Chaim Selig Slonimski and His Adding Devices

Valéry Monnier
Sannois Public Library, France

Walter Szrek
Szrek2Solutions

Janusz Zalewski
Florida Gulf Coast University

This article presents the accomplishments of Chaim Selig Slonimski (1810–1904), an important but not sufficiently known figure in the history of calculating devices. In addition to briefly discussing Slonimski's life, his patents, and the similarities of his work to that of others, the authors present a previously unknown example of one of his devices.

Chaim Selig Slonimski (1810–1904)[1] introduced two types of calculating devices. First, he introduced the adding device, complete with an ingenious carry mechanism that gave birth to a carry mechanism in the most popular 20th century adding device: the slide adder. Second, he introduced a simple multiplying device based on the mathematical theory that he developed. None of Slonimski's devices have been known to survive, but during our research, we found one of Slonimski's adding devices that was previously unknown. In this article we present the results of our research on Selig Slonimski's adding devices.

Slonimski designed, but never had enough funds to build a third type of device: a logarithmic machine for calculating logarithms of 14-digit numbers. (However, we were unable to find details about this device.) He did develop at least two different adding devices based on the same principles. We were able to uncover Slonimski's unknown British patent for both his adding and multiplying devices. Both of these devices were different from the ones he previously invented.

Adding and multiplying instruments are generally divided in two categories:

- *calculating machines*, which are devices that mechanically enforce carry through for all decimal positions, and
- *calculating devices*, which are devices with carry over enforced or added manually by an operator.

Slonimski contributed to the development of calculating devices in two important ways. First, he designed a carry mechanism that was later used in slide adders. Second, he designed a multiplication device that did not require mentally adding a carry.

In the article, we first look briefly into Slonimski's life and the recognition he received for his inventions. Then, we present a detailed design of his adding devices and compare them to other known adders. The details of Slonimski's multiplying devices are left for future work.

Slonimski's Life and Calculating Devices

Chaim Selig Slonimski was born in 1810 in Bialystok, now in Poland, which at that time was a part of the Russian Empire. He died in Warsaw in 1904. He had a traditional Jewish upbringing and Talmudic education. The social context of the times and place where he lived did not encourage studying science or making technological innovations. The closest academic towns—Warsaw, Vilnius, and Königsberg—were relatively remote, and publications on science in Yiddish or Hebrew were nonexistent. Without going

 Published by the IEEE Computer Society

through a formal schooling, Slonimski taught himself mathematics, astronomy, and foreign languages. He published books on astronomy and mathematics in Hebrew. He was an inventor, a popularizer of science, and a prominent member of the Jewish Enlightenment known as *Haskala*.[2,3] For 10 years he was a principal of the Rabbinical School in Zytomierz (*Zhitomir*). Slonimski was also deeply involved in some religious issues such as the correctness of the Jewish calendar, and he published the first popular science publication in Hebrew, *Ha-Zefirah*.[4]

His path as an inventor of calculating devices began in 1838 when he went to Warsaw and met another inventor, Abraham Stern.[5] This meeting impressed him and inspired to think about building arithmetical devices himself. Shortly after, Slonimski moved to Vilnius, now the capital of Lithuania, for six months to publish his mathematics handbook in Hebrew.[6] In September 1839, he wrote to a friend that he had built a calculating machine and that he was working on a 20-digit logarithmic device.[7] The June 1840 issue of *Kuryer Litewski* includes the following:

> A Jew S(elig) Slonimski born in Bialystok, recently invented a small machine for calculating, which thanks to its dimensions (length 10 inches, width 3 inches and 1 inch height), comfort, and low price deserves to be widely used. Everybody who knows digits only can, with the help of this machine, make calculations easily, fast, and without need to think. This machine can be seen at the inventor's residence, where he is now working on a new machine for calculating logarithms. With the help of this machine one can simply and comfortably find the differences of Bruget logarithms, as well as natural logarithms up to 14 decimal digits.[8]

A nearly identical note appeared a few months later in *Tygodnik Petersburski*, published in Warsaw.[9] Gradually after that, Slonimski presented his inventions to academies of sciences in Berlin and St. Petersburg and received recognition across the region.

In 1841 Slonimski presented his adding device at the University in Königsberg, where it was highly praised.

Slonimski's Recognition in Prussia

In 1841 Slonimski presented his adding device at the University in Königsberg (then part of Prussia, now in Russia), where it was highly praised.[10] While in Königsberg, he discussed his logarithmic device with Carl Gustav Jacobi. Jacobi wrote a letter to his brother Moritz Hermann von Jacobi about this encounter:

> Dear Moritz, it would be very pleasurable to me, if you could help Mr. S. Slonimski – a very educated mathematician, who's acquaintance is very pleasant to us here. This is both because of his knowledge and his sophisticated calculation machine. In particular it would be of interest if the funds could be procured, so that his big logarithm machine, with which he would calculate from 14 digit numbers 14 digits logarithm, could be built. Please also ask Staatsrat von Fuss, who certainly will be interested in these inventions, to support/take care of Mr. Slonimski to realize the goals he wanted to pursue in St. Petersburg.[11]

Later, in 1844, when Slonimski went to Berlin to present his calculating devices at the Prussian Academy of Sciences, both C.G. Jacobi and S.W. Bessel, who were teaching in Königsberg, gave him letters of recommendation. In Berlin, in addition to his adding device, Slonimski presented to the Royal Prussian Academy of Sciences two multiplying devices.[11,12]

All contemporary authors write that Slonimski created just one multiplying device. Most details point to his second multiplying device. Although we did not find any details about Slonimski's logarithmic device, we found details of three different models of multiplying devices: one with indexing next to multiplied numbers and two later devices with indexing on the bottom of the calculating machine. These two later devices were built based on the mathematical theory that Slonimski himself discovered.[13] All devices allowed multiplication without adding a carry over manually or using a carry-over mechanism between decimal positions. At least one multiplication device was built by 1843. A detailed description of it was printed in 1844.[14]

Slonimski was introduced to the King of Prussia by Alexander von Humboldt, as an inventor of calculating instruments.[15] Slonimski later wrote in Hebrew a book about Humboldt, which was recently translated into German.[16] In Berlin he met August Leopold Crelle. Slonimski told Crelle about his multiplying devices and the mathematical theory behind them. He also published an article about calculating machines in *Crelle's Journal*,[17] which was a leading mathematical periodical at the time. Two years later Crelle, with permission of Selig Slonimski, published his own proof of Slonimski's theorem in his journal.[18]

