concerned, the fact of non-novelty is given", "since the applicant presupposes that what is to be claimed as new is already known in the generic term of the main claim itself". In the main claim, it was stated as an essential feature of the invention "that the calculation plan (from a scanner) continuously and automatically indicates the desired sequence of operations". However, it was stated that "the use of a planning unit for controlling the entire system by means of a calculation plan is assumed to be known, as can be seen, for example, in German patent specifications 414823[30], 458481[31],

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[27] Wolf to Reich Patent Office, 16.10.1944, ZuP 006/001.
[28] Date mentioned in: *Remarks,* cf. footnote 37.
[29] See the appendix to this paper.

[30] DRP 414823: German patent of the inventor Rolf Hofgaard from Ljan, Norway, with the company O. Collett & Co.A/S. in Oslo with the designation "Electrically operated calculating machine" from 1923. The object of the invention was a "new principle for carrying out arithmetic operations [...] which carries out calculations in all types of arithmetic by electrical means and makes it possible to record (write down) the arithmetic operations carried out at all times. [...] The principle is based mainly on the fact that, in order to connect each numeric key to any recording device, a corresponding number of couplings (for example, electrical connection contacts) are provided, the activation of which is controlled by the recording device actuated by the previously depressed key." The machine registered the first summand or factor entered via a numeric keypad by means of an electromechanical switching operation on a paper tape. The second summand or factor entered was automatically offset against the registered number and the result again punched into the paper tape. The machine performed all four basic arithmetic operations.

[31] DRP 458481: The patent specification "Electrical Calculating and Writing Machine" by the inventor Bernhard Weiner in Prague-Dejvice from 1923 is extremely comprehensive, contains 104 patent claims and is probably one of the first fundamental applications for calculating machines that are completely equipped with electromechanical relays.

"Most calculating machines known up to now carry out the calculations by means of relatively complicated movements of engine parts, which on the one hand leads to frequent disturbances during operation and on the other hand limits the possibility of automation. The machine according to the present invention contains nothing but a series of electromagnetic groups (relays) which, by their electrical interaction, carry out any calculation within the real numerical range. Some of the relays are connected to the keyboard, i.e. they can be activated from the keyboard, while other groups of relays form circuits via a writing apparatus in which the writing of the result is carried out. All basic arithmetic operations (addition, subtraction, multiplication of all one-digit numbers, division of all one-digit and two-digit numbers by all one-digit numbers) are built into the relay groups as an electrical connection in such a way that with the setting of a number all these results are latently set and with the pressing of the execution key the results to be considered are selected and combined in the machine by auxiliary relays as partial results to the total result."

The main advantages were: "Since no machine elements other than the armatures and contacts have to be set in motion, this machine works almost noiselessly (!) and with a speed that cannot be achieved by any of the machines known up to now. [...] In the construction of the calculating machine, the spatial arrangement of the individual magnets is completely unimportant, both relative to each other and in the overall picture of the machine. The circuit alone is essential. [...] Whether electromagnets or solenoids are used is completely irrelevant to the essence of the machine".

476688[32], 575290[33], all class 42m group 14". On the other hand, the objection recognised the "undoubtedly new inventive idea", but criticised "a certain lack of clarity in the interpretation of the scope of protection", which "could arise after the patent had been granted". The objection recommended a "clearer delimitation of the request for protection and a flawless emphasis of the undoubtedly new inventive idea in a new, more sharply formulated main claim"[34].

At that time, Triumph was probably interested in securing the then current registration and temporary storage of numbers and information, for example on pieces of punched tape, as they came into question for the combination of booking machines, typewriters, cash registers and so on for setting up complex booking systems. Zuse's "calculating plan" and the calculating plan-controlled machine were obviously not necessarily equated with the electronic calculating systems that had emerged in the meantime and were much discussed, later referred to as "computers". After all, he had also included combinations with four-species machines as computing units in his claim.

29.6.1953 In his development, Zuse rejected the presentation of his main claim through the objection: "From the statement that a planning unit for controlling the entire system is provided by a calculation plan cannot yet be concluded as to the type of control. The arithmetic unit according to claim 2, which operates in the binary number system, is "an

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[32] DRP 476688 (see footnote 30): German patent by R. Hofgaard from 1927 - a company is no longer mentioned - for an improvement of the calculating machine (414823). The new machine was based on the same principles as the old one. However, instead of the paper tape, the registration took place in a "number of multiple contact relays [...], each energised by a current in the lines of one set of digit lines". Another new feature was a "device for automatically changing the order of the digits fed into the machine when the machine is intended for multi-digit numbers [...], in order to make it possible for the numbers to used for calculations to be introduced beginning with the digit of the highest order of magnitude, while the last digit introduced, i.e. the digit of the smallest order of magnitude, comes into effect first in the formation of the result, and so on, thus facilitating the tabulating work to a great extent".

[33] DRP 575290: No inventor was named on the patent specification "calculating machine" of the Tabulating Machine Company New York belonging to IBM from 1928. The invention "relates to a calculating machine for carrying out calculations with two number sizes according to the four basic arithmetic operations, which for this purpose contains systems of setting bodies, each of which contains as many elements as the number of basic numbers, and which are arranged in a convenient manner, The setting bodies of the one system determine by their setting when establishing the relationship with a setting body of the other system, which result is displayed by the machine."

[34] Triumph to Patent Office, 2 4.1953, ZuP 006/001.

advantageous embodiment of the invention according to claim 1" and is "by no means a necessary component of the general idea of the invention". The opposing patent specifications were in no case "computing machines whose individual elements are controlled by a calculation plan containing the individual calculation data and calculation operations in the form of a recording medium".[35] Nevertheless, Zuse filed a new version of his claim 1.[36]

14.12.1955 The patent office informed the Zuse company that a further appeal had been filed, but that it was considered "not raised", since it was not received until 5.12.1953, but the objection period had already expired on 4.4.1953 and the fees had not been paid.[37] However, the Patent Office stated that since a valid objection had already been filed, the objected material should "be taken into account ex officio". Thus, after the expiry of the objection period, material which quickly proved to be decisive was introduced into the proceedings by a practically uninvolved party. This material included the book by Charles Babbage, *Passages from* the *Life of a Philosopher*, published in London in 1864. Here, an *Analytical Engine* was described as a computing device "in which the computational plan is available in the form of command sequences containing input carriers and in which memory and arithmetic unit cooperate on the basis of these command sequences to perform arithmetic operations". Since this corresponded with Zuse's claim in "all essential details", the Patent Office did not consider the claim to be allowable. If the important claim were to be maintained "in its present form or in a form similar thereto", the patent would "probably be refused in its entirety". The patent office asked Zuse to amend the claims accordingly and to resubmit them.

The "material" was evidently only communicated to Zuse in an unsigned document "Remarks on the patent application 'calculating device'" 18 months after it had been received by the patent office. The very first sentence showed the new quality of the citation: "Claim 1 is essentially intended to patent the programme control for calculating apparatuses, according to the language used today". Thus, in the course of the patent procedure, the first time in December 1953, the additional "calculation plan" was referred to by the already familiar term "program". The remarks went on to say: "This idea had already been realised several times long before the first Zuse patent application date, or at least had been proposed in such a way that it could be realised by a person skilled in the art on the basis of these proposals". As evidence, the literature on the *Analytical Engine* by Charles

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35 Zuse to Patent Office, 29.6.1953, ZuP 006/001.

36 Presumably not included in the Zuse papers.

37 Patent Office to Zuse, 14.12.1955, with enclosure: Remarks on the patent application "Rechenvorrichtung" by Dipl.-Ing. Konrad Zuse, ZuP 006/001.

