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Computing in Russia

The History of Computer Devices and Information Technology revealed

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The Slonimskiy Theorem and its Implementation in Simple Multiplication Devices

In the middle of the last century, the mathematician Zinovy (Zelig) J. Slonimsky (1810-1904) invented a simple multiplication device to implement one of the theorems, which he had proven. The device could multiply every number of permitted length (i.e. the length permitted by the device-design) by every simple number. In other words, the device was something like a mechanical multiplication table. Later, the Slonimsky theorem was used for another simple multiplication device, namely for the calculating bars designed by Jofe. Both devices are interesting as examples of technical implementations of complicated mathematical ideas rather than as mechanical innovations. The review of the invention given by the St. Petersburg Academy of Sciences read: " The device in question is so simple that it could hardly be named 'a machine'. The theoretical foundations implemented in it are the most important features of the invention.... That fact represents its principle difference from the other machines, which are (largely) entirely based on very complicated mechanisms". (4, p. 566)

Z. Slonimsky was a self-educated mathematician. He was born in 1810 in Belostok[3]. The family was not rich but well educated. Slonimsky himself demonstrated an interest in mathematics already at an early age. He was a born popularizer; at the age of 23, he composed a brief practical guide on the foundations of mathematics. The first part of the guide, dedicated to algebra, was published in Vilnius in 1834. In 1835, inspired by the general interest in the passing of Halley's Comet, he published "The Star with a Tail", a book on astronomy. In 1838, he published one more book on astronomy, in which he described his own research on the calculations of eclipse dates and in composing the calendar. His interest in mechanical calculations probably appeared after his meeting with his future father-in-law A. Stern in Warsaw, where Slonimsky published his astronomical books. A. Stern himself invented a calculating machine, which was unfortunately not described. However, it is known that he demonstrated it to the Emperor of Russia Alexander I[4] in the salon of Mikhail Radzivill[5].

Before 1843, Slonimsky invented and produced two devices. These devices were multiplication and addition machines, which could perform combined calculations. In the same year, he brought them to Berlin, where they were demonstrated to A.

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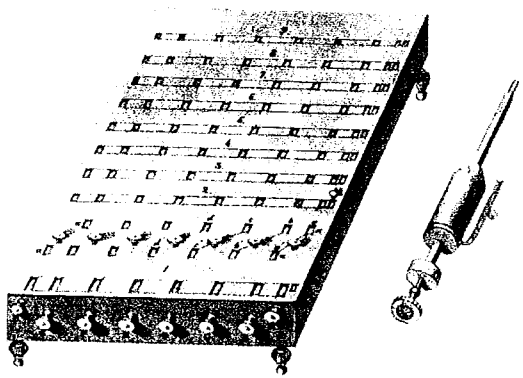
3 Belostok was a border town in Poland. Before the Russian Socialist Revolution (1917), Eastern Poland (including Warsaw) belonged to the Russian Empire.

4 Since Tsar Alexander I died in 1825, the machine of Stern could have only been invented before that date.

5 Mikhail Radzivill, a Polish magnate and maecenas, and other members of the Radzivill family, were active supporters of education and science. The family estate with its castle (which has partly survived up to the present) was established in Nesvizh in 1726 (see the "Jakobson Machine"). It was an important cultural centre with an art gallery, an armory, a public library, and a printing shop, where M. Radzivill published his own newspaper. It also contained numerous mechanical and jewellery work-shops. Other important inventions, such as one of the first successful experiments in electro-photography by Narkevich-Jodko (beginning of the 1900s), later known as the Kirlian Method, are also associated with this place.

Humboldt, F. Bessel, A. Krell and others. Slonimsky's work was highly appreciated. In August 1844, he successfully presented his multiplication machine at the Berlin Academy of Sciences. In 1845, Slonimsky applied to the St.Petersburg Academy. In St.Petersburg Slonimskiy was invited to a seminar at the department of physics and mathematics where he "first demonstrated his machine, then explained its design and finally suggested a written variant of his theorem" (4, p. 565). At this seminar, which took place on April 4th, 1845, the academician V.A. Bunyakovskiy and the scientific secretary P.N. Fuss (Voss) were authorized to compose the official review of the invention. It was very positive; the main reason for this positive appraisal - it was specially noticed - was the solid mathematical basis of the presented work. Since the Slonimskiy theorem is described in detail in the books (5) and (1), we will only give a brief description here. The theorem is derived from the Farey numbers (a sequence of the irreducible irrational numbers **a/b** where **b<=n**, which belongs to the segment /0,1/ and is arranged in increasing order). Using his theorem, Slonimskiy composed a table with 280 columns, each of which contained 9 numbers. The table was placed (engraved) on the cylinders; as the main component of the device, these cylinders can both revolve around the axis (the shaft) and move (reciprocate) along it. Aside from the main cylinders, there are two small- or mini-cylinders with digits from 0 to 9 on one of them and the letters **a**, **b**, **c**, **d** together with digits 1 to 7 on the other. The cylinders are driven with the use of handles fastened to the shaft end. While the mini-cylinders are immobile, the main cylinders are moved along their axis with toothed gearing, driven with screws mounted on the cover. There are also handles on the cover which set the numbers (multiplicands). The machine itself is shown in illustration 3.

