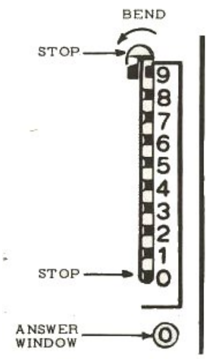
Stephan Weiss

Non-decimal Slide Adders[1] and the Carry

I'm sure everyone knows those small thin adders with parallel arranged and hook-shaped slots. They were mainly used for additions and subtractions. Multiplication can be easily performed only with mechanical aids [5] and divisions are almost impossible, at least with low effort.

The usage of such a device is explained best with the words in an ancient instruction flyer:



"Important rules when adding. Always insert stylus in slots to left of numbers you are adding. If slot is white, it means you should pull stylus down towards answer window, as far as stylus can go (until it touches the stop).
If slot is red, it means you should push stylus up away from answer windows, turning stylus up around bend at top of column as far as stylus can go (until it touches the stop)"[2].

To be more precise: the numbers are added digit by digit, starting with the units. The colors distuingish two cases. If the sum of a number already set and the number to be added is lower than ten they are simply added, if the sum will be equal or more than ten the ten's complement is subtracted and a positive carry is added to the next higher place.
For subtraction one has to use another input field, the directions of movement depend on the colors in a slot, also. Here if a difference will be less than zero the ten's complement is added and a negative carry is subtracted from the next higher place.[3]
Signs in the sight openings point to necessary additional carries, as in 9999 + 1, which

1 Also called sliding bar adders.

2 Figure and text cited from a flyer "Instructions how to use your Addiator", published by Hasting Products Inc, N.Y., undated.

3 Based on the relations $a + b = a - (10 - b) + 10$ if $(a + b) \geq 10$ for addition and $a - b = a + (10 - b) - 10$ if $(a - b) < 0$ for subtraction. The adaption of these relations to non-decimal adders makes the starting point of patent DE408032 for Quantotar (description see below in text).

the user has to perform by himself.

The bend is used for carrying operation in a way that the stylus is guided to a toothed side of the next slider with higher order and moves exactly one unit there. As far as I can see, the bend first appeared with the device of Kummer in Russia, patented 1847 [2, fig. on p. 28]. We find it again in US patent US90275 of 1869 for Henry Kummer in New York. The relation between these two men Kummer is unknown. Mass production started with the Arithmographe Troncet, French patent[4] FR197579 of 1889. The most important manufacturer was Addiator company in Germany, founded by Carl Kuebler. They produced various types of slide adders from 1920 to 1975, when the electronic calculator made so many calculating aids useless. With regard to the carry mechanism it is worthy to note that Addiator's base patent DE367599 of 1919 uses two slots, a short and a long one, instead of a bend which was introduced shortly afterwards. Besides Addiator, the Addimult company, run by the son of Carl Kuebler, produced very similar adders from the end of WW II to 1973 [1].

In addition to their adders for the decimal number system both offered a variety of adders for non-decimal number systems, currencies and measuring units.
Next I add a list of non-decimal slide adders of straight type manufactured by Addiator and Addimult in Germany. The short notation I use here needs an explanation: grouped slots are marked with square brackets ([]). Each group shows its possibly used caption on the adder, followed by all highest addable numbers next to the slots, separated by a hyphen (-). A short description and a selection of patent numbers are additionally given.

- Addiator Octadat
  [7-7-7-7-7-7]

Addiator Octadat

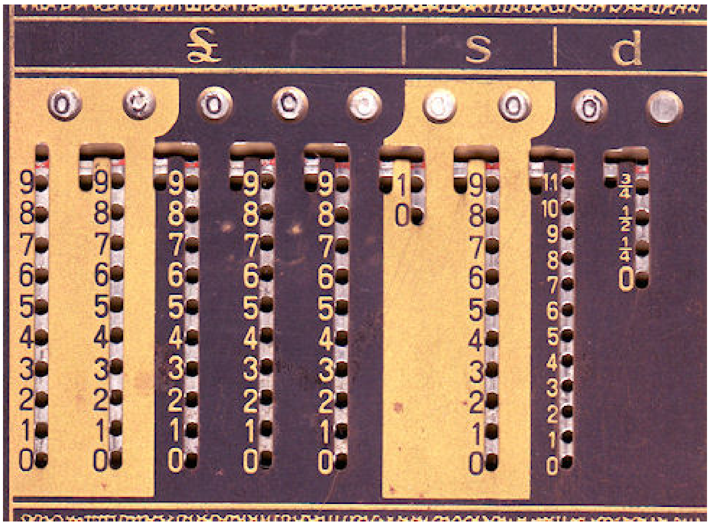
4 It was never published "as the 2nd year fees were not paid" (quotation from [4]).

for computing in the octal number system.