Babbage was cited. After Babbage - according to the "Remarks" - the idea of a program- controlled calculating machine was also worked out and published by Torres y Quevedo[38] and Louis Couffignal[39]. In the latter, as early as 1938, "the idea of a program-controlled calculating machine in the two-number system was discussed in a technically feasible way, especially since quite detailed information is given about the possibilities of realising the calculating units themselves with the help of relay circuits".

For the semi-logarithmic number representation mentioned in Zuse's third claim, the term "calculating with floating point" was invoked and the objection was raised that the method "has always been common in physics" and "has always been used with the slide rule". Further technical realisations could not be cited for this.

The objections had the character of notices and requests to the patent office to consult certain literature; for example: "To what extent the relay circuits for computing and control operations are related to those of Couffignal or Valtat, for example, or to what extent they occur elsewhere

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38 Torres y Quevedo, "Arithmometre electromecanique", *Bulletin de la société d'encouragement pour l'industrie nationale*, vol. 119, 1920, pp. 588-599; English translation in: Randell, op. cit., pp. 109-120.

39 Couffignal, L., *Sur l'analyse mécanique - Application aux machines à calculer et aux calculs de la mécanique celeste*, Thèses Faculté Sciences Paris, 1938; reprinted in: *Bulletin Astronomique*, 2nd ser., 10.1937, Paris, pp. 139-270; excerpted in: Randell, op. cit.; a summary of the machine described by Couffignal is given in a memorandum, annex to the letter Hagen to Patent Office, 20.3.1961, ZuP 006/001:
"If one summarises the main features of the logical structure of the machine proposed by Couffignal, one sees the following:
1. It is a fully binary machine that runs an arbitrary programme defined on a punched tape and processes numerical values that are also defined on punched tape. The punched tape is binary perforated.
2. The machine has a fast-acting, limited-capacity storage unit and this storage unit is supplemented, if necessary, by punched stripes produced during the computing operation by feeding numbers from the main controller to a punch which produces a new punched stripe which then forms a buffer for feeding intermediate results obtained into the machine.
3. The machine is designed in such a way that through the punched tape of the program control a table can be visited which also consists of a punched tape and has different groups of binary holes in each row; one group is used to find the rows (argument value) and the other groups contain the corresponding function values (for example the trigonometric functions belonging to the argument).
4. The individual instructions of the programme strip consist of at least one operation (arithmetic operation or transfer instruction) and several addresses which characterise where the operand is to be taken and where the result of the arithmetic operation is to go."

in relay calculating machines in the two-step system with floating decimal point, cannot be examined in detail here. In any case, the report by G. R. Stibitz on the "Bell Complex Number Computer" from 1940 was also given.[40]

7.5.1956 Zuse reformulated seven claims. He tried to define the decisive features that his working machine possessed over the descriptions of Babbage and Couffignal into the main claim. This now reads:

"A calculating device consisting of an actual calculating unit which, after setting the operands and the calculating operation to be carried out, automatically determines the result, a storage unit with several cells, each cell being capable of accommodating the data (digits, sign and so on) required to identify a number, and each cell being capable of being connected to the setting members for the operands - or result members of the calculating unit - for the purpose of mutual number transmission, and a planning unit, controlled by command, for controlling the entire installation, characterised in that the commands effecting the control, which may have the meaning of operation commands as well as transmission commands, are transmitted by the calculating unit command-controlled plan unit for controlling the entire installation, characterised in that the commands effecting the control, which can have the meaning both of operation commands and of transmission commands, are set successively on common setting members or on a common command register, from where, by means of decoding devices, the type of operation is set on the arithmetic unit, the reading or storage commands are set on the storage unit and the numbers of the storage cells are set continuously and automatically on a selection unit."

A number of other requirements were also practised and transposed by Zuse. The tendency in the delimitation was towards a more precise, more differentiated recording of the details that were the basis of the principles described by Babbage and Couffignal and also used by Zuse, i.e. from the general principle of programme control to a specific machine that realised the principle. In the description section, Zuse now took into account the "state of the art" that had been determined in the meantime, pointing out that the idea of calculating automata was "not new in itself", "however, complete constructive solutions to this problem have not yet been described or elaborated".

Even now, in 1956, Zuse mentioned in the description the possibility of using "for example a 4-species calculating machine" for the fully automatic calculating unit.[41]

8.5.1956 Zuse sent his reply to the patent office with amendments and the new claims.[42] He agreed that Babbage was

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[40] Reference was made to the article in *Bulletin of the American Mathematical Society*, vol. 46, 1940, p. 861. Stibitz's work played no other role in the Z391 proceedings.

[41] New notification Z391 of 7.5.1956, ZuP 005/007.

[42] Zuse to Patent Office, 8.5.1956, ZuP 006/001.

the first to articulate the basic idea of program control. The literature cited, however, contained "only very general information about constructive solutions to the problem". Babbage had "not progressed constructively beyond parts of the calculus". Similarly, Couffignal had described "special arrangements and circuits which deal with the automatic solution of certain calculation processes; but a constructive solution of a program-controlled calculating machine in the sense of the application" was not described there either. In his application, on the other hand, "the first complete solution to the problem" was presented. The machine described here corresponded in almost all details to the "Z3" model built by the inventor between 1938 and 1941. In doing so, he had "for the first time implemented the principle of programme control with a consistency that had not yet been achieved even in the later first American machines of this type". A series of features had "in the meantime become generally accepted". Zuse regarded this fact as a criterion for the "technical progress" of his invention.

He then listed the most important problems that had been solved by him in contrast to Babbage and Couffignal: "A representation of the sequence of commands that is as simple and concise as possible" had only been solved "crudely" in Babbage's case, and in Couffignal's case "liberally only very generally hinted at". Babbage had not yet achieved the consistent form of "running all commands only via common setting elements via a common command register". Zuse proved that this was an "essential technical advance", "that today it has become almost universally accepted for such devices".

Compared to Babbage, Zuse declared as completely new "the use of encrypted instructions in connection with decryption devices (selection pyramid), which allow the number of the memory cell, today called the 'address', and the operation itself to be stored in concentrated form on the calculation plan".

19.11.1956 The Patent Office wrote to Zuse that the new first patent claim was not admissible, since calculating devices, in which "the commands effecting control, both for the operation commands and for the transmission commands, are set on common setting members, [...] were generally known on the date of the present application". "For example", the American patent specification 2244241[43] was

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[43] US Patent 2244241 dated 1.10.1937 entitled "Cross-Adding Accounting Machine and Programing Means Therefor" filed by James W. Bryce, Glen Ridge, N. J., "assignor to International Business Machines corporation, New York, N. Y., a corporation of New York."

The passages cited by the Patent Office against Zuse read: "A further object of the present invention resides in the provision of novel programming means for cross-adding machines. Such programming means will enable the operator to program the sequence of transfers and to selectively route the transfers from any selected accumulator to any other selected accumulator and to also perform the selective transfer of such amounts either additively or subtractively. A

cited. Likewise, "tape-like recording devices for setting commands" and also "the transmission of binary coded numbers by means of punched cards to setting registers" (US patent 2191567[44]) were generally known. Thus, even with the newly formulated claims, the patent would "at any rate probably" be refused in its entirety. Even an oral discussion, as suggested by Zuse, "did not appear to be appropriate at first".[45]

6. Continuation of the proceedings until the end of 1957

7.5.1957 Zuse sent his reply to the Patent Office's decision of 19.11.1956 to his lawyers.[46] He set a new tone. Against the reproach of Babbage's invention, he replied that "it is true that the task for all the systems in question has basically remained the same since Charles Babbage: namely to design this system or machine in such a way that calculations in the form of a so-called programme sequence can be carried out more or less automatically". On the other hand, the solution in his patent claim was essentially different from the previously known solutions. The technical progress of his invention consisted in the fact that "it is precisely the use of coded instructions in connection with the selection device according to the invention which gives rise to the versatility, i.e. the very great variety of possible combinations".

