

# Successors of Slonimsky's Multiplying Device 1844: Knight, Filipowski, Joffe<sup>1</sup>

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In 2011 I wrote an article about Hayyim Selig Slonimsky<sup>2</sup> (1810–1904), his theorem and his multiplying device, the latter he introduced in 1844 [11]. For every multiplication table that gives products of an arbitrary multi-digit number multiplied by 2, by 3, up to 9 only 280 unique columns exist and two indices within the range 1 to 28 for connection between them are necessary. This system avoids difficulties in performing a tens carry during calculations. The whole set of columns and their connections, arranged and published by the mathematician August Leopold Crelle, is shown in the appendix. Crelle also gave a proof of Slonimsky's theorem in 1848 [5]. For derivation of this system and its usage I refer to my previous article.

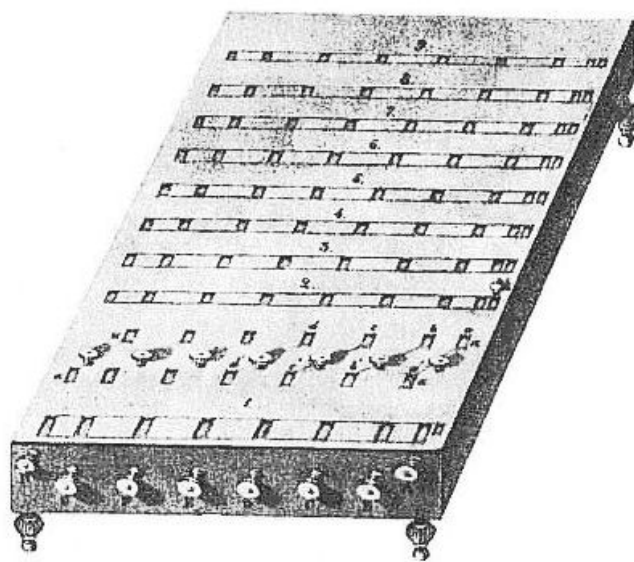


Fig. 1: Slonimsky's Multiplying Device

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1 This is an enlarged version of my article *Successors of Slonimsky's Multiplying Device 1844* from Aug. 2013.

2 Also written Slonimski or Slonimskii.

Slonimsky himself was the first who designed a multiplying device based on these 280 columns. They are written onto turnable cylinders, mounted side by side in a frame (see fig. 1). Later inventors took a different approach.<sup>3</sup>

## Knight 1847

Only one year after publication of Crelle's complete table Henry Knight published his *Multiplication Tablets* [8]. Here he uses the same arrangement as Crelle with a separated page for every digit (fig. 2).

The booklet is extremely rare, perhaps due to the fact that it contains 3 errors.

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<sup>3</sup> In the years 1846 and 1847 David Barnett from Birmingham were granted two patents for his calculating instrument [2, 3]. This instrument looks quite similar to that of Slonimsky and it works with parallel mounted turnable cylinders too, but the used system differs from Slonimsky's theorem.

3											
0 1 2 3 4					5 6 7 8 9						
1	0	3	6	9	2		5	8	1	4	7 9
2	0	3	6	9	2		5	8	1	4	8 9
3	0	3	6	9	2		5	8	1	5	8 9
4	0	3	6	9	2		5	8	2	5	8 9
5	0	3	6	9	2		5	9	2	5	8 9
6	0	3	6	9	2		6	9	2	5	8 9
7	0	3	6	9	2		6	9	2	5	9 9
8	0	3	6	9	3		6	9	2	6	9 9
9	0	3	6	9	3		6	9	3	6	9 9
10	0	3	6	0	3		6	0	3	6	0 10
11	0	3	6	0	3		6	0	3	7	0 10
12	0	3	6	0	3		7	0	3	7	0 10
13	0	3	6	0	3		7	0	4	7	0 10
14	0	3	6	0	3		7	0	4	7	1 10
15	0	3	7	0	4		7	1	4	8	1 10
16	0	3	7	0	4		7	1	4	8	2 10
17	0	3	7	0	4		7	1	5	8	2 10
18	0	3	7	0	4		8	1	5	8	2 10
19	0	3	7	0	4		8	1	5	9	2 10
20	0	3	7	1	4		8	2	5	9	3 10
21	0	3	7	1	4		8	2	6	9	3 10
22	0	3	7	1	5		8	2	6	0	3 11
23	0	3	7	1	5		8	2	6	0	4 11
24	0	3	7	1	5		9	2	6	0	4 11
25	0	3	7	1	5		9	3	6	0	4 11
26	0	3	7	1	5		9	3	7	0	4 11
27	0	3	7	1	5		9	3	7	1	4 11
28	0	3	7	1	5		9	3	7	1	5 11
0 1 2 3 4					5 6 7 8 9						
3											