Slonimski must have hoped that he would be able to commercialize or at least popularize his adding and multiplying devices in Prussia. Although he did not receive any grant or stipend, his devices, especially his second multiplying device, were highly appreciated and praised.[19]

Slonimski's Recognition in Russia

In the following year (1845), Slonimski went to St. Petersburg with recommendations from Jacobi, Bessel, and Humboldt. He brought the improved (second) multiplying device and adding device and applied for the Demidov Prize:

> A great role for stimulating inventive activity (in Russia) was the Demidov prize. … The St. Petersburg Academy of Sciences could award it to authors of original scientific works, teaching manuals, translations of classical scientific works and to inventors of scientific instruments.[20]

There were two meetings of the General Assembly of the Academy of Sciences in St. Petersburg held to consider his devices.[21–23] On 17 April 1845, Slonimski presented his multiplying machine and explained the theory. One and a half months later, on 7 June, he submitted a written theoretical explanation for the machine.[24]

The academy recommended him for the secondary Demidov Prize (2,500 rubles). The recommendation read, "the device is so simple that we cannot call it the machine; the most important is the theoretical basis on which it was developed." This theoretical basis was important for the academics.

In addition to the Demidov Prize, Slonimski received a title of honorary citizen, which gave him the right to live in the areas restricted for Jews. With the recommendation of Russian Academy of Sciences, Slonimski obtained a 10-year Russian patent for his adding device on 24 November 1845.[25]

Innovations and Patents

The following year Slonimski was working on further improvements to his multiplying and adding devices. Using both letters and numbers as indexes on a multiplying device seemed overly complex, so he redesigned the "index" area. The original adding device did not allow adding and subtracting on the same side of the device. The new device allowed for both operations to be made on the same side. This time Slonimski was able to commercialize his arithmetic devices for the first time.

He sold the rights to Great Britain and the US for both of his adding and multiplying machines to David Barnett and Samuel J. Neustadt from Birmingham, trading under the name Neustadt and Barnett: "By a stroke of luck he managed to sell the rights of the manufacture of his adding machine to England for £400. He invested the money in the acquisition of a fruit orchard in the Ukrainian town of Tomashov."[10]

In 1847, H. Knight, also from Birmingham, published multiplication tables based on Slonimski's theorem.[26] On Slonimski's behalf, Barnett filed for a patent and on, 3 May 1847, received British patent number 11,411.[27] He retained patent rights for himself and his partner because, before 1852 in Great Britain, "Importers of foreign discoveries were allowed to obtain domestic patent protection in their own right."[28]

From the petition by Slonimski to the US commissioner of patents,[29] we learned that Slonimski applied for a US patent. Neustadt and Barnettt hired Thomas P. Jones to help with the process of acquiring a US patent because he had previously served as superintendent and examiner of the United States Patent and Trademark Office. Jones died shortly after he started work on the patent process, however, and the US patent was never granted. Neustadt and Barnett only attempted to protect patent rights to these arithmetic devices. We could not find any records concerning if they ever tried to manufacture or market them.

After selling rights to his calculating devices, Slonimski was no longer developing them. He still created many other inventions. In 1857, he invented double-duplex telegraphy, 15 years before Thomas Edison.[30] This fact is not widely known because it was difficult for Slonimski to market this invention.

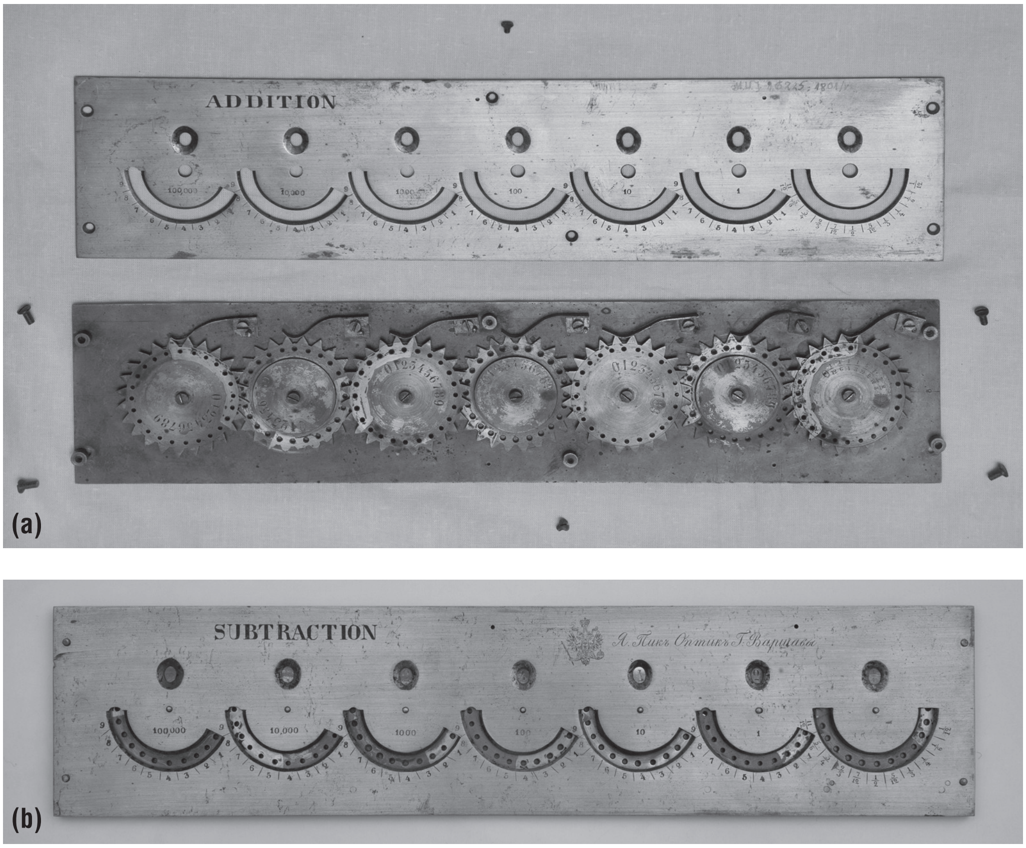


Figure 1. Slonimski's adding device from 1845. ''Addition'' top plate and internals of the mechanism and ''subtraction'' top plate of a newly discovered Slonimski's adding calculator. (Courtesy of the Jagiellonian University Museum, Kraków, Poland.)

(The description of this interesting device is outside of scope of this article.)