The US patent 2244241, which is also cited, describes a machine "in which the commands effecting control are given both to the operation

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further object of the present invention resides in the provision of controls to automatically terminate transfer cycles selectively after any cycle at the will of the operator and without manual intervention and to provide other machine controls which will thereupon come into action to re-initiate a new calculation pertaining to a new record.

44 US Patent 2191567: "Calculating machine". Patent granted on 27 February 1940 to Rolf Hofgaard, Brate Gard, Strommen, Norway. Priority in Sweden 4 January 1936. "The present invention refers to calculating machines operating with electric circuits in conjunction with registering or accumulating members and relays controlling contacts for closing said circuits. Prior machines of this general type operate with digit lines comprising lead groups of ten digit leads or, in other prior machines, the group of leads corresponding to the digit lines of the decimal system occur in a number smaller than 10. These groups of leads, by means of which one- figure numbers of the decimal system are expressed in code form, are connected to registering members for each denominational order. The said registering members have the common feature that a transfer from a lower order to the next higher order takes place when the value registered in the lower order exceeds the capacity of the registering member for the lower order, such as for instance the number 9 in the units order."

45 Patent Office to Zuse, 19.11.1956, ZuP 006/001.

46 Zuse to Eder, Lehmann, 7.5.1957, ZuP 006/001.

and for the transmission commands to be set on common setting elements". Zuse, on the other hand, claimed a patent for the fact that "on the setting device the transmissions to be output are set in coded form [...], but that in addition by means of the said selection device the setting combination on the setting elements is automatically decoded [...] and the associated data transmissions are effected by the operation of associated active elements". Zuse emphasised: "It is precisely in the combination of the various functions mentioned in a single constructive element within the machine that the essential novelty of the invention is to be seen".

The second US patent specification 2191567, which was cited, described the transmission of binary-encrypted numbers by means of punched cards to setting registers. Zuse replied: "It should be noted, however, that it is precisely the use of encrypted numbers in connection with the subject-matter of the invention using punched cards (or punched tape) which provides the particularly advantageous design of the machine according to the new claim 3 (new): The complete automatic solution of any arithmetical problem on the basis of an arithmetical plan with the least possible expenditure of space and construction and with great simplicity of operation, quite apart from the increase in the speed of operation."

ca. June 1957 Zuse's lawyers filed newly accentuated patent claims. It was stated with regard to "all previous objections", that here, in contrast to Zuse's application, "there is a direct assignment between the setting elements and the machine elements to be operated (active elements). Since [...] no selectors are provided, there is also no encryption and decryption in the sense of the present invention." The new claim 1 was directed "to an electrical device for storing and selecting numbers, in particular for calculating machines, since this is to be regarded as a basic element of the present invention". With this, Zuse and his lawyers had now made a clear amendment to the main claim. Whereas previously the main claim had been concerned with the universal "calculating device" with program control, it was now stated: "The invention is to be seen generally in the practical combination of a special selection mechanism with a storage mechanism."[47]

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[47] Eder, Lehmann to Patent Office, no date, with handwritten note: "circa June 1957", ZuP 006/001.
New claim 1: "A machine processing data, for example numbers, in particular a calculating machine, comprising means for processing data and means for storing data, characterized by selection means controlling the transmissions of data between the individual data-emitting and data-receiving locations, for example memory cells, arithmetic unit registers and so on, which selection means contain, on the output side, more operative members which are assigned to the individual transmission possibilities than setting members are provided on the input side, in such a way that, at the setting members, the transmissions to be output are provided in coded form, for example

26.6.1957 The Patent Office sent a new notice. In it, the "use of selectors for connecting the called memory cell" was recognised as a patentable invention. Nevertheless, claim 1 was again rejected. As a "precautionary measure", the Patent Office also pointed out that the conversion of and into the binary number system - with reference to Valtat - is to be assumed as known.[48]

26.8.1957 Zuse reacted to the decision of the Patent Office with a further amendment of the claims. The devices for storing numbers, the input members for setting the numbers to be stored, the output members for reading the stored numbers and the setting members for controlling the transmission devices were included as "per se known" features in the generic term of the main claim. "The characterisation part of new claim 1[49] was directed to the use of a selection device for connecting the selected memory cells. It was also included in the identification part that the memory cell to be selected is set on the selection unit in the form of numbers or the like."[50]

9.10.1957 Triumph requested the Patent Office not to patent Zuse's connection of the memory cells by means of selection units. The reason given was that the invention "of selection devices for connecting the selected memory cell", which was now mentioned in the main claim, was already assumed to be known in the description section of the application.[51]

29.11.1957 The Patent Office accepted Triumph's objection and informed Zuse of its intention to "refuse the patent in full". The Patent Office now cited the German patent

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in the form of numbers, and these selection devices cause the decoding of the setting combinations and the assigned data transmission by the confirmation of assigned active elements".

48 Patent Office to Eder, Lehmann, 26.6.1957, ZuP 006/001.

49 New Claim 1 of 26.8.1957: "An electrical device for storing and selecting numbers, particularly for calculating machines, comprising means for storing numbers, input means for setting the numbers to be stored, output means for reading the stored numbers, setting means for calling memory cells at which the memory cell to be called is set, setting means for controlling the transmission means, characterized by the use of a selection device, on which the called memory cell is set in the form of numbers or the like, for connecting the memory cell to be called to the input and output elements, respectively, which contains more actuators on the output side than setting elements are provided on the input side and which performs the decoding of the numbers set on the setting elements and effects the connection of the called memory cells to the input and output elements, respectively, via assigned actuators." RePP 006/001.

50 Eder, Lehmann to Patent Office, 26.8.1957, ZuP 006/001.

51 Triumph to Patent Office, 9.10.1957, ZuP 006/001.

643803[52], "in which an electrical device for storing and selecting numbers" had already been described. A selection device was also described in Valtat's patent DRP 664012, which had already been mentioned several times. However, the Patent Office did not take up Triumph's objection that in the introduction to Zuse's application the selection mechanism was already assumed to be known.[53]

With the decision of the patent office, Zuse's attempt to obtain the patent by modifying the main claim to a selection mechanism - as the main novelty compared to Babbage - failed. After this renewed failure of the efforts, Zuse handed over the application to the patent attorney of Telefunken. Zuse was informed by Telefunken about the course of the proceedings. He examined the objections and formulated the newly defined texts.

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[52] German patent 643803 by Gustav Tauschek, New York, "Electromagnetic memory for numbers and other data, especially for bookkeeping devices". The patent, filed with priority in the USA in 1932 and in Germany in 1933, was granted in 1937.
"An object of the invention is a storage device, in particular for numerical data, such as account balances and the like, which makes it possible to keep a large number of balances stored in an extremely small space and, if necessary, to read off each individual stored number quickly and at will. The invention consists in providing a member, for example an electromagnet or the like, for influencing a plurality of storage elements, each of which is capable of representing a number or indication, can be set by the selector or the like to a particular memory element and, once set, can be moved relative to the memory element, whereby in certain sections of the relative movement the memory element is influenced by the magnet according to the number or information to be stored.
In the following example, the storage elements are influenced by current pulse series by way of magnetic induction (point magnetisation according to Poulsen), the number of pulses being equal to the numerical value of the number to be stored. If, for example, the number 7 is to be stored, then seven successive currents are first induced by a device. These currents excite an electromagnet seven times in succession. If a steel surface moves in the area of the magnet, the successive fields induce magnetic sections or points on the steel surface. These magnetic sections of the steel surface represent the stored number, namely the number of sections is equal to the numerical value. If the stored number is to be sensed by the steel sheet and displayed in a manner perceptible to the human senses, then the reverse process is performed. The steel sheet is moved past an electromagnet and the magnetic sections of the steel sheet induce currents of the same number of sections in the winding of the magnet as they pass. These current surges switch the indicator so that it displays the corresponding number."