Fig. 2: Table for digit 3 at Knight 1847

Filipowski 1860

The next inventor in our sequence is Herschell Filipowski<sup>4</sup> (1816-1872). He worked as Hebraist as well as an actuary and seems to have been a successful

4 His name varies. It is written *Hirsch Filipowski* (*Phillip*) in the Jewish Encyclopedia (<http://www.jewishencyclopedia.com>), *Herschell E. Filipowski*, mostly used in his mathematical publications, or simply *H. Filipowski* (see *Mathematics of Computation*, V. 3, N. 21 (1948) p. 67). An article in *The Assurance Magazine, and Journal of the Institute of Actuaries*, Vol. 4, No. 3 (1854), p. 245, he signs with *Herschel Filipowski*.

writer, translator and publisher in both professions. With regard to mathematics he translated Napier's *Wonderful Canon* from Latin to English [9], published a logarithmic table [6], a Table of Exchange [7] and various articles about actuarial mathematics. The Jewish Encyclopedia provides additional information about his life and work. The printed label inside the lid of a box containing his calculating rods notes

*'N.B. — H. Filipowski gives lessons in Mathematics and Astronomy; also in the German and Oriental Languages, at very moderate terms. London, 25, Wilson street, Finsbury-square'.*

About 1860 he designed and published a multiplying device, shown in fig. 3.



Fig. 3: Set of Filipowski's Calculating Rods

The box includes a set of 56 cylindrical rods, made of wood and stored in holes in a wooden case with overall dimensions 128 mm x 130 mm x 75 mm. Up to 8 rods can be arranged side by side in a slim wooden tray in order to build the desired multiplication table. Each rod shows ten columns with digits and letters printed on paper and bears a knob on its top. The knob is marked with a single letter.

Within the lid of the box a complete instruction of use is added.

The underlying principle of this device can easily be determined when we follow the calculating example Filipowski gives on the printed label inside the box. He completes his description with a table showing the aimed result, which is reproduced below.

Required are the first nine multiples of number 37582. For units the rod with its so called initial letter A on top of its knob has to be used in every calculation. The rod is set into the tray on the right side and turned until figure 2, the unit in 37582, shows up. Now on top the column below A initial B can be read. According to this letter a rod with a B on its knob is set next on the left side and turned until the tens figure 8 is visible. The new column initial H marks the next rod to be used and so on. Filipowski's explanatory table added to his example looks like this:

The rod initials	Q	X	U	H	B	A
The column initials	A	Q	X	U	H	B
<b>The figures proposed</b>	<b>0</b>	<b>3</b>	<b>7</b>	<b>5</b>	<b>8</b>	<b>2</b>
Second multiple	0	7	5	1	6	4
Third multiple	1	1	2	7	4	6
Fourth multiple	1	5	0	3	2	8
Fifth multiple	1	8	7	9	1	0
Sixth multiple	2	2	5	4	9	2
Seventh multiple	2	6	3	0	7	4
Eighth multiple	3	0	0	6	5	6
Ninth multiple	3	3	8	2	3	8

From this example it is evident, that Filipowski uses Slonimsky's theorem, although Slonimsky isn't mentioned at all in the explanatory text. The only modification concerns the replacement of indices by letters. In comparison with Crelle's arrangement each rod bears those ten rows of multiples, arranged as columns, that are given in a single horizontal line at Crelle. The bold index number at Crelle on the left and right side of a line is replaced here by a letter on top of each knob. Finally a column initial points to the next rod to be used.