Fig. 3 Slonimskiy calculating machine



On its cover, there are 11 rows of windows. The first (lower) window shows the multiplicand. When the number is set in the first row, both letters and numbers appear in the windows of the second and third rows. Their combination is the code which informs the operator which screw should be turned (and which cylinder is to be shifted). After this, windows 4 - 11 show the resulting numbers. The 4th row shows the product of multiplication by 2, the 5th by 3, the 6th by 4 etc. Finally, the products of all ranks are displayed. After adding them on paper, the desired product was obtained. Needless to say, the convenience of this method was rather questionable, and it is no wonder that there is no evidence of its systematic practical usage. Nevertheless, it did bring "indirect" practical results, since it became the prototype for Joffe bars, which was a simple and popular multiplication device.

More importantly, this machine was the only available device for discrete calculating; the basic principle of its work was the theory of numbers, rather than complicated mechanics alone. It was the "mathematical art" of the device, which was so highly appreciated by the St.Petersburg Academy, and personally by Ostrogradskiy [6]. As the Academy report noted, "the discovery of the basic feature of multiple numbers was the principle but not the only condition for composing this calculating machine". "The inventor also should arrange the aforementioned 280 types in a proper order and also invent a phantom key (the code - I.A.). Finally, the surface of each of the six cylinders is covered with complicated system of 2280 numbers and 600 letters with indicators. This artificial ordering demonstrates the shrewdness of its author's mind, which raises Mr. Slonimsky's device to the level of an analytical mathematical instrument. It is not just a calculator, of which the main idea is represented by the numbers of its pinions." ([4] p. 567). The Academy commissioned Slonimskiy to publish the proof of his theorem, together with a detailed description of the machine in Russian language. The task was performed within a short time, and the book appeared in 1845. Soon afterwards, in November 1845, Slonimskiy received a 10 year patent for his invention. He was also awarded the Demidov prize of the Second grade [7].

Slonimskiy lived a long life. He made a number of other inventions, among them a quadrupled telegraph connection (1858), which enabled simultaneous double transmission and reception; four active communication channels were open through one wire at the same time. Later, the same invention was repeated by Thomas Edison, who could hardly have known anything about Slonimsky's work. From 1858 until his death in 1904, Slonimskiy published a popular scientific newspaper, being both its editor and an active author. During his life-time, Slonimskiy could already see the practical implementation of some of his ideas on computing machinery. Also, Kummer's counter, a further technical development of his adding machine, and the Joffe counting bars were produced in significant amounts.

Joffe's Counting Bars

Joffe presented his invention in 1881. In 1882, his calculating bars received an honorable mention at the All-Russian exhibition. Their basic principle is derived from the Slonimskiy theorem. The Joffe device consisted of 70 rectangular bars. The 280 columns of the Slonimskiy table were placed on their 280 sides. Each bar and each of its sides were marked. Both Roman and Arabic numbers, and Latin letters were used. The Latin letters and Roman numbers were used to arrange the bars correctly, while each multiplication of the multiplicand by one rank of the factor naturally require a new combination. (For details, see [1], p. 98-100). Thus the number of products was equal to the number of ranks in the factor. Similarly to Slonimsky's method, the obtained products were added together on paper.

Today, working with these bars seems like a child's game for learning arithmetic, despite of their solid mathematical basis. However, in the 19th century, people thought differently. There were almost no reliable arithmometers - the mass production of Odhner-machines started ten years later - and even such authoritative authors as the famous Russian mathematician General V.G. von Bool came to the following conclusion (in 1896): "The Joffe bars simplify multiplication even more than Napier sticks or their later modifications" (7, p. 197). This book by V.G. von Bool was the first systematized description of facilitated calculation appliances in Russia.

6 One more calculating (arithmetical) machine was devised by Izrael Abraham Staffel in Warsaw in 1845. The work was much prized at the St.Petersburg Academy by Bunyakovskiy and Yakoby, and Ostrogradskiy even suggested to award Staffel Demidov's premium. In 1851 Staffel demonstrated the machine at the first international exhibition in London, where he received a medal ("The best machine of the kind ...". Report by the Juries, 1852).

7 The N. Demidov / Demidov family were Russian industrial magnates of the 18th and 19th centuries. The family established a prize foundation in support of science and education.
The Second grade prize amounted to 2500 Rubles. For comparison, one should say that a university scholarship of 20 Rubels per month could easily cover a student's living and educational expenditures. //A.N.