[53] Patent Office to Eder, Lehmann, 29.11.1957, ZuP 006/001.

7. Continuation of the proceedings until mid-1959

9.5.1958 Zuse drafted newly formulated claims.[54] The known features, which in the previous main claim had only been included in the preamble while the selector mechanism had been indicated as a characteristic of the invention, were now again combined in one combined claim. The opposing patent specifications concerned "only a memory unit which is not suitable for use in calculating machines with programme control" and a calculating machine "in which calculation is to be carried out in a number system whose base is smaller than 10 - preferably 2 - and deals in particular with [...] recoding". He pointed out that he had already dealt with the latter on 26.8.1957.[55]

12.5.1958 Rewording of the description and the claims. In the description, the demarcation from Babbage has been addressed: "The aim of the work at that time (by Babbage, H.P.) was to construct a programme-controlled calculating machine using the punched cards known at that time for controlling looms as programme carriers. Each of the different operation commands and memory locations was assigned to a certain hole on a punched card, whereby separate punched cards were provided for the operations and for the memory locations. On the other hand, the invention uses a program developed according to operation and transmission procedures, which runs as an ordered sequence of individual instructions coded in the form of numbers or the like. This makes it possible to use a selection mechanism for decoding the set instructions and for selecting the associated arithmetic operations and transmissions, which contains considerably more active elements on the output side than there are setting elements on the input side. In this way, the command code is simplified

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[54] New claim 1 (draft): "Calculating machine, characterised by the combination of the following features, some of which are known per se:
I. At least one memory unit for storing the numbers in specific memory cells,
II. at least one arithmetic unit,
III. a planning unit for controlling operations according to a predetermined program, which cooperates with a device suitable for delivering character combinations in such a way that the program, developed according to operation and transmission patterns, runs successively as an ordered sequence of individual instructions encoded in the form of numbers or the like.
IV. and at least one arithmetic logic unit for decoding the set instructions and for triggering the associated arithmetic operations and transmissions by connecting the called memory cells to setting or residual elements of the arithmetic logic unit, such an arithmetic logic unit containing more active elements on the output side than there are setting elements on the input side".

[55] Draft dictated by Johannesson in the presence of Zuse, to Patent Office, 9.5.1958, ZuP 006/001.

compared to Babbage's solution, in that the number of the memory cell to be called, designated as the address, and the operation to be carried out can be recorded in a more concentrated form in the calculation plan (programme)."[56]

30.7.1959 The Patent Office affirmed the patentability. In its decision on the grant of the patent, it stated with regard to the objections: "The objections to the patent specifications concern individual parts of the calculating machine forming the subject-matter of the present application, none of these specifications describes a machine which contains all these parts in such a combination as is indicated by the new main claim filed on 13 May 1958. Furthermore, in none of the machines and devices described in the above-mentioned patent specifications are the commands indicated in the form of numbers, so that no command encryption or command decryption and no selection mechanism are required for the alternate connection of individual machine parts to one another." From the writings of Babbage, Couffignal, Torres y Quevedo or Stibitz, the patent office's Class 42m Prüfungsstelle was also unable to find "any program-controlled calculating machine [...] whose construction and mode of operation correspond to the machine forming the subject of the present application". Accordingly, none of the documents "prevented the application from being patented". The patentability was confirmed and the patent office intended to grant the patent.

The decision approved Zuse's application: "It can be recognised that the subject-matter of the invention provides a program-controlled calculating machine which is particularly advantageous in that it allows the processing of a program developed according to operation and transmission procedures which runs as an ordered sequence of individual instructions coded in the form of numbers or combinations of letters. This makes it possible to use a selection mechanism for the decoding of the set commands and for the selection of the associated arithmetic and transmission operations, which contains more active elements on the output side than setting elements on the input side. This, in turn, simplifies the instruction code by allowing the number of the memory cell to be called, designated as the address, and the operation to be performed to be inserted into the programme in concentrated form. Such a program- controlled calculating machine is not suggested either by the patent specifications and literature cited in opposition or by the state of the art in the field of calculating machines."[57]

This was the opinion of the competent examination department of the patent office on 30 July 1959, at a time when the telecommunications industry in the Federal Republic of Germany was partly developing the first generation of its computer systems,

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[56] Weber-Schäfer to Patent Office, 12.5.1958, ZuP 006/001.
[57] Patent Office to Johannesson, 30.7.1959, ZuP 006/001.

partly already delivering them, and the demand for computers could not be estimated at all.

8. The refusal of registration

11.1.1960 Triumph, represented by new counsel, appealed again. The objection was based on Ludgate's paper "On a proposed analytical machine", which was published in Dublin in 1909.[58] As the objection said, claim 1 was identically anticipated by Zuse and therefore claims 2 to 5 were also not inventive.

In 1909 Ludgate had described a program-controlled calculating machine similar to that of Babbage. He too had taken the control from the Jacquard machine. The machine had an arithmetic unit for the four basic arithmetic operations and also a memory unit for the numbers. In the appeal it was particularly pointed out that in the machine described by Ludgate "only one roll of perforated paper is used, on which are recorded both the operations and the addresses of the operands to be processed in the course of the calculation and which are stored in the memory". Ludgate referred to the paper roll as "formula-paper".

In addition to Ludgate's paper, a number of other patent specifications were cited. The patent specifications of Couffignal, French patent 819695[59] and US patent 2318591,[60] contained descriptions of a binary calculator for the four basic arithmetic operations and root extraction. A similar arithmetic unit, which, however, worked in the 1, 2, 4 and 8 system, was described in US patent 2191567[61], a decimal electromechanical

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58 Ludgate, P. E., "On a proposed analytical machine", Sci. Proc. Roy. Dublin Soc., 12, 1909, pp. 77-91; reprinted in: Randell, op. cit., pp. 73-87.

59 French patent 819695: "Perfectionnements apportés aux appareils comportant une représentation materiélle de nombres, notamment aux appareils à calculer fonctionnant électriquement", Société dite: L 'Outillage R . B . V. résident en France (Seine), registered on 24 March 1937, published on 23 October 1937. Priority in Belgium, 27 March 1936. "L'invention due à Couffignal, Louis, est relative aux appareils tels que télécommandes, télétype, téléphone automatique etc.. [...]".

60 US Patent 2 318 591: "Apparatus calling for a material representation of numbers". Patent granted on 11 May 1943 to Pierre Louis Couffignal, Brest, France; vested in the Alien Property Custodian. Priority in Belgium, “The present invention relates to apparatuses such as telecontrol devices, etc., calling for a material representation of numbers, and it is more especially, although not exclusively, concerned, among these apparatuses, with calculating apparatuses, and in particular such devices of the electric type, that is to say all apparatuses capable of solving operations or problems of an arithmetic nature, or of an algebraic nature, the data of which are introduced either automatically or not into said apparatus."