Financing of the Projects

Calculating machines required a significant investment of time and money. Many of the early inventors of mechanical devices were clockmakers or mechanics that were able to make their devices themselves. In the case of other Polish inventors, Jakobson, Stern, and Staffel were mechanics that still needed financial help.[31] Some others, such as Thomas de Colmar, the inventor of the arithmometer,[32] were independently wealthy and could finance their inventions themselves. Others were able to secure financing from sponsors, either individuals or institutions.

Slonimski was very poor, and he was not a mechanic. He needed funds to make and market these devices as well as the opportunity to travel to different places for increased exposure and financing possibilities. Slonimski had mixed success in finding sponsors to finance his calculating machine inventions. In his younger years, he approached some businessmen to assist in the publication of his books. *Mosde Hokhmah* [Foundations of Wisdom] was published in Vilnius[6] in 1834 with the help of Moshe Rosental. Later on in 1835, Avraham Zakheim funded the printing of *Kokhva de Shavit* [Stars of the Comet].[3]

Also in Vilnius in 1840, ''Klatzko offered him the means to proceed with his invention'' of an adding device. Then in Warsaw, ''Mr. Rosen, a rich banker, a real friend and patron … supplied him with means to go to Berlin'' to present his inventions.[10] Ultimately, however, Slonimski was not particularly successful in getting any resources in Prussia, but as mentioned earlier, he did get letters of recommendation from distinguished mathematicians C.G. Jacobi and S.W. Bessel that later helped him pursue the Demidov Prize from the St. Petersburg Academy of Sciences.[20]

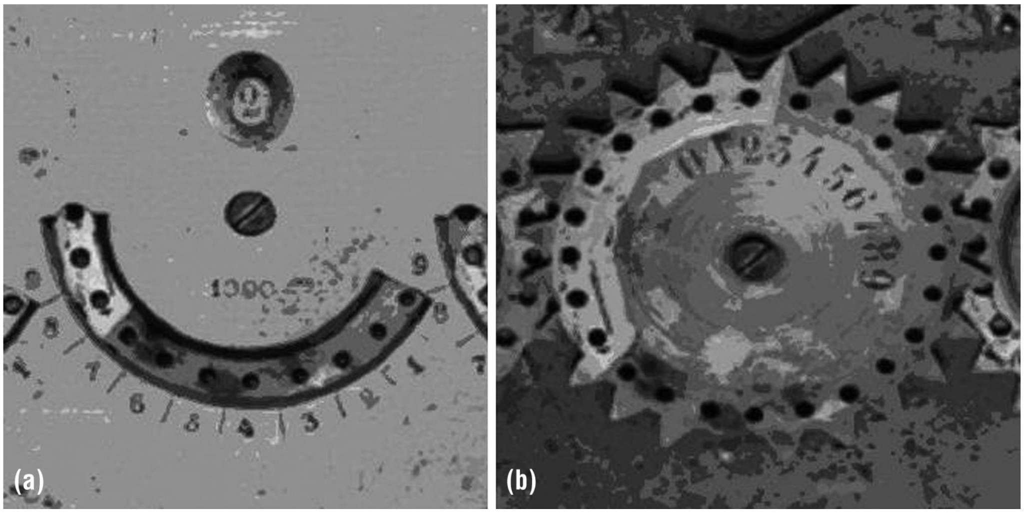


Figure 2. Enlarged view of Slonimski's adding device from 1845. (a) Closer view of one of the dials and (b) a toothed wheel with 24 holes on the circumference. (Courtesy of the Jagiellonian University Museum, Kraków, Poland.)

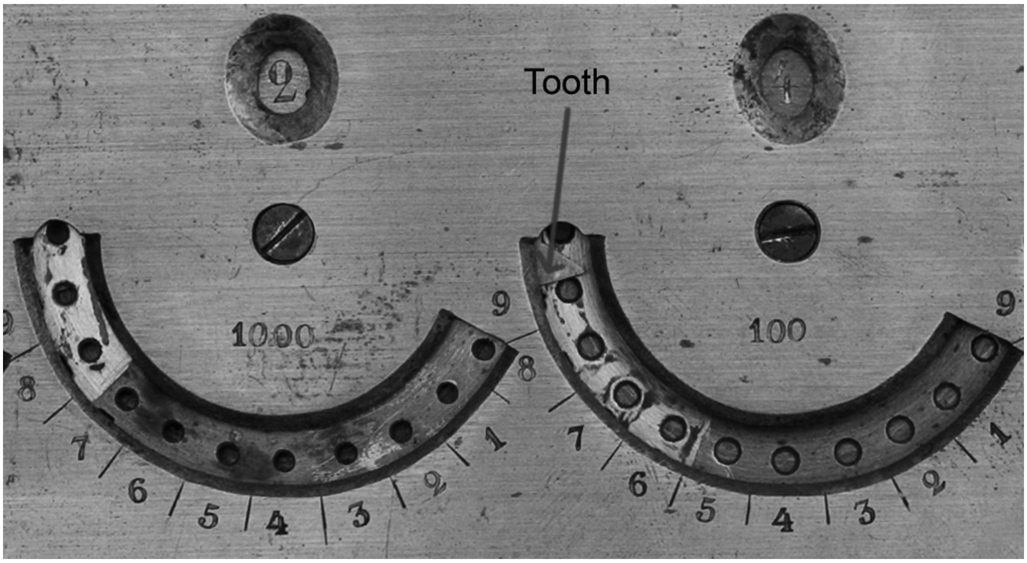


Figure 3. Illustration of the effect of moving a wheel on Slonimski's 1845 adding device with a stylus. (Courtesy of the Jagiellonian University Museum, Kraków, Poland.)

Slonimski's Newly Discovered Adding Device

Even though Slonimski's pursuit of funding was only occasionally successful, there are signs that his ideas and designs were considered by manufacturers for commercialization. As proof of this conjecture, in the Jagiellonian University Museum in Krakow, we found one of Slonimski's previously unknown adding devices (see Figures 1, 2, and 3). The device was originally attributed to Jakob Pik, who manufactured it, and not to Slonimski who actually designed it.