- Addiator Hexadat
  [F-F-F-F-F-F-F-F]
  for computing in the hexadecimal number system. Used by computer programmers for their work. Registered design Germany DE1963993U of 1967.

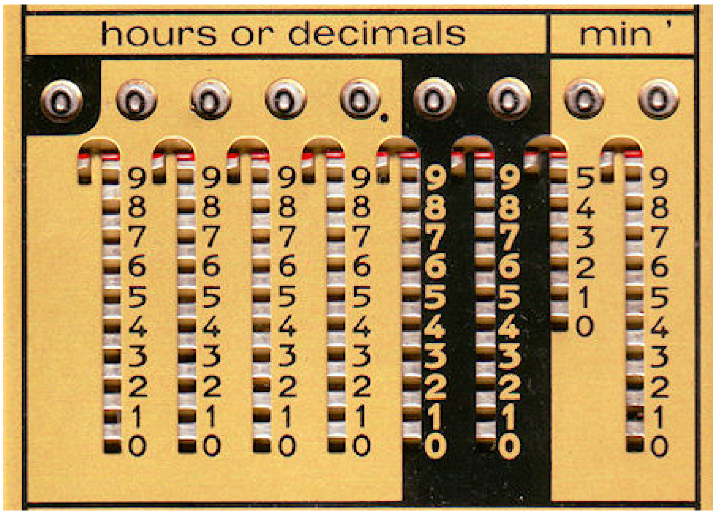
- Addiator Elsarie
  [9-9-9-9-9-9-9-9-7/8]
  with Arabic inscription.

- Addiator Sterling
- Addimult Addmaster
  [£ 9-9-9-9-9] [s 1-9] [d 11-3/4]
- Addimult Addmaster-Junior
  [£ 9-9-9-9] [s 1-9] [d 11-3/4]
- Addimult Addmaster-Baby
  [£ 9-9-9] [s 1-9] [d 11]
  used for currency in Britain before decimalisation in 1971. The pound (£) is divided into 20 shillings (s), each of 12 old pence (d) and up to 1960 1 pence divided into 4 farthings.



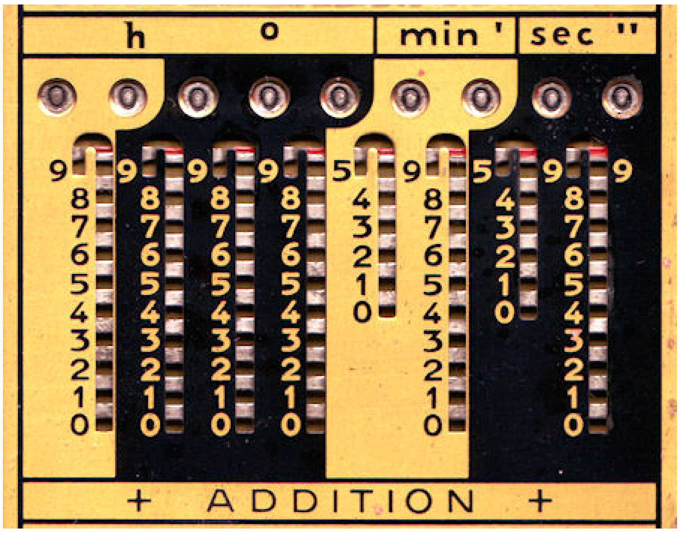
Addiator Sterling

- Addiator Add-a-time
  [hours or decimals 9-9-9-9.-9-9] [min ' 5-9]
  for addditions of hours and minutes (1 h = 60 mins) or tenths of an hour (= 6 mins), used for calculations with times of production. Note the decimal point within the group of hour digits.