61 US patent 2191567, see Footnote 44.

calculating machine is described in DRP 458481.[62] Against the binary-coded representation on the punched tape, the objection cited the American patent specification 2199541[63], which described a typewriter controlled by a punched tape, and the Swiss patent specification 181926[64] with a punched tape transmission method, in which the characters transmitted encoded not only letters and numbers but also selection processes. This new objection called for a rejection of Zuse's application in its entirety.[65]

28.1.1960 The lawyer sent the new submission to Zuse, saying that he believed that "a whole new situation had been created", as it is "an objection to be taken seriously".[66]

2.3.1960 Zuse sent notes to Telefunken for the rejection of the Ludgate objection. In his opinion

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[62] DRP 458481, see Footnote 31.

[63] US patent 2199541: The American patent "Data Transcribing Machine" was applied for in 1937 by L. S. Harrison, Hartsdale and E. J. Rabenda, Binghampton, N.Y., assignors to IBM, and granted in 1940. "This case relates to a machine for automatically transcribing information, and particularly to a typewriter controlled by a perforated record tape. The general object of the invention is to provide improved means for controlling a transcribing apparatus, such as a typewriter, by means of coded designations as by representations on a record tape".

[64] Swiss patent 181926: The patent "Method for sending telegrams via a telegraph system" was applied for in Switzerland in 1933, with priority in the USA in 1933, and granted in 1936. The inventor was E. E. Kleinschmidt, Chicago. The application contains 2 main claims:
"1. Method for sending telegrams via a telegraph system comprising subscriber stations equipped with teleprinters and automatic switching offices, characterised in that the sending subscriber always sends the address of the dialled subscriber and the telegram to a recording device placed in his office, which, in addition to setting up the connection, also automatically initiates the transmission of the text, the address of the remote subscriber being automatically repeated after the connection has been set up, and in that, furthermore, the transmitting subscriber is disconnected from the remote subscriber immediately after the telegram has been sent to the remote subscriber, so that the apparatuses of the two subscribers are never connected to one another.
II. Telegraph installation for carrying out the method according to claim I, with one or more stations equipped with automatic diallers and recording devices and subscriber stations equipped with telegraphs, characterised in that each recording device is associated with a punch, and automatic devices for the control of the diallers and for the transmission of the telegram text and furthermore automatic devices are assigned which, after the setting of the diallers effected by the address punching, enable both address and telegram text to be transmitted together and that the recording device is equipped with switches which cause the movement of the punched tape."

[65] Hagen to Patent Office, 11.1.1960, ZuP 006/001.

[66] Weber-Schäfer to Zuse, 28.1.1960, ZuP 006/001.

Ludgate introduced "no new points of view with regard to the claim". He saw the essential novelty of Ludgate compared to Babbage in the introduction of the punched tape, which, however, was not claimed as an essential feature in application Z391. Zuse completely denied that Ludgate had already provided for address coding. According to the Jacquard card, which assigned a hole field to each element to be operated on the loom, a hole field was to be assigned to each memory location in Ludgate. Accordingly, Ludgate's paper did not offer any new points of view with regard to address coding, instruction registers and dialing.[67]

29.3.1960 Zuse's lawyer drafted the letter to the Patent Office. The application, which was again redefined, was given the new title "Program-controlled calculating machine". The use of a selector mechanism "in an electric calculating machine" was again stated as an essential feature of the invention, "which contains more active elements on the output side than setting elements on the input side [...]. The new idea underlying the invention consists in the use of an encrypted operating code for the programme control of an electric calculating machine, and the implementation of this idea is only made possible by the existence of the aforementioned selector mechanism".

The citation of the punched tape control in teleprinters is irrelevant to the application "since the application does not seek to protect the encrypted representation of messages and data per se, but the use of a decrypting selection unit in conjunction with an electric data transmission machine".[68]

28.4.1960 The attorney sent a new claim 1 [69] and a new introduction to the description to the Patent Office, in which also the requested changes were taken into account.[70]

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67 Zuse to Weber-Schäfer, 2.3.1960, ZuP 006/001.

68 Draft Weber-Schäfer to Patent Office, 29.3.1960, ZuP 006/001.

69 New claim 1 of 29.3.1960: "Program-controlled calculating machine with at least one memory unit for storing numbers in specific memory cells, at least one arithmetic unit and with a planning unit for controlling operation sequences according to a predetermined program, characterised in that in the case of an electric calculating machine at least one selector unit is provided, which contains more active output elements than there are adjusting input elements, and the adjusting input elements are supplied with the program developed in a manner known per se after operation and transmission procedures are successively transmitted to the selector unit in the form of commands encoded from electrical character combinations from the planning unit, and which is used to decode the commands and via its active elements to execute the calculating operations and transmissions assigned to the commands by connecting the electrically selected memory cells to setting or result elements of the calculating unit." ZuP 006/001.

70 Johannesson to Patent Office, 24.4.1960, ZuP 006/001.

20.3.1961 The opposing lawyer supplemented the objections with the Couffignal dissertation of 1938.[71] Here Zuse's main claim was said to be fully anticipated. This was accompanied by a memorandum describing Couffignal's binary data-processing program-controlled machine in summary. "It needs no further explanation that the binary data processing machine planned by Couffignal has the features marked I to III. [...] Feature IV of the patent claim necessarily results from the fact that the program strip of the machine planned by Couffignal is binary coded, and from the fact that the program has both operation and addresses in one instruction. Thus, the control stage controlled by the program strip must necessarily have a selector for issuing operation commands and a selector for selecting addresses."[72]

5.6.1961 The opposing party's attorney filed with the Patent Office as new material in support of his opposition the Italian patent 385130[73] from 1941. This was said to describe a punched tape control in a programmed computer which has a circuit arrangement with yes-no switching elements. He also requested a statement on Couffignal.[74]

2.8.1961 Zuse formulated a draft submission to the patent office, which was sent to the lawyer on 15.8.1961. After Zuse had read the complete Couffignal dissertation, he replied to the objection: Couffignal was only concerned with the basic possibility of programme control and did not go into further detail on the technique. He left it open whether and in what form command verifications and decisions were envisaged. The opponents, on the other hand, had modernised Couffignal's general explanations with terms from current data processing that had become widespread in the meantime.[75]

18.8.1961 The attorney sent the opinion to the Patent Office.[76] On 15.11.1961, the Patent Office informed that claim 1 could not be granted, since it would already be assumed as known in the description.[77]

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71 Cf. Footnote 39.

72 Hagen to Patent Office, 20.3.1961, ZuP 006/001 (cf. Footnote 54).

73 Italian patent 385130, Boni's invention of 1941, for a program-controlled calculating machine, especially for ballistic calculations, in which several operands are magnetically stored on a steel wire or strip. Various references in ZuP 006/001.

