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(FOR KEY SEE REVERSE)

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1. In early 1955, development of a relay-operated computer for optical calculations was completed at VEB Carl Zeiss, Jena. The name of the computer is OPREMA (Optische Rechenmaschine). The development was carried out under the supervision of Dr. W. Kaemmerer of the Zeiss firm. As many as 200 technicians worked on the development at one time or another. Prof. N. Joachim Lehmann of the Institute for Applied Mathematics at Dresden Technical University repeatedly provided scientific advice to the Zeiss team engaged in the development of the computer.[1] The OPREMA computer was completed in two models which are as well able to control each other as to carry out calculations independently from each other. 25X1

2. The general principles upon which the Zeiss machine was built and specific technical details on the machine are contained in a secret report which Dr. W. Kaemmerer forwarded to the East German Academy of Sciences in early March 1955. [redacted] 25X1

The program-controlled computing machine of VEB Carl Zeiss-Jena

a. In May 1954 VEB Carl Zeiss, Jena, was ordered to develop a program-controlled computing installation mainly for the purpose of carrying out calculations of the enterprise. Development and construction of the machine were taken up immediately and at the same time. After seven and a half months, the machine was completed. Operation of several large construction components was already started during the period of development.

b. The computer, consisting of two twin machines, occupies an area of 55 square meters in a large room which has a floor surface of 240 square meters. The following requirements were to be met:

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Operating safety, calculating safety, highest possible calculation speed and longest possible life of the machine. These demands were to be reasonably weighed against various possibilities of computer construction available at the present level of technology. Machines using electron tubes present advantages for calculating speed. [illegible]. Operating safety, however, is greater with relay-operated machines. The idea of using transistors had to be discarded because their mass production is not yet possible.

c. Since in general the number of necessary digits amounts to about 40 dual digits, one can shorten the calculating time by the factor 40 if one sets out to construct the machine as a "parallel machine", i.e. all digits of a figure will be processed at the same time. However, since the width is thus increased forty times, the number of relays will be correspondingly higher. This is no drawback because the relays will not suffer from wear[illegible], if the machine is built expertly, and they thus represent a one-time expenditure only (contrary to tubes). Moreover, construction of the control installation is less complicated in a parallel system than in a serial system. It is understood that a tube-operated serial machine works about 25 times faster than a parallel machine; however, this factor can be reduced to about 8 through special construction of the parallel machine. Tube-operated machines are frequently constructed as mono-address machines in order to reduce the number of construction elements subjected to wear[illegible]. Relay-operated machines, however, can use the three-address system without disadvantage.

d. There is only one method of giving [illegible] figures to the machine, namely by indicating to the machine the number of that memory (Speicherregister) where these figures are stored. In a three-address machine, addition is a basic operation: two figures are given [illegible] to the machine by means of two addresses* and the operation results in a third figure, their sum, which by means of a third address is stored or "written" in a certain place. The mono-address machine, however, splits the addition into three individual operations. The first operation command with the aid of the address attached to it fetches one term of the addition and throws it into the accumulator which first must be emptied and therefore contains the figure zero. The second operation command does the same thing with the second term so that the sum of both terms is eventually in the accumulator. Only the third operation command will store the contents in the desired memory and, at the same time, will empty the accumulator in order to prepare it for the next operation. To exemplify: if the figures 4.276 and 5.412 are stored in the registers 3 and 7 and register 11 is to receive the result, the program schedule of a three-address machine is of the following structure:

1. Address	Operation	2. Address	3. Address
3	Addition	7	11

whereas the program schedule of a mono-address machine appears in thisway:

Address	Operation
3	Throw figure from register into accumulator
7	Throw figure from register into accumulator
11	Throw figure from accumulator into register

e. After it was decided that the three-address system was to be used, a very serious question remained to be solved, that of the life span of the machine. Experience gained in all countries of the world, plus independent experiments carried out in the Zeiss firm, made it clear that under normal conditions a relay will be able to make between ten million and a hundred million connections. This figure is liable to greatly limit the life span of the machine.