Fifty-six rods bear  $560 = 2 \times 280$  columns, which therefore hold two complete sets of columns. From the given example the assignments  $A \equiv 1$ ,  $B \equiv 6$ ,  $H \equiv 24$ ,  $Q \equiv 11$ ,  $U \equiv 17$ ,  $X \equiv 22$  can be derived. Further assignments remain unsolved at the moment, especially it is unknown which signs he uses to separate 28 different rods with only 26 letters. The provided images don't allow a closer look. We must assume that the letters A – Z, a, b are used since furthermore he mentions two rods 'c' and 'd' which should serve as substitutes whenever a repetition of one and the same initial may occur.

**Rod c**

A	J	B	C	R	E	G	Y	b	I
0	1	2	3	4	5	6	7	8	9

**Rod d**

A	A	N	P	S	T	V	X	I	I
0	1	2	3	4	5	6	7	8	9

Dimitry Zlatopolski reconstructed the 28 rods A – Z, a, b (Fig. 4)

A									
A	A	B	C	R	E	F	G	H	I
0	1	2	3	4	5	6	7	8	9
0	2	4	6	8	0	2	4	6	8
0	3	6	9	2	5	8	1	4	7
0	4	8	2	6	0	4	8	2	6
0	5	0	5	0	5	0	5	0	5
0	6	2	8	4	0	6	2	8	4
0	7	4	1	8	5	2	9	6	3
0	8	6	4	2	0	8	6	4	2
0	9	8	7	6	5	4	3	2	1

B									
A	J	B	C	R	E	F	W	H	I
0	1	2	3	4	5	6	7	8	9
0	2	4	6	8	0	2	4	6	8
0	3	6	9	2	5	8	1	4	7
0	4	8	2	6	0	4	8	2	6
1	6	1	6	1	6	1	6	1	6
1	7	3	9	5	1	7	3	9	5
1	8	5	2	9	6	3	0	7	4
1	9	7	5	3	1	9	7	5	3
1	0	9	8	7	6	5	4	3	2

Fig. 4: Two Reconstructions of Filipowski

Up to now two original sets of Filipowski's rods are known to me: one at the Science Museum, London, from where fig. 3 is a copy. The other set has been sold for £ 4400 at the auction Dominic Winter, Gloucestershire, UK, held at April 10<sup>th</sup>, 2013.

## Joffe 1881

Only little is known about Joffe. In the Jewish Encyclopedia he is named Zebi Hirsch Jaffe<sup>5</sup>. He has been a Russian mathematician and writer. Among others the Encyclopedia tells us

'He received the usual Talmudic education and early showed extraordinary mathematical talent. His father would not allow him to enter a public school, and, not having the opportunity to study mathematics from books, Jaffe began to solve algebraic problems according to rules of his own discovery. In 1873 his father presented him with Hayyim Selig Slonimsky's works as well as with other mathematical works in Hebrew. In 1877 Jaffe published in "Ha-Zefirah" (No. 24) his first mathematical article, and since that time he has contributed many mathematical and Talmudic articles to that periodical and to "Ha-Asif." In 1881 Jaffe went to Moscow, where he exhibited his calculating-machine, which won him honorary mention by the administration of the exhibition.'

It should be pointed out that he obviously has been familiar with Slonimsky's work. His success at the All-Russian exhibition in 1882 is also mentioned by Apokin [1].

Later indications of the rods are not known to me.