74 Hagen to Patent Office, 5.6.1961, ZuP 006/001.

75 Weber-Schäfer to Zuse, 2.8.1961, ZuP 006/001.

76 Weber-Schäfer to Patent Office, 18.8.1961, ZuP 006/001.

77 Patent Office to Johannesson, 15.11.1961, ZuP 006/001.

8.12.1961 The lawyer informed Zuse of the decision. He attributed the unexpected decision to the fact that, because of the new version of the patent law that had just come into force, the decision was taken by a new patent office division which, "in contrast to the previous examiner", was "initially" opposed to the application "because it sees contradictions between the final formulation of the claim and the documents interpreted."[78]

25.1.1962 Zuse's lawyer filed a new version of the patent claim. The renewed definition set the focus thus: "The central idea of the invention is, as already explained several times in previous entries, to use an instruction code encrypted in yes-no value combinations in a program-controlled calculating machine. Accordingly, the feature of claim 1 is directed to the technical means necessary to implement this idea. These are essentially the decoding means [...] provided in the program unit, to which the program developed in a manner known per se according to operation and transmission processes is fed on the input side from the planning unit in the form of yes-no value combinations. In order to complete the given technical instruction, the function of the decoding means [...] is specified in the further features of claim 1 in such a way that they serve, on the one hand, for decoding the memory address and for connecting the selected memory cell with setting or result elements of the arithmetic unit and, on the other hand, for decoding the operation instructions and, via the control unit, for executing the operations assigned to the instructions in the arithmetic unit."[79]

29.6.1962 The Patent Office again rejected the new main claim as known. The decision referred to the work of Couffignal: "Through this preliminary publication, a calculating machine has thus become known in which the calculation plan is developed in symbolic notation according to operation and transmission procedures and in compliance with the machine organisation, and the calculation plan thus obtained is converted onto punched tape and fed to the calculating machine as a control programme. [...] The object of the application differs from this known program-controlled calculating machine with punched tape input only in that it is particularly emphasised that a combination code (yes-no value combination) is used on the program punched tape. [...] However, the selection of a particular coding cannot be regarded as a patentable invention."[80]

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78 Weber-Schäfer to Zuse, 8.12.1961, ZuP 006/001.
79 Weber-Schäfer to Patent Office, 25.1.1962, ZuP 006/001.
80 Patent Office to Johannesson, 29.6.1962, ZuP 006/001.

8.8.1962 Zuse's lawyer drafted a request for an 'appealable decision' from the Patent Office, as he did not want further discussion of the patentability in the first instance.[81]

20.9.1962 The Patent Office decided to refuse the patent.[82]

9. The rejection by the Federal Patent Court

14.11.1962 Zuse's lawyer filed the complaint[83] and on 19.12.1962 the statement of grounds. The grounds of appeal cited "the idea supporting the invention" that program-controlled calculating machines used an instruction code encrypted in yes-no value combinations, which was not explicitly stated in any of the works of Babbage, Ludgate or Couffignal.[84]

7.8.1963 The opposing counsel filed a motion to dismiss the appeal. "The alleged invention, which is not correctly identified in the statement of 25 January 1962 and in the aforementioned passage of the statement of 19 December 1962, lacks novelty in comparison with the doctoral thesis of Couffignal and the Italian patent 385130. It also lacks inventive step with regard to the general punched tape control technology in connection with the classical feeders of the program-controlled calculating machine (Babbage, Ludgate). [...] The applicant's assertion that it is an inventive step to apply the purely binary and thus binary representation not only to numbers taken from a tape, but also to operation instructions taken from the tape, cannot be sustained in any way, For both the Italian patent specification 385130 discussed above and the tape shown in the American patent specification 2199541 show clearly and without doubt that on the tape used there operation commands and addresses are treated as ordinal numbers, namely in binary-coded form. It would also be absurd to infer anything else from the Couffignal publication in this respect."[85]

6.3.1964 Zuse's lawyer informed the Federal Patent Court (BPG) that the application for rejection did not raise any substantially new aspects.[86]

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81 Johannesson to Patent Office, 8.8.1962, ZuP 006/001.
82 Decision, Patent Office 20.9.1962, ZuP 006/001.
83 Weber-Schäfer to Patent Office, 14.11.1962, ZuP 006/001.
84 Johannesson to Patent Office, 19.12.1962, ZuP 006/001.
85 Hagen to BPG, 7.8.1963, ZuP 006/001 (cf. footnotes 73 and 63).
86 Johannesson to BPG, 6.3.1963, ZuP 006/001.

22.5.1964 Zuse's lawyer proposed to prepare "possible options for withdrawal if the main claim is not granted". In addition to instruction encryption, floating point encryption could also be addressed. Claim 16 [87] could now also be important for "the microprogramme control technique by means of stepping chains *[η3]* which is widely used today. The corresponding claims should be reformulated as independent claims for which instruction encryption is no longer a prerequisite.[88]

12.6.1964 The opposing counsel replied to the opinion of 6.3.1964: "The distinguishing feature of the new patent claim 1, cleansed of overdetermining dummy features, can be summarised as follows: the programme to be entered is coded in a bit-saving manner […]. The bit-saving encoding of the programme brings an advantage only for the usual programme carrier, not for the system as a whole. It is an advantage if the programme carrier is designed bit-saving in its programme parts. This advantage has nothing to do with the calculating functions of the calculating machine itself […]. Since the bit-saving coding of the programme stream thus only serves the purpose of the bit economy of the programme stream, the alleged invention characterised by the new patent claim 1 only consists of what has already been known for a long time in the technology of programme-controlled accounting machines.[89]

22.6.1964 Zuse reformulated the patent specification. The description began: "The invention relates to a program-controlled calculating machine with a memory consisting of individually callable memory cells, each storing an operand as a multi-digit binary number, with an arithmetic unit which can be set to perform various arithmetic operations and with a program unit for setting the operation sequences in the arithmetic unit and the operand and result transports between the arithmetic unit and the memory unit in accordance with a predetermined sequence of operation and transport instructions which are automatically read in succession and recorded on a program carrier. Such machines have been described several times, but so far it has not been possible to build a functional programme-controlled calculating machine." The introduction also mentioned Couffignal and commented on his writing: "However, nothing more can be gleaned from this proposal about the technical means for programme control than from the older works of Babbage and Ludgate."

The "state of the art" was further delimited: "Electrical devices for storing and selecting numerical data were already known, in which by using a dialling unit, to which the

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87 Claim 16 related to "relay chain" circuits in the calculator.
88 Johannesson to Zuse, 22.5.1964, ZuP 006/001.
89 Hagen to BPG, 12.6.1964, ZuP 006/001.

η3 *Translation note: 'Stepping chains' is a literal translation of 'Fortschalteketten', but perhaps Zuse meant the use of multi-phase timing, where the completion of each phase or timing period is followed by the initiation of the next phase.*

memory cells that are called up can be connected to the output and input elements respectively. However, this is an arrangement constructed in the manner of a lever-rotary selector, which is controlled by series of currents. Relay contact pyramids and similar arrangements for the selection of a line from a multitude of lines have become known for various purposes. Their use in the indicated manner in program-controlled calculating machines brings the particular advantage that instructions can be used which are encrypted as yes-no value combinations, which require a minimum of space when recording, for example on a punched tape, and that a minimum of expenditure, for example on relays, is required for the instruction registers and transmission elements."[90]

15.9.1964 The opposing counsel filed his observations on the new wording of the patent. He criticised the new main claim, which "constitutes an inadmissible alteration and extension of the subject-matter of the published application documents. Neither an address register [...] nor an operations order register [...] is disclosed in these documents."[91]

22.10.1965 Zuse's lawyer submitted to the BPG as material to clarify the issue of technical progress an essay by Dr. Ganzhorn[92] (IBM), who acknowledged Zuse as the inventor.[93]

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[90] New claim 1 of 22.6.1964: "Program-controlled calculating machine with a *memory,* consisting of individually callable memory cells, each storing an operand as a multi-digit binary number, with an arithmetic *unit* adjustable for the execution of various arithmetic operations and with a *program unit* for setting the operation sequences in the arithmetic unit and the operand and result transports between the arithmetic unit and the memory unit according to a predetermined sequence, recorded on a program trip, of operation and transport commands read off automatically one after the other, *characterised in* that two contact fields with individually controllable switch groups and more output active lines than input control lines (relay contact pyramids, [...]) are provided in the program unit, one of which [...], controlled by an address register set by the read transport commands and formed from changeover elements [...], controlled by an address register set by the read transport instructions and formed of switching elements [...], causes the connection of the memory cells set in the address register with the operand setting and result elements of the arithmetic unit [...] and the other [...], controlled by an operation instruction register set by the read operation instructions and formed of switching elements [...], causes the switching on of operation switches (operation relays [...]) initiating the operations in the arithmetic unit". ReP 006/001.