* Note i.e., the number of a given "memory" (Speicherregister)

Therefore, a way was sought and finally found which allowed the number of connections of one relay to increase almost without limit. An experiment which took several months, has been carried out and has resulted in over one billion connections under conditions as they prevail in the machine. No limit for the duration of this experiment are foreseeable.

f. For reasons of calculating safety, two machines were built at the same time. They act as twin machines and check each other mutually after every basic operation. However, they can also be operated as individual machines.

g. While the machine works with a binary code system (dual verschluesselt), the input and output equipment work with the decimal system in order to have a reasonable relation between the preparatory and the evaluation time on the one hand and the calculation time proper on the other hand. In order to make possible a very flexible program handling, particularly in order to make variation calculations possible, the input of programs and figures is done with the aid of Steckтafeln . The special purposes served by this machine require cyclic programs "in mehrfacher Verschachtelung".* Handling of such programs was made possible through adding a fourth address which permits conditional and unconditional jumps in the sequence of operations and through an additional register (Speicher) which works cyclically. In order to cover as large a range of figures as possible, semi-logarithmic representation ($\pm$ a·10$^{\pm b}$) was chosen whereby b is confined to the range of -15 to +15 and 'a' is an eight-digit number with the comma after the first digit. This number must have such a form that the digit preceding the comma is different from zero. Results are given in this form by the machine itself, i.e. they are "normed" by the machine. The figures "zero", "infinite" without sign and "undetermined" (or "imaginary") are introduced as special symbols. Every decimal figure is represented by a four-digit number (Tetrade) of binary digits. Since the ten figures from 0 to 9 can be coded in 16 (2^4) combinations, the following code combinations were selected:

0 equals OOLL	5 equals LOOO
1 equals OLOO	6 equals LOOL
2 equals OLOL	7 equals LOLO
3 equals OLLO	8 equals LOLL
4 equals OLLL	9 equals LLOO

The advantage of this system lies in the fact that transit is easy from any figure to the one which complements it to 9; this transit is done by interchanging O and L. Thus subtractions can be easily changed into additions.

h. A total of 32 possible operations are provided for. So far the following ones have been selected:

1 to 16: Algebraic sums in such a form that the sums of the absolute values of the terms can also be obtained;
17: Multiplication;
18: Division;
19 to 20: Square root with positive or negative sign of the root;
21: Transfer from one register into another one;
22 to 24: Three special operations enabling the machine to make a decision with regard to conditional jumps. The first operation classifies all possible numbers (including zero, infinite and undetermined) into one group containing all positive numbers, and another one containing all other numbers. The second operation classifies them into one group containing only zero and into another one containing all other numbers. The third operation gives the same classification as the second one with "infinite" being the only number in the first group;
25: Calculation terminated.

* Literally in multiple insertions into one another.

i. The results are printed. An electrical typewriter writes the results in semi-logarithmic form (e.g. +87042635 - o2 for $+8.7042635 \cdot 10^{-2} = 0.087042635$). The length of lines of writing can be adjusted. The command desk has switch connections for either twin operation of the machines or for individual operation. Colored lamps indicate whether the calculation is carried out without disturbances. If, in a twin operation, a red lamp is lighted, this means that the machines have produced different results; the machines will then stop operations. In such case, the input values, operations, addresses and results can be re-read from lines of lamps for both machines. The last operation which of necessity must include the error, can then be repeated.

j. The installation (i.e. both machines) has 17,000 relays and approximately 90,000 selenium rectifiers. The total wiring has a length of about 500 km. The number of welding spots is about one million. The installation is fed with 6V and 12V current taken from a buffer battery which is connected with the regular net. The required power is about 30 Watts.

k. All relays are arranged in broad bands on the outside walls of the installation which is 73 meters long. The wiring is well protected inside the installation which can be entered through a door. An aisle of 1.40 meters width and 2.40 meters height can be illuminated through ceiling lamps.

l. Following are the calculation speeds which are counted from the moment when a command is accepted to the moment when the result is fed into the register:

Algebraic addition:	about 120 milli-seconds
Multiplication :	about 300 milli-seconds
Division :	about 600 milli-seconds
Extraction of roots:	about 1,200 milli-seconds

m. The machine has the capacity of 120 trained computers.

1. [redacted] Comment: Prof. Lehmann is a specialist on computer development. [redacted] on his development of the Dresden digital computer. 25X1 25X1

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