Addiator Add-a-time

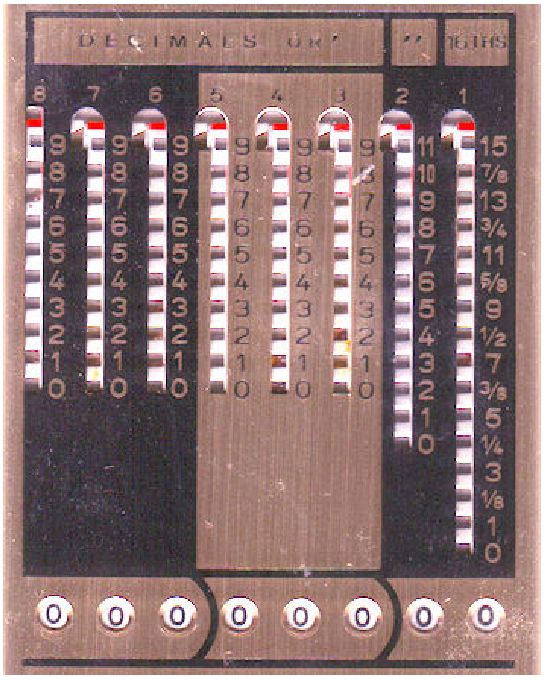
- Addiator Astro
  [h ° 9-9-9-9-9] [min ' 5-9] [sec " 5-9]
  for the units hours resp. angular degrees, and their parts minutes and seconds. This adder was also available with seconds to four places i.e. up to 59.99. Registered design Germany DE1629785U of 1951.



Addiator Astro

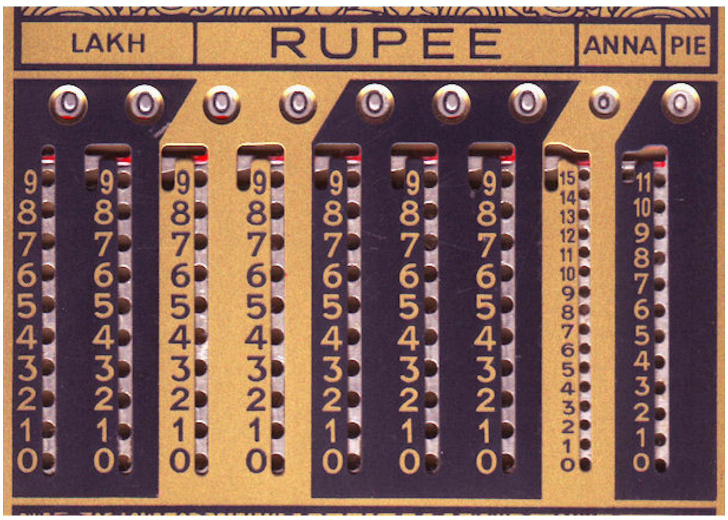
- Addiator Addfeet
  [9-9-9-9] [11-7/8]
  adapted for the addition of lenght units feet und inches (1 foot = 12 inches), the latter broken into eighths.

- Addiator Sizematic
  [Decimals or ' 9-9-9-9-9-9] [" 11] [16ths 15]
  like Addiator Addfeet but with the inch broken into sixteen parts.