[91] Hagen to BPG, 15.9.1964, ZuP 006/001.

[92] Ganzhorn, K., "Historische Entwicklung der lnformationsverarbeitung", *IBM-Nachrichten,* Vol. 14, 1994, pp. 2152-2156. *[Translators note η3]*

[93] Johannesson to BPG, 20.12.1965, ZuP 006/001. *[η4]*

η4 Translation note: In Footnote 92 the year is probably 1964 instead of 1994

2.12.1965 In his reply, the opposing lawyer pointed out the central problem of the basic application of the builder of the Z3: “The article gives a summary of the history of the construction of data-processing machines from the point of view of a practice-oriented expert. The article therefore primarily presents development contributions which consisted in the construction of more or less operational machines, while numerous fundamental theoretical contributions are not mentioned. As an example, the names of Ludgate, Couffignal, Turing, Shannon and Dirks are mentioned, who went down in the history of computing machine development less as designers of finished machines, but rather as creators of machine structures and concepts. An approach that only takes into account ideas that have been realised in practice is not relevant to the understanding of patent law, since the Patent Act does not require that the subject matter of the invention or prior publication has been realised in practice, either for the grant of a patent for a new invention or for the validity of a prior publication in printed form as material that is prejudicial to novelty.”[94]

20.12.1965 Zuse's lawyer sent a reply: "In the applicant's view, however, an essential indication of the patentability of an invention is still to be seen in the fact that the content of this invention has led directly to the construction of an operational machine, whereas the contributions of earlier authors, which essentially relate to system questions, exhausted themselves in the theoretical. [...] When Ganzhorn points out in his article that the Z3 'already worked according to a program controlled by a punched strip', the significance of this statement must be understood in its full scope in connection with his remark [...], in that he refers to Zuse's first application of binary logic, adapted and superior to technology, to the construction of calculating machines. Furthermore, if one considers the [...] statement that one of the essential points of the concept introduced by J. v. Neumann in the technology of electronic calculating machines consists in 'encoding the programme of a calculating machine as information in such a way that it can be stored in its information memory', it becomes clear that the precondition for this concept is given by the encoded instruction encryption, which was disclosed for the first time in the present application for the purposeful design of the program work. The details given in the preceding paragraph [...] for the first electronic calculating machine ENIAC, which caused a sensation at the time, and which was still equipped with decadic ring numbers in the calculating unit as well as in the registers, and with a programme plugged into a plugboard on the control panel."

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[94] Hagen to BPG, 2.12.1965, ZuP 006/001.

The lawyer drew the conclusion from these historical facts: "Although individual features of the invention were already known in themselves, partly from theoretical considerations about program-controlled calculating machines, partly from the technology of the key-controlled calculating machine, their combination, which led for the first time to the realisation of a program-controlled calculating machine in the form of the Z3, cannot have been as obvious as the opponent might believe, if the independent development in the country leading this branch of technology still had to take such detours."[95]

7.1.1966 In response to the German patent specification 664012[96] cited in opposition, Zuse's counsel replied: "Nor did the use of the binary number system in German patent specification 664012 take place in the same way as in the invention, in that the binary numbers as such were also stored in the memory; rather, in the known arrangement, conversion from the decimal system to the binary system took place before each individual calculation and back to the decimal system after each individual calculation."[97]

31.1.1966 Zuse's lawyer sent a supplementary letter to the BPG stating: "Subsequent to the submission of 7.1.66, the following is hereby noted that Dr. Zuse had drawn the attention of the undersigned to the fact that at the presentation of the 'Harry Goode Memorial Award' it had been pointed out that the realisation of the 'floating point' principle in binary computers had had a significant influence on modern computer technology."[98]

6.4.1966 Zuse's lawyer filed a newly formulated 1st claim: "Program-controlled calculating machine with a *memory*, comprising individually callable memory cells each storing an operand as a multi-digit binary number, having a *calculating unit which can* be set to execute various *calculating* operations, and having a *program unit* for setting the operation sequences in the calculating unit and the operand and result transports between the calculating unit and the memory unit in accordance with a predetermined sequence of operation and transport commands recorded automatically one after the other on a program carrier, sequence of operation and transport commands which are automatically read one after the other and recorded on a program carrier, *characterised in* that two contact panels with individually controllable switch groups and more active output lines than input control lines (relay contact pyramids, [...]) are provided in the program unit [...], one of which [...], controlled by a set of address recording elements [...] set by the read transport commands, connects the memory cells set in these recording elements with the

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95 Johannesson to BPG, 20.12.1965, ZuP 006/001.
96 DRP 664012, supra note 22.
97 Johannesson to BPG, 7.1.1966, ZuP 006/001.
98 Johannesson to BPG, 31.1.1966, ZuP 006/001.

operand setting or result elements of the arithmetic unit [...] and their other [...], controlled by a set of operation command recording elements set by the read operation commands [...], causes the activation of operation switches [...] initiating the operations in the arithmetic unit.[99]

19.4.1966 The opposing counsel pointed out to the BPG that in the opposing US patent 2141598[100] by Bryce "discloses the principle of floating point calculus", since mantissa and exponent values are formed and stored here according to this principle.

Then he commented on Zuse's objections: "The opponent fully recognises the merits of Dr. Zuse; it regards the honours conferred on him as a deserved reward for his outstanding achievement in being the first to realise a program computing machine in practice. However, the opponent cannot accept that these merits can serve as a substitute for the lack of legal requirements for the grant of a patent on the present application. Only the content of the application documents disclosed as essential to the invention, the state of the art to be taken into consideration and any inventive surplus resulting therefrom, but not the person of the inventor, can be decisive for a judgement on the patentability of the subject-matter of the application"[101].

23.5.1966 The opposing counsel stated that with the new claim 1 "the further assertion of a storage property for the "punched tape sensing relays [...] have been dispensed with".[102]

before 21.7.1966 The opposing lawyer requested the BPG not to grant the patent due to lack of inventive step. He again objected to the fact that "the coding of commands and addresses in a program-controlled calculating machine, irrespective of the

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99 Johannesson to BPG, 6.4.1966, ZuP 006/001.

100 US patent 2141598: The American patent "Automatic Decimal Point Selecting Device for Accounting-Machines" was filed in 1934 by J. W. Bryce, Bloomfield, N. J., assignor to IBM Corp. N. Y., and granted in 1938. The main claim is: "A record controlled accounting machine, including record controlled entry receiving means, record analyzing means for reading designations of amounts to be entered there in, shiftable connections between said entry receiving means and the analyzing means, presenting means for presenting amount designations on the records to determine the denominational magnitude thereof and means controlled by said last named means for controlling the shiftable connections and effecting a columnar shift go vary denominationally the entries into the receiving means depending upon denominational magnitude of amounts."
In 1935, IBM applied for the corresponding patent 667044 in Germany without naming the inventor. It was also granted in 1938 and had the title "Multiplication machine with device for product registration".