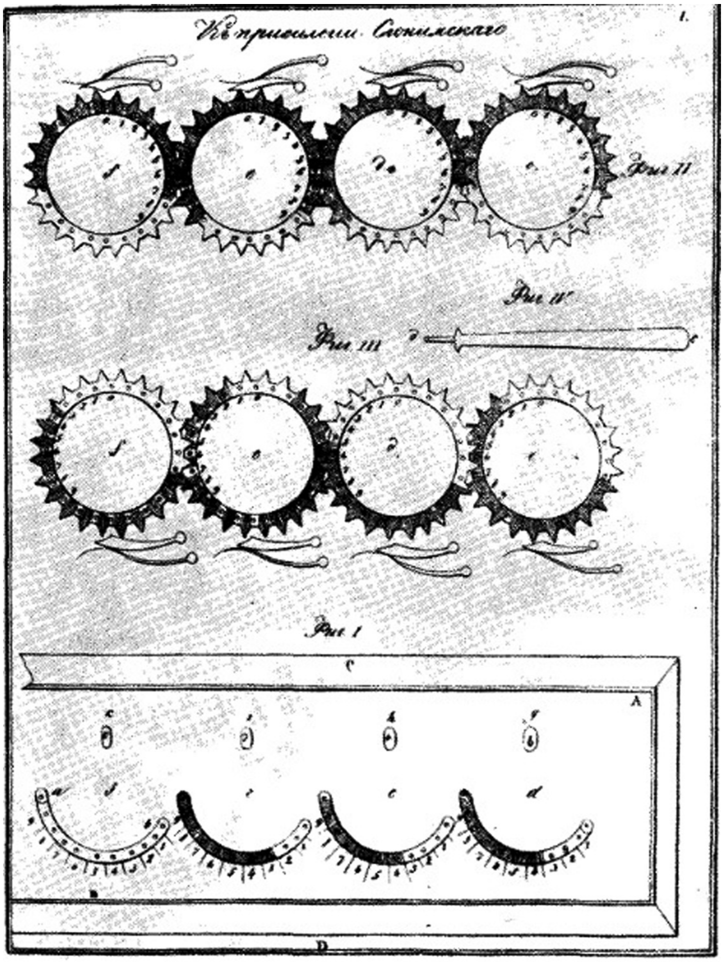
A closer examination reveals that the adder was made according to a 1845 Russian patent. It has remarkable similarities with the diagrams published in the patent description,[25] one of which is shown in Figure 4. This device is two sided; one side is used for adding, and the other is used for subtracting. To switch the operation from adding to subtracting, one needs to reverse the device.

On the "subtraction" side of the cover, there is an inscription: a double-headed Russian eagle and a text in Russian "J. Pik Optician of Warsaw." According to *Kurier Warszawski* (no. 121, in 1847), Pik was given an honorary title of ''Mechanic and Optician of Warsaw'' and received a right to mark his products with the Russian national emblem.[33] This device is described in more detail in the next section.

Slonimski's Adding Devices

To summarize, Slonimski received a Russian patent for an instrument performing additions and subtractions on 24 November 1845. The device and the theory behind it were described in the patent document (see Figure 4).[25] Two years later, in 1847, a similar patent was granted in England to David Barnett, a resident of Birmingham.[27] The new adding device had several improvements but did not differ much from the principles described in the patent issued in 1845.

Here, we describe in more detail the only known example of this adding machine, from the collection of Jagiellonian University Museum in Kraków, Poland.



Чертежи к патенту второй машины Слонимского

Figure 4. Russian patent illustration of a 1845 model of the adding device.[25]

Model of 1845

The 1845 device consists of two rectangular plates made of brass, in which there are curved incisions showing wheel dials (see Figure 2). There are seven wheels, each corresponding to one decimal position. Little windows above the incisions allow the display of results. On one side, the machine is used for additions (top plate), and on the other side, it is used for subtractions (back plate).

The internal mechanism is relatively simple. Wheels equipped with 24 teeth are mounted on independent axes. On the circumference, 24 holes are drilled (Figure 2). These holes appear across the digits, permitting the operator to advance the wheels by from 1 to 9 units with the use of a special stylus.

A ribbon spring above each wheel, composed of a simple band, stops the uncontrolled advancement of the wheel. The teeth located between the wheels partially overlap, an important detail for the transmission of a carry. They are alternately placed above or below each other depending on the side that is used.

To compensate for this difference in levels, the dials of appropriate thickness were mounted on the sides of the lower wheels (wheels 2, 4, and 6 for addition and wheels 1, 3, 5, and 7 for subtraction) to improve reading of the results.

Next to the teeth on these wheels are a series of numbers engraved (0 through 9), with the exception of the extreme right one, which consists of fractions 1/12 and 11/12. The same numbers are also engraved on the plates. This arrangement may, of course, vary depending on the needs, whether the device is intended to count money (kopecks, shillings, and so forth) or to perform math calculations (in decimal numbers). In the patent description, however, the machine does not include fractions.

Note that these digits are present only on a part (10/24) of the circumference of the wheels; the remainder is not engraved.

The toothed wheels have traces of silver on their circumference (see Figure 3), which is not a coincidence. This visual indicator can be found on the Caze (1720) adding device and on later adders such as the ones developed by Kummer (1847) or by Troncet (1891).[34] Caze's indicator is a single black square; Kummer and Troncet have an