Joffe places Slonimsky's resp. Crelle's columns onto 280 sides of 70 square rods. Bohl [4] presents four sides on four rods (fig. 5a). The figures to build a multi-digit number are set on top, in fig. 5a this number is 0325. Combinations of uppercase letters with Roman numerals are placed below and at the bottom of a side. In comparison with Crelle's arrangement these specific signs represent the indexes

$1 \equiv \text{IA}$ ,  $2 \equiv \text{IIA}$ , ...,  $7 \equiv \text{VIIA}$ ,  $8 \equiv \text{IB}$ ,  $9 \equiv \text{IIB}$ , ...,  $14 \equiv \text{VIIB}$ , ..., up to  $28 \equiv \text{VIID}$ .

We can assume that he used combined signs, because they are easier visually perceived than pure numbers and therefore prevent errors.

For the first rod of units on the right side always rod IA must be used. The sign at the lower end indicates the set of rods to be used left of it for the tens and so on.

In the image at Bohl the rods are positioned in an U-shaped frame with inscriptions x2, x3,... down to x9. The frame eases positioning of rods and reading of multiples but it isn't strictly necessary.

Like other devices based on Slonimsky the rods replace the labour of tens carry by only selecting rods. On the other hand to get an overview of 70 rods with 280 sides needs some organising. Moreover 70 rods will hardly be enough. Since each column is represented only once and with use of a single rod 3 sides are no longer available we must assume that much more than a single set with 70 rods is necessary to build the multi-digit number.

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<sup>5</sup> Also written Iofe or Jofe. I thank Georgi Dalakov from <http://history-computer.com/> for pointing me to the entry in the Jewish Encyclopedia.

Now having reconstructed the design of Joffe's rods, the whole set can be re-created. For that purpose I scanned Crelle's table with tools for optical character recognition, checked the figures with software written for that purpose by myself. With help of the graphical environment *Processing*<sup>6</sup> and a few hours programming a printout of 70 rods with their 4 sides has been created. Fig. 5b shows two reconstructed rods. In a last step the prints need to be cut and pasted around wooden rods from a do-it-yourself store.

	K			
N =	0	3	2	5
K'	II	I	I	I
	B	B	C	A
Nx2=	0	6	5	0
Nx3=	0	9	7	5
Nx4=	1	3	0	0
Nx5=	1	6	2	5
Nx6=	1	9	5	0
Nx7=	2	2	7	5
Nx8=	2	6	0	0
Nx9=	2	9	2	5
K'	I	II	I	I
	A	B	B	C
	K			

Фиг. 66.

Fig. 5a: A Joffe's rod in Bohl 1896

6 URL <http://processing.org/>



5	5	5	5
VII	I	II	III
C	D	D	D
1	1	1	1
7	7	7	7
2	3	3	3
8	8	8	9
4	4	4	4
0	0	0	0
5	6	6	6
1	1	2	2
III	III	III	III
C	C	C	C

5	5	5	5
III	V	VI	VII
D	D	D	D
1	1	1	1
7	7	7	7
3	3	3	3
9	9	9	9
5	5	5	5
0	1	1	1
6	6	7	7
2	2	2	3
III	III	III	III
C	C	C	C

Fig. 5b: Two Joffe's rods from reconstructed set

In 1891, ten years after Joffe having presented his invention, Genaille and Lucas solved the problem of automatic tens carry much better with less different rods [10].

A final addition should be made to avoid confusion, found now and then in descriptions. The mentioned rods, designed by Filipowski and Joffe, are by no means derived from Napier's rods although they look quite similar. Whereas with Napier's rods the user has to perform a tens carry by himself, here the tens carry is already implemented within the columns.

Source: Crelle, *Journal* 1846 [5]

Crelle's Journal f. d. M. Bd. XXX. Heft 3.