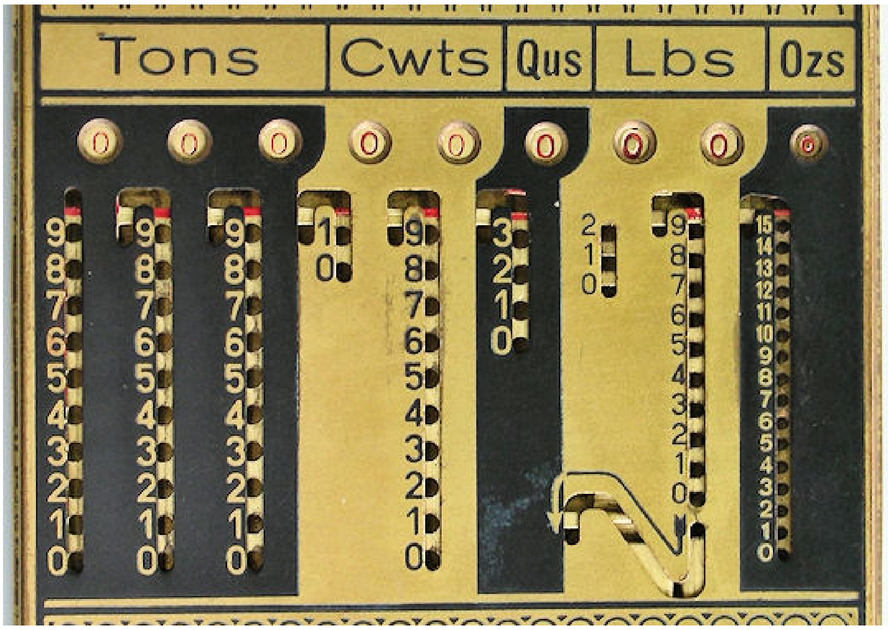
Addiator Sizematic

- Addiator Rupee
- Addimult Summator Rupee
  [LAKH 9-9] [RUPEE 9-9-9-9-9] [ANNA 15] [PIE 11]
  used for Indian currency. Conversions: 1 lakh = 100,000 rupees, and up to decimalisation in 1957, 1 rupee = 16 annas, 1 anna = 12 pai.



Addiator Rupee

- Addiator Quantotar
  [Tons 9-9-9] [Cwts 1-9] [Qus 3] [Lbs 2-9] [Ozs 15]
  used for British weight units. Conversions: 1 ton = 20 cwts (hundredweights), 1 cwt = 4 qus (quarters), 1 qu = 28 lbs (pounds), 1 lb = 16 oz (ounces). German patent DE408032 of 1925. The carry mechanism over two places is explained below. Reportedly they offered a variant without that special carry equipment, but until now I never saw one.



Addiator Quantotar

A question arises: how do non-decimal adders handle the carry? How do they calculate 46 secs + 43 secs = 1 min 29 secs? From a mathematical point of view it would be wrong to speak of tens carry, although with one exception the mechanisms are the same, as we will see.
For values from 4 up to 16 the inventors used different slot lengths and made an appropriate number of holes in the slider available. A carry mechanism like that in decimal system bundles the measuring units to the next higher place.
With bigger values than 16 the slot would become too long. Therefore the maximum value is splitted into two slots, one for units and the other one for tens. This is why for seconds and for minutes we find a slot with units from 0 to 9 and a slot with tens from 0 to 5. Such a separation works well as long as the highest value to be set on the slots, equals the conversion factor minus one, like in 1 min = 60 secs or 1 ton = 20 cwts.
The system fails if the named condition isn't valid like in British weight conversion 1 qu = 28 lbs. Within the range 1 to 27 lbs we need units from 0 to 9 and tens from 0 to 2 in order to set 19 lbs or 23 lbs or the like. On the other hand a carry mechanism like usual from units to tens to the next higher measuring unit would lead to the wrong conversion 1 qu = 30 lbs. Actually we need a carry system that executes 30 lbs = 1 qu plus 2 lbs. This is why they invented a very special carry mechanism, described in

detail in patent DE408032 of 1919, which led to the most complex slide adder called Addiator Quantotar.

When the pounds (lbs) reach a value of 30 or more during addition, a signal is given as demand to perform a special carry. The user has to put the stylus into that "S"-shaped slot on bottom of the input field and to follow that slot. First the movement leads down and adds 2 to the units. Next the stylus moves up diagonally and thus clears the tens. This is done with help of horizontal immersions in that slider. They allow a movement of the stylus up and to the left simultaneously. At last the stylus moves down again and adds 1 to the quarters (qs).
One disadvantage remains unsolved: the mechanism doesn't detect values of 28 or 29 which should be shortened too.

For subtraction another input field is available on the rear side which works the analoguous way.

With respect to Addiator Sterling I should mention two other slide adders for British currency: (1) "The GEM Calculator", patented with GB189015062 of 1890 for J. Guthrie and (2) patent GB189614645 of 1896 for G. J. D. Coleridge. Both adders use the five slots [pounds 90-9] [shillings 19] [pence 11] [farthings 3/4]. Note the single slot for shillings divided into 19 parts.

References

[1] Diestelkamp, Friedrich: Addiator.
URL http://www.addiator.de (last visit Aug. 9, 2009)

[2] Marguin, Jean: *Histoire des instruments et machines à calculer*. Herrmann, Paris 1994.

[3] Otnes, Robert