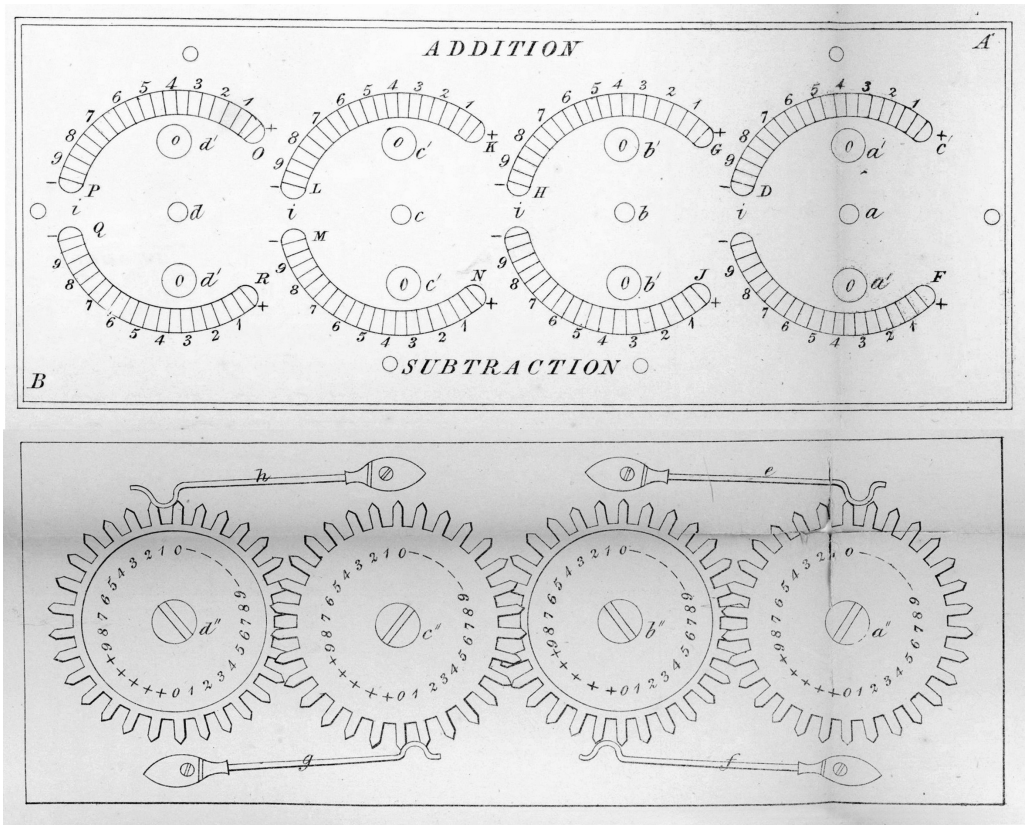


Figure 5. British patent illustration of an 1846 model of the adding device (upper) with notches used for addition and subtraction (lower).[27]

indicator covering multiple digits, following Slonimski's invention.

If one moves the wheel two positions (from left to right), the digit 2 will appear in the (result) window (see Figure 3). Note that at the same time that the silver area surrounding the part of the circumference of the wheel will begin to appear on the left side of the incision. If the operator points the stylus in this silver zone, the wheel must be turned in the opposite direction to force a carry over to the next decimal position.

This is a method of complements; there are two ways that the operation forcing a carry can be performed. For example, to add 8 to 2 (that is, to go from 2 to 10, there are two possibilities: starting from 2, one can add 8 or subtract 2. In both cases, it is required to transmit a carry to a higher decimal place.

The Slonimski device can alternate between two options. If the operator wants to add digit 7 to 2, the operator places the stylus in the hole corresponding to the digit 7 (non-silver zone) and advances the wheel to the right until it hits the plate, which causes a stop. The total amounts to 9, and there is no carry. But when one wants to add 8, for example, there is a problem. After placing the stylus in the hole corresponding to the digit 8 (silver zone), the operator will have to turn the wheel not to the right but to the left, until it stops. This will advance two notches (2 is the complement of 8).

In doing so, the stylus will meet on its way one tooth of the wheel situated immediately on the left (higher decimal place) and turn up a notch. The carry has been performed. The adder shows 10. In the case of additions with a carry in a series (999 + 1), the same operation has to be performed consecutively on each wheel.

Model of 1846

The British patent of 1847 describes an improved version of the calculating device.[27] As in the Russian patent (Figure 4),[25] the mechanism consists of a series of four toothed wheels mounted on independent axes (see Figure 5). They all have 30 teeth, as opposed to 24, and are arranged with their teeth partially overlapping. To compensate for the difference in level, little plates with numbers (dials) of appropriate thickness were mounted on the sides of the lower wheels (2 and 4) to improve the reading of the results. Wheels 1 and 3 do not have dials added. The digits are engraved directly on the body of the wheel, and thus the wheel automatically becomes a dial.

The spring jumpers, made of simple leaf springs attached to the lower plate, stop the advance of the wheel at each tooth (one unit). The device described in the patent has the capability of four digits and operates on decimal numbers (calculations up to 9,999). The wheels have engravings of two sets of 10 digits (0 through 9). Each series of digits is separated from the other by two signs "+" and "–" (five each). There are a total of 30 digits and signs, which are engraved on each wheel and correspond to 30 teeth on the wheel; one tooth corresponds to one digit or sign.

The upper plate has eight curved incisions that partially show the teeth of the wheels (Figure 5). One half of those are used for additions and the other half for subtractions. Small windows beveled in the plate allow the results to display.

Digits 1 through 9 are engraved on the edge of incisions. For subtraction, they are reversed. The digit 0 (zero) is not engraved. In fact, it corresponds to the stop area of the stylus.

The direction of rotation of the wheel is indicated at the ends of the incisions. For example, for addition the operator should turn the wheel clockwise from left to right. When the transmission of a carry is necessary, a dual visual indicator appears:

- At the level of the results windows, the signs appear rather than digits, one "–" for subtraction and "+" for addition.
- A color appears at the level of the incision on the teeth of the wheels.

This clearly indicates to the operator when to turn the wheel in the opposite direction to allow for the transmission of a carry. This is made possible by a partial overlap of the toothed wheels; the laws of mechanics require that the two wheels proceed in the opposite directions. While the number is subtracted on one wheel using a method of complements, a carry is added to the other wheel.

The 1846 model provided a number of improvements over the 1845 model. The first improvement was in placing the incisions for addition and subtraction on the upper plate, thus allowing for more convenient use. This also resulted in doubling the number of digits on each wheel-dial that were engraved on one side. The second improvement was the simplification of the wheel itself. The holes were removed, and the teeth appeared at the level of incisions. The operator only had to place the stylus between the teeth and push the wheel forward or backward when the operation involved a carry over. The mechanism of transmitting the carry remained the same.

There are no known copies of this device. It is difficult to tell if it was ever made.

Slonimski's adding device had a significant impact on the development of calculating devices.

Slonimski's Work versus Similar Inventions

To understand Slonimski's inventions properly and to give him the credit he deserves, his accomplishments should be placed in a broader context of similar inventions of his predecessors, especially those made by the inventors who followed him. Here, we are only concerned with Slonimski's contributions to the invention of adding devices, leaving the discussion of the significance of his multiplying devices for another article.

One has to go back in time to fully understand these issues. In Slonimski's device, the carry results from the deliberate action of the operator. The visual indicators tell the operator when to turn the wheel in the opposite direction to make the transmission of the carry. If the operator were to ignore the visual indicator, they would continue to turn the adder without enforcing the carry, getting erroneous results. Various nonmechanical devices were built before Slonimski's time. They generally work using a simple visual indicator: when the color changes an operator needs to add "1" on the next decimal position.

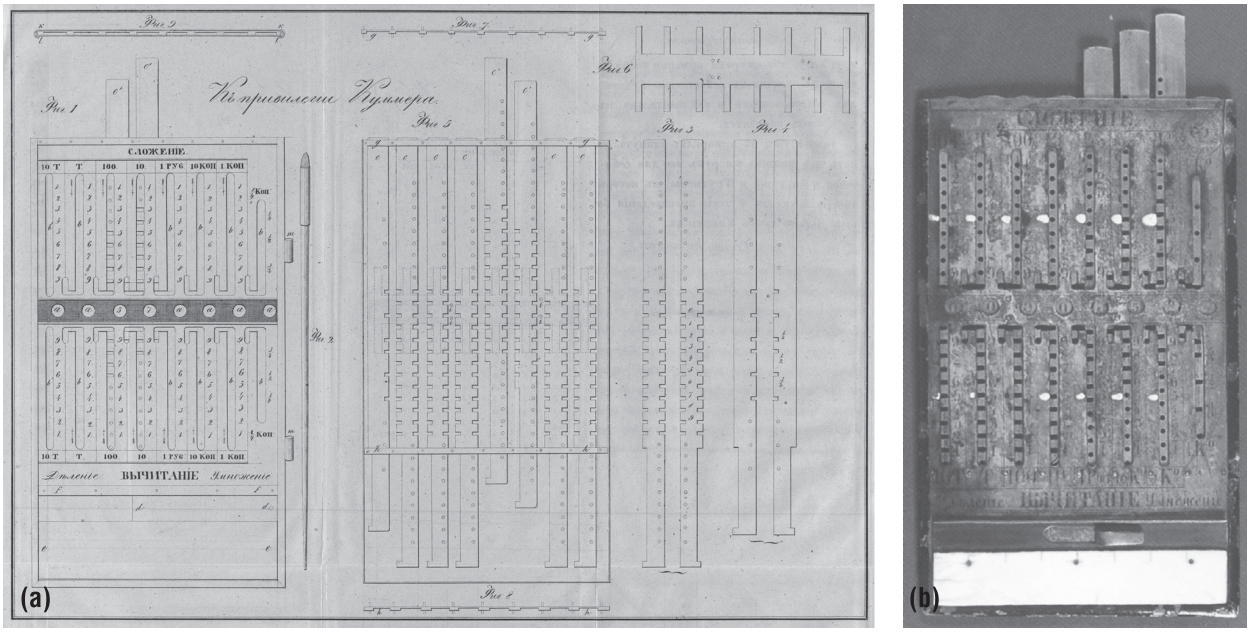


Figure 6. Russian patent drawing of a Kummer device and Kummer adder from the Polytechnical Museum Moscow.[36] (Courtesy of Rechnerlexikon, www.rechnerlexikon.de.)

Slonimski managed to adapt the principle of vertical strips in a circular device used by C. Caze around 1720.[35] In Caze's adding device, which is derived directly from the abacus, the beads are replaced by sliding strips. Caze's device had no mechanism for carry over; only a visual indication told the operator when a carry needed to be performed. By replacing the strips with toothed wheels, partially overlapping, Slonimski managed to ''almost'' automate the carry. Unfortunately, his design had flaws; a carry needed to be manually propagated for each position, and if the operator was not careful, mistakes could be made.

One has to remember that each set of digits occupy 10/24-th of the circumference of the wheel and one of these digits still has to be visible in the results window. If operators attempt to add 6 + 6 ignoring visual indicators of a carry and turning the wheel in the same direction, they would find themselves in a grotesque situation when the dial did not show the result. One could still move back a dial to enforce a carry and show the correct result, but if they did not notice, they would get errors.

Despite its imperfection, Slonimski's adding device had a significant impact on the development of calculating devices, which was generally unknown and mainly acknowledged only in the Russian literature and most recently in an article by Timo Leipälä.[36]

A year after Slonimski received a patent in St. Petersburg for his adding device, Heinrich Kummer, who was a music teacher in St. Petersburg, designed a slide adder or what we now call a Kummer or Troncet type adder. Although apparently different, the adding Slonimski (1845) and Kummer (1847) devices illustrated in Figure 6 show many similarities.[36] As much as it differs in design, Kummer's device took an idea for handling a carry between decimal positions from Slonimski's adder.

Kummer sent his device to the Department of Physics and Mathematics of the St. Petersburg Academy. In their evaluation report it was noted that ''although the basic mathematical idea of the machine was taken from the Slonimski method, its resulting design was incomparably simpler and more convenient in operation.''[13] Furthermore, the author of the report, Mr. Ostrogradskii, states that Kummer ''did so well in adopting the idea'' that his unit is actually easier to use and has many advantages.[36]

In this regard, Kummer's device is better. An ingenious construction allows the operator to move the slider by one notch higher without lifting the stylus. Similar to Slonimski's device, a visual indicator (color) tells the operator when to do it. The device is designed so that the slides still show the result, even if the result is incorrect, when a carry was not added. This defect was partially corrected in the Slonimski and Barnett adding device of 1846, by adding the signs ''+++++'' and ''−−−−−'', which filled an empty area on circumference of the wheels/dials.

These slide adders became the most popular adding devices in the Western hemisphere. They were manufactured until the mid-1970s. Some of them even adopted hexadecimal and octal arithmetic to help with programming early computers. Finally, it should also be noticed that although the carry mechanism invented by Slonimski had a large following in slide adders, only a few rotary devices emerged with operator enforced carry, among them the arithmograph of Clabor (1906) and Bair-Fulton (1930).[34]

Confusion about Authorship

There is some confusion regarding who actually was the inventor of these calculating machines: Slonimski or his father in-law, who was himself a creator of calculating machines. Even Selig's grandson, Nicolas Slonimski, 140 years later,[37] thought that his grandfather was improving the machine of his great-grandfather Abraham Stern.

The first attribution of Slonimski's machine to Stern can be found as early as November 1840.[38] Allgemeine Zeitung des Judenthums commented in an article in *Gazeta Poranna* from 21 October 1840 (issue 280) that it must be a mistake that Slonimski made a calculating machine and is working on machine for logarithms. They argued that Slonimski was a known astronomer and mathematician, not a mechanic, and most likely, it was Abraham Stern who made a calculating machine and was working ''on the machine for logarithms.'' It looks like the argument was made without consulting either Stern or Slonimski. There was never any animosity or controversy between them. When Slonimski got into financial problems, Stern offered him help. At the beginning of 1842, shortly before Stern's death, Slonimski married his daughter Sarah.

Five years later, the same newspaper attributed Slonimski's adding and multiplying devices unequivocally to Slonimski (text signed by Dr. Lilienthal).[39] This information was cleared up earlier,[7] but rumors persisted and one can see them even in the current literature. Slonimski's multiplying devices were designed after Stern's death. From what we know about the working principles of these devices, all such allegations are erroneous.

Conclusion

Selig Slonimski was a unique inventor, who although relatively unknown, in our opinion left a mark on the history of calculating devices and on telecommunications by inventing a one-of-a-kind design of simultaneous transmissions via the telegraph.[30] Between 1839 and 1847, Slonimski also invented various mathematical devices. He invented two different adding devices with the ingenious carry mechanism later used on all Kummer/Troncet type adders. Slonimski invented three different multiplying devices, two of which were based on his mathematical theory. These devices provided multiplication results using a system of indexing without use of a carry mechanism and did not require mentally adding a carry. Slonimski also designed a machine to calculate 14-digit logarithms but never obtained the funds to build it.

Acknowledgments

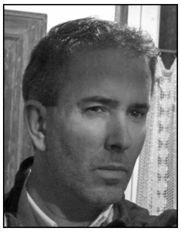
Several people contributed to expanding our knowledge and producing this account of Slonimski's work. In particular, Ewa Wyka of Jagellonian University, Krzysztof Zielnica of Wrocław, and Albertas Čaplinskas of Vilnius University are gratefully acknowledged for assisting us in obtaining copies of important historical materials. Ewa and her colleague Maciej Kluza provided us with an insightful article about Jakub Pik and pictures of the Slonimski's adder from Jagiellonian University Museum. Herbert Schneemann, creator of www.Rechenmaschinen-Illustrated.com, helped us with translating old German texts, for which we are grateful. Leo Weinstock and Nathan Gottlieb are gratefully acknowledged for their translations from Yiddish. We also thank the Jagiellonian University Museum for permission to use pictures of Slonimski's adder. Lastly, we thank the anonymous reviewers for making important suggestions to improve the quality of this article.

References and Notes

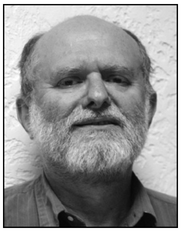
1. This is the most commonly used spelling of Slonimski's name. Other spellings include Hayyim Selig Slonimsky and Chaim Zelig Slonimski, as well as some variations of those.
2. I. Robinson, ''Hayyim Selig Slonimski and the Diffusion of Science among Russian Jewery,'' *The Interaction of Scientific and Jewish Cultures in Modern Times,* Y. Rabkin and I. Robinson, eds., Edwin Mellen Press, 1994, pp. 49–65.

3. I. Sneh, ''Hayim Zelig Slonimski and the Founding of Ha-Tsefirah: The Early Career of an East European Jewish Enlightener and Popularizer of Science, 1810–1862,'' master's thesis, McGill University, 1991.
4. I. Goldberg, ''Chaim Selig Slonimski: 19th-Century Popularizer of Science,'' *Samuel K. Mirsky Memorial Volume,* G. Appel, ed., Sura Inst. for Research, 1970, pp. 247–261.
5. Abraham Stern (1769–1842) was himself a well-regarded inventor. More information, including the English translation of his ''Treatise on an Arithmetic Machine'' of 1818 can be found here: http://chc60.fgcu.edu/EN/HistoryDetail.aspx?c=9.
6. C. Selig Slonimski, *Mosde Hokhmah* [Fundamentals of Science], Manes & Zymel, 1834.
7. *Israelitische Annalen: ein Centralblatt für Geschichte, Literatur und Cultur der Israeliten aller Zeiten und Länder,* no. 5, 29 Jan. 1841, pp. 38–39. This provides the first account of calculating devices (adding and logarithmic) by Slonimski, referring a letter to a friend. It dates the letter to Sept. 1839.
8. *Kuryer Litewski,* no. 60, 21 June 1840, p. 471 (in Polish).
9. *Tygodnik Petersburski,* vol. XXII, 1 Oct. 1840, p. 421 (in Polish).
10. M. Lilienthal, ''Chajim Selig Slonimski, the Mathematician,'' *The Occident and American Jews Advocate,* vol. V, nos. 1–3, April, May, and June 1847; URL: www.theoccident.com/Occident/volume5/apr1847/selig.html.
11. Carl Gustav Jakob Jacobi, Moritz Hermann von Jacobi, Wilhelm Ahrens, *Briefwechsel zwischen C.G.J. Jacobi und M. H. Jacobi* [Correspondence Between C.G.J. Jacobi and M. H. Jacobi], V.G. Teuben, 1907, p. 84.
12. *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich-Preußischen Akademie der Wissenschaften zu Berlin,* June/Aug. 1844, Gesammtsitzung der Akademie – 8 Aug. 1844 [General Meeting of the Academy], pp. 298–299; http://bibliothek.bbaw.de/bbaw/bibliothek-digital/digitalequellen/schriften/anzeige/index_html?band=08-verh/1844.
13. I.A. Apokin, ''Mechanical Computing Devices for Digital Arithmetic Operations,'' *Computing in Russia,* G. Trogemann, W. Ernst, and A.Y. Nitussov, eds., Vieweg, 2002, pp. 29–31. A section about Slonimski explaining the concept behind his multiplying device is available at http://chc60.fgcu.edu/images/articles/ComputingInRussia.pdf.
14. M. Frajder, *Beschreibung einer von Herrn S. Slonimski Neu Erfundenen Rechenmaschine zur Greichterung der Multiplikation, Division und aus ziehung der quadratwurzel* [Description of a Newly Invented Calculating Machine by Mr. S. Slonimsky for Multiplication, Division, and Square Root Extraction], Königsberg, 1844. This booklet describes the first Slonimski multiplying device. This device is not based on his theorem. The introduction to the description is dated 16 June 1843 (Warsaw).
15. K. Zielnica, ''Chaim Selig Slonimski und Alexander von Humboldt,'' *Acta Historica Leopoldina,* vol. 27, 1997, pp. 123-141 (in German).
16. C.S. Slonimski, *Zur Freiheit bestimmt: Alexander von Humboldt - eine hebraische Lebensbeschreibung* [Destined for Freedom: Alexander von Humboldt - A Hebraic Biography], Bouvier Verlag, 1997.
17. C.S. Slonimski, ''Allgemeine Bemerkungen uber Rechenmaschinen, und Prospectus eines neu erfundenen Rechen-Instruments'' [General Comments about Calculating Machines and Prospectus of a Newly Invented Calculating Instrument], *Journal für die reine und angewandte Mathematik,* vol. 26, 1844, pp. 184–190. This is Slonimski's article on calculating machines, available at http://chc60.fgcu.edu/images/articles/slonimskitheorem.pdf.
18. A.L. Crellé, ''Démonstration d'un théorème de Mr. Slonimski sur les nombres, avec une application de ce théorème au calcul de chiffres''. *Journal für die reine und angewandte Mathematik*, vol. 28, 1846, pp. 215–229. This provides a formal proof of Slonimski's theorem, available at http://chc60.fgcu.edu/images/articles/slonimskicrelle.pdf.
19. ''Selig Slonimski und sein Recheninstrument'' [Selig Slonimski and His Calculating Instrument], *Illustrierte Zeitung,* vol. 5, no. 110, 1845, pp. 90–92; http://chc60.fgcu.edu/images/articles/SlonimskiIllustrirte.pdf.
20. L. Brylevskaya, ''Prizes of the St. Petersburg Academy of Sciences: Joining Efforts of Russian and European Inventors in Creating of Mechanical Digital Calculating Machines,'' *Proc. XXV Scientific Instrument Symp.: East and West, the Common European Heritage,* Scientific Instruments Commission, 2006, pp. 277–279.
21. M.I. Radovskii, ''Изобретатель арифметической машины З.Я. Слонимский'' [Inventor of an Arithmetic Machine, Z.Ya. Slonimskii], *Vestnik Akademii Nauk SSSR,* vol. 10, 1952, pp. 115–120.
22. I.A. Apokin and L.E. Maystrov, *Развитие вычислительных машин* [Development of Computing Machines], Nauka, 1974, pp. 93–98.
23. I.A. Apokin and L.E. Maystrov, *История вычислительной техники* [History of Computing Technology], Nauka, 1990. Section 2.6 covers Slonimski's machines.

24. Selig Slonimski, *Описание новаго числительнаго инструмента* [Description of a New Calculating Instrument], Imperial Academy of Sciences, 1845.
25. Russian patent by Selig Slonimski, printed in *Журнал мануфактур и торговли* (J. of Manufacturing and Commerce), 1845, nos. 10–12, pp. 66–71; www.rechnerlexikon.de/en/artikel/Patent:RU1845-11.
26. H. Knight, *Multiplication Tablets Derived from a Theorem of S. Slonimski,* Birmigham, 1847. Stephen Weiss analyzed and published this booklet on his website: www.mechrech.info/publikat/KnightTablets1847.pdf.
27. G. E. Eyre and W. Spottiswoode, ''Machines for Facilitating Certain Arithmetical Processes,'' UK patent 11,441 (1846), London, 1857. Barnett patented on Slonimski's behalf the adding device and the third model of his multiplying device.
28. B.Z. Khan, ''An Economic History of Patent Institutions,'' Bowdoin College, Feb. 2010; http://eh.net/encyclopedia/article/khan.patents.
29. J. Shatzky, ''Chaim Zelig Slonimski: Unknown Attempt to Takeout a Patent on a Calculating Machine in Washington.'' *YIVO Bletter – J. Yiddish Scientific Inst.,* vol. 38, 1954, pp. 342–343 (in Yiddish). An English translation of the description of the patent application is available at http://chc60.fgcu.edu/Images/articles/ZeligPatents.pdf.
30. Z. Slonimski, *Описание способа передачи двухъ различных депешъ въ тоже самое время приема двухъ другихъ депешъ по одному и томуже проводнику* [Description of the Method of Trasmitting Two Different Telegrams while Receiving Two Other Telegrams over the Same Wire], M.O. Wolf, 1859.
31. M. Detlefsen, ''Polnische Rechenmaschinenerfinder des 19. Jahrhunderts'' [Polish Inventors of Calculating Machines in the 19th Century], *Wissenschaft und Fortschritt,* vol. 26, 1976, pp. 86–90; www.rechenmaschinen-illustrated.com/Detlefsen.pdf.
32. V. Monnier, ''Les Arithmomètres de Thomas de Colmar & Payen,'' 2013; www.arithmometre.org.
33. M. Kluza, ''Instytut Optyczny Jakóba Pika'' [Optical Institute of Jakob Pik], Collegium Maius, Jagiellonian University, 2002 (in Polish). This is the first known article with a partial picture of Slonimski's adding device. The device is attributed to Jakob Pik, who manufactured it.
34. J. Marguin, *Histoire des instruments et machines à calculer: trois siècles de mécanique pensante, 1642–1942* [History of Instruments and Calculating Machines: Three Centuries of Mechanical Thinking, 1642–1942], Hermann, 1994.
35. W. Aspray, ed., *Computing Before Computers,* Iowa State Univ. Press, 1990.
36. T. Leipälä, *Kummer and His 1847 Slide Adder,* Dec. 2009; www.rechnerlexikon.de/en/upload/d/df/Kummer-Heinrich-Bericht-TL.pdf.
37. N. Slonimsky, ''My Grandfather Invented the Telegraph,'' *Commentary,* Jan. 1977, pp. 56–60.
38. *Allgemeine Zeitung des Judenthums,* vol. 4, no. 48, 28 Nov. 1840, pp. 680–681.
39. *Allgemeine Zeitung des Judenthums,* vol. 9, 1845, pp. 498–499, 509–510, 525–526, 569–572, 586–588, 600–602.



Valéry Monnier is a librarian working at the Sannois Public Library, near Paris, France. For many years, he studied the history of Thomas de Colmar arithmometers, which were the first calculating machines to be commercialized in the 19th century. His internationally known website, www.arithmometre.org, is devoted to these beautiful machines. Contact him at valery.monnier@gmail.com.



Walter Szrek is a systems architect at Szrek2Solutions, a US company specializing in various applications of digital time stamping in gaming, and a collector of calculating devices. Together with Herbert Schneemann, he created www.rechenmaschinen-illustrated.com, a website on calculating machines. Szrek has an MS in computer science from the Warsaw University of Technology. Contact him at walter@szrek.com.

Janusz Zalewski is a professor of computer science and software engineering at the Florida Gulf Coast University. His research interests include computing education and history. Under his direction, a team of FGCU students developed a website on Polish contributions to computing: http://chc60.fgcu.edu. Zalewski has a PhD in computer science and engineering from the Warsaw University of Technology. Contact him at zalewski@fgcu.edu.