5										6										7										8										9									
0 1 2 3 4 5 6 7 8 9 No.										0 1 2 3 4 5 6 7 8 9 No.										0 1 2 3 4 5 6 7 8 9 No.										0 1 2 3 4 5 6 7 8 9 No.										0 1 2 3 4 5 6 7 8 9 No.									
0 5 0 5 0 5 0 5 0 5 15										0 6 2 8 4 0 6 2 8 4 18										0 7 4 1 8 5 2 9 6 3 20										0 8 6 4 2 0 8 6 4 2 24										0 9 8 7 6 5 4 3 2 1 28									
0 5 0 5 0 5 0 5 0 6 15										0 6 2 8 4 0 6 2 8 5 18										0 7 4 1 8 5 2 9 6 4 20										0 8 6 4 2 0 8 6 4 3 24										0 9 8 7 6 5 4 3 2 2 28									
0 5 0 5 0 5 0 5 1 6 15										0 6 2 8 4 0 6 2 9 5 18										0 7 4 1 8 5 2 9 7 4 20										0 8 6 4 2 0 8 6 5 3 24										0 9 8 7 6 5 4 3 3 2 28									
0 5 0 5 0 5 0 6 1 6 15										0 6 2 8 4 0 6 3 9 5 18										0 7 4 1 8 5 2 0 7 4 21										0 8 6 4 2 0 8 7 5 3 24										0 9 8 7 6 5 4 4 3 2 28									
0 5 0 5 0 5 1 6 1 6 15										0 6 2 8 4 0 7 3 9 5 18										0 7 4 1 8 5 3 0 7 4 21										0 8 6 4 2 0 9 7 5 3 24										0 9 8 7 6 5 5 4 3 2 28									
0 5 0 5 0 6 1 6 1 6 15										0 6 2 8 4 1 7 3 9 5 18										0 7 4 1 8 6 3 0 7 4 21										0 8 6 4 2 1 9 7 5 3 24										0 9 8 7 6 6 5 4 3 2 28									
0 5 0 5 0 6 1 6 1 7 15										0 6 2 8 4 1 7 3 9 6 18										0 7 4 1 8 6 3 0 7 5 21										0 8 6 4 2 1 9 7 5 4 24										0 9 8 7 6 6 5 4 3 3 28									
0 5 0 5 1 6 1 6 2 7 15										0 6 2 8 5 1 7 3 0 6 19										0 7 4 1 9 6 3 0 8 5 21										0 8 6 4 3 1 9 7 6 4 24										0 9 8 7 7 6 5 4 4 3 28									
0 5 0 5 1 6 1 7 2 7 15										0 6 2 8 5 1 7 4 0 6 19										0 7 4 1 9 6 3 1 8 5 21										0 8 6 4 3 1 9 8 6 4 24										0 9 8 7 7 6 5 5 4 3 28									
0 5 0 6 1 6 2 7 2 8 15										0 6 2 9 5 1 8 4 0 7 19										0 7 4 2 9 6 4 1 8 6 21										0 8 6 5 3 1 0 8 6 5 25										0 9 8 8 7 6 6 5 4 4 28									
0 5 0 6 1 6 2 7 3 8 15										0 6 2 9 5 1 8 4 1 7 19										0 7 4 2 9 6 4 1 9 6 21										0 8 6 5 3 1 0 8 7 5 25										0 9 8 8 7 6 6 5 5 4 28									
0 5 0 6 1 7 2 7 3 8 15										0 6 2 9 5 2 8 4 1 7 19										0 7 4 2 9 7 4 1 9 6 21										0 8 6 5 3 2 0 8 7 5 25										0 9 8 8 7 7 6 5 5 4 28									
0 5 0 6 1 7 2 8 3 8 15										0 6 2 9 5 2 8 5 1 7 19										0 7 4 2 9 7 4 2 9 6 21										0 8 6 5 3 2 0 9 7 5 25										0 9 8 8 7 7 6 6 5 4 28									
0 5 0 6 1 7 2 8 3 9 15										0 6 2 9 5 2 8 5 1 8 19										0 7 4 2 9 7 4 2 9 7 21										0 8 6 5 3 2 0 9 7 6 25										0 9 8 8 7 7 6 6 5 5 28									
0 5 1 6 2 7 3 8 4 9 15										0 6 3 9 6 2 9 5 2 8 19										0 7 5 2 0 7 5 2 0 7 22										0 8 7 5 4 2 1 9 8 6 25										0 9 9 8 8 7 7 6 6 5 28									