101 Hagen to BPG, 19.4.1966, ZuP 006/001.

102 Hagen to BPG, 23.5.1966, ZuP 006/001.

number, command and address coding that was customary on the filing date for a wide variety of purposes" and cited the German patent specifications 641105[103], 535888[104] and the English patent specifications 525330[105] to. [106]

3.10.1966 Zuse's lawyer asked the BPG for a decision as soon as possible.[107]

17.11.1966 The opposing counsel pointed out that the opposing German patent specifications 535888 and 641105 "are to be considered in connection with the other prior art which has been proved to be known". This included, above all, the publication by Couffignal, where "the method of selective storage and retrieval of data in memory slots which are addressable by the program instructions is made full use of."[108]

14.7.1967 The BPG rejected the complaint, stating: "The complaint is admissible, but could not succeed.

1. The application deals in the generic term of the patent claims with program-controlled calculating machines with a memory, an arithmetic unit

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103 DRP 641105: The patent "booking machine" was applied for in 1927 by the National Cash Register Company, Dayton, Ohio, USA, and published in 1936. "A booking or static machine controlled by punched strips or cards, in which by means of adjusting members one of several hole combinations associated with an adder can be selectively made effective and certain rows of holes, depending on the position of the one adjusting member, form a partial cycle of the machine in which substantially only the strip feed device operates, or a total cycle in which also the counting-off, the adder selection and the adder device operate".

104 DRP 535888: The patent "Registering Machine" was filed in 1926 by the National Cash Register Company, Dayton, Ohio, USA, and published in 1931. It is a "registering machine with the number of additions selected by punched cards and transferred to the amounts also determined by the perforations of the punched strip".

105 British Patent Office 525330: "Improvements in or relating to Electrically Operated Calculating Apparatus", filed in 1938 by the Hungarian Ladislas Kozma and the Dutch Jakob Kruithof for Standard Telephones and Cables Limited, London, and granted in 1940. "This invention relates to electrically-operated calculating apparatus. The equipment is conceived as a central calculating equipment accessible from a number of different positions, from any one of which the equipment can be seized and provided with a calculating problem to be performed, the answer being transmitted back to the station and printed or otherwise indicated to the operator at the station. [...] can be applied to equipment in which the key set and calculating equipment are built as a unit, or to any desired calculating problem, for instance accounting and banking prob- lems. [...] these and other calculating facilities may be provided in a centralised calculating service for a number of stations or for unitary equipment."

106 Hagen to BPG, 21.7.1966, ZuP 006/001.

107 Johannesson to BPG, 3.10.1966, ZuP 006/001.

108 Hagen to BPG, 17.11.1966 (date of receipt), ZuP 006/001.

and a programme unit which records the operation and transport commands on a programme carrier. According to the second paragraph of the new introduction to the description of 22 June 1964, it is based on the task of specifying possibilities for the construction of such machines, which have only been described so far, but not implemented.

2. A task which is itself inventive is therefore obviously not present [...]. Consistent with this, the applicant, in defending the subject-matter of the application, did not rely on the position of the task, but on the means identified in the claim, with which it intends to solve the task.[109]

10. Conclusion

Several questions remain. One of them is the extent to which the designation "inventor of the computer" applies to Zuse at all. Knowing the facts of the rejected patent application, it was defiantly propagated by Zuse himself, demonstratively taken up and repeated in countless interviews, journalistic publications and television films. Zuse did not accept that his theoretical findings and their implementation in technical applications had resulted solely from contemporary knowledge without "inventive achievement". The vast majority of computer experts did not disagree. Instead, the authority and competence of the patent institutions was more or less clearly called into question and the story of the misjudged inventive genius who could not compete with foreign interests was often told. Even if one ignores all the superficial verbiage, the impression remains that the argumentation of the representatives of patent law can hardly be understood within the legal context. However, the significance of the "invention of the computer" is obviously an essential part of very general ideas about our world today. The patent office does not have a monopoly on the awarding of the title "inventor". However, the granting of a patent is the effective lever that makes financial claims legally enforceable.

If one follows the back and forth of submissions, reformulations, objections and rejections through the years and decades, the difficulties that an inventor has to overcome in his efforts to obtain a patent become clear. This is especially true when the importance of the claims increases during this time. Although Konrad Zuse spent countless hours and days putting his inventions into words, illustrating them with drawings, formulating and delimiting claims, his efforts remained unsuccessful. One gets the impression that, at least until 1944, there was hardly any guidance from the patent attorney

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[109] Decision of the Federal Patent Court of 14.7.1967, ZuP 005/009.

or it was poorly circumscribed. Unfortunately, there are no sources that shed light on this. Without legally qualified guidance, the apparatus of the patent system is just as inaccessible as that of criminal law.

It is hardly possible to answer the question of what the granting of the patent in 1967 would have meant. At that time, not only the opposing party had recognised the "outstanding achievement of being the first to realise a programmatic calculating machine in practice"; in the end, however, it was solely a matter of the legally recognized "inventive strength". The financial consequences depended on its recognition. The assumption that the entire international computer industry had to pay Zuse licence fees does not seem very realistic. It must also remain open whether the granting of the patent would have given Zuse KG relief in its difficult financial situation and prolonged its period of independence. In 1994, Zuse characterised the rejected patent succinctly: "All computers would have been covered under this fallen patent." He said nothing about the consequences expected at the time from a granting of the patent.[110]

Appendix

The following list of Konrad Zuse's patents was compiled by employees of Zuse KG on 8 October 1959, ZuP 020/003.
Patent applications by Dipl.-Ing. Dr. K. Zuse (period: 1936-1947)

1. Pat.-Anm. Z23139 IX/ 42m:
   "Procedure for the self-completion of invoices",
   Date of application: 11.4.1936,
   not published; withdrawn August 1940.

2. Pat.-Anm. Z23624 IXb/42m:
   "Rechenmaschine - calculating machine",
   Date of application: 24.12.1936,
   not published; withdrawn February 1943.

3. Pat.-Anm. Z23189 IXb/42m = Z396 IXb/42m:
   "Mechanical switching element",
   Date of application: 9.5.1936,
   published: 18.9.1952,
   Patent granted: 10.9.1953 No. 907948,
   Waiver of 23.8.1955.

4. Pat.-Anm. Z23967 IXb/42m = Z397 IXb/42m:
   "Mechanical distribution switchgear",

[110] *Frankfurter Allgemeine Zeitung,* supplement "Deutsche Wirtschaft", 14.6.1994.

Addition to Z396 IXb/42m, Date of application: 2.7.1937,
published: 18.12.1952,
Patent granted: 22.7.1954 No. 919017,
Waiver of 23.8.1955.

5. Pat.-Anm. Z24062 IXb/42m = Z395 IXb/42m:
"Storage mechanism constructed from mechanical switching elements",
addition to Z397,
Date of application: 2.7.1937,
published: 18.6.1953,
Patent granted: 29.11.1954 No. 924107,
Waiver of 23.8.1955.

6. Pat.-Anm. Z26476 IXb/42m = Z391 IXb/42m:
"Calculating device",
Date of application: 16.6.1941,
published: 4.12.1952.

7. Pat.-Anm. Z28222 IXb/42m = Z392 IXb/42m:
"Method for scanning surfaces and device for carrying out the method",
Date of application: 2.10.1943,
published: 3.7.1952,
Patent granted, published: 26.2.1953 No. 872645.

8. Pat.-Anm. Z28571 IXb/42m = Z393 IXb/42m:
"Method of multiplying numbers",
date of application: 16.5.1944,
published: 28.2.1952,
posted on 28.12.1956.

9. Pat.-Anm. Z28780 IXb/42m = Z394 IXb/42m:
"Device for deriving result data by means of basic operations of the propositional calculus" = "(Logistic) calculating device",
Date of application: 11.10.1944,
announced: 12.3.1953.

10. Osterreichische Pat. Anm. A1526/47:
"Device for deriving result data by means of basic operations of the propositional calculus",
Date of application: 2.4.1947,
patent granted: 1.7.1952 No. 172288.