0 5 1 6 2 7 3 8 4 0 16										0 6 3 9 6 2 9 5 2 9 19										0 7 5 2 0 7 5 2 0 8 22										0 8 7 5 4 2 1 9 8 7 25										0 9 9 8 8 7 7 6 6 6 28									
0 5 1 6 2 7 3 9 4 0 16										0 6 3 9 6 2 9 6 2 9 19										0 7 5 2 0 7 5 3 0 8 22										0 8 7 5 4 2 1 0 8 7 26										0 9 9 8 8 7 7 7 6 6 28									
0 5 1 6 2 8 3 9 4 0 16										0 6 3 9 6 3 9 6 2 9 19										0 7 5 2 0 8 5 3 0 8 22										0 8 7 5 4 3 1 0 8 7 26										0 9 9 8 8 8 7 7 6 6 28									
0 5 1 6 2 8 3 9 5 0 16										0 6 3 9 6 3 9 6 3 9 19										0 7 5 2 0 8 5 3 1 8 22										0 8 7 5 4 3 1 0 9 7 26										0 9 9 8 8 8 7 7 7 6 28									
0 5 1 7 2 8 4 9 5 1 16										0 6 3 0 6 3 0 6 3 0 20										0 7 5 3 0 8 6 3 1 9 22										0 8 7 6 4 3 2 0 9 8 26										0 9 9 9 8 8 8 7 7 7 28									
0 5 1 7 2 8 4 0 5 1 17										0 6 3 0 6 3 0 7 3 0 20										0 7 5 3 0 8 6 4 1 9 22										0 8 7 6 4 3 2 1 9 8 26										0 9 9 9 8 8 8 8 7 7 28									
0 5 1 7 3 8 4 0 6 1 17										0 6 3 0 7 3 0 7 4 0 20										0 7 5 3 1 8 6 4 2 9 22										0 8 7 6 5 3 2 1 0 8 27										0 9 9 9 9 8 8 8 8 7 28									
0 5 1 7 3 8 4 0 6 2 17										0 6 3 0 7 3 0 7 4 1 20										0 7 5 3 1 8 6 4 2 0 23										0 8 7 6 5 3 2 1 0 9 27										0 9 9 9 9 8 8 8 8 8 28									
0 5 1 7 3 8 4 0 6 2 17										0 6 3 0 7 4 0 7 4 1 20										0 7 5 3 1 9 6 4 2 0 23										0 8 7 6 5 4 2 1 0 9 27										0 9 9 9 9 8 8 8 8 8 28									
0 5 1 7 3 9 5 0 6 2 17										0 6 3 0 7 4 1 7 4 1 20										0 7 5 3 1 9 7 4 2 0 23										0 8 7 6 5 4 3 1 0 9 27										0 9 9 9 9 9 8 8 8 8 28									
0 5 1 7 3 9 5 1 6 2 17										0 6 3 0 7 4 1 8 4 1 20										0 7 5 3 1 9 7 5 2 0 23										0 8 7 6 5 4 3 2 0 9 27										0 9 9 9 9 9 9 8 8 8 28									
0 5 1 7 3 9 5 1 7 2 17										0 6 3 0 7 4 1 8 5 1 20										0 7 5 3 1 9 7 5 3 0 23										0 8 7 6 5 4 3 2 1 0 9 27										0 9 9 9 9 9 9 9 8 8 28									
0 5 1 7 3 9 5 1 7 3 17										0 6 3 0 7 4 1 8 5 2 20										0 7 5 3 1 9 7 5 3 1 23										0 8 7 6 5 4 3 2 1 0 28										0 9 9 9 9 9 9 9 9 8 28									

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For unabridged version see <http://www.mechrech.info/publikat/SloniMultE.pdf>.

## Figures

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- 2 H. Knight [8]
- 3 Science Museum Group, Collections Online, Object Number 1931-621.  
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Credited to Science Museum / Science & Society Picture Library, here reproduced with kind permission.
- 4 Reconstruction by Dimitry Zlatopolski, here reproduced with his kind permission
- 5a Bohl [4]
- 5b Reconstruction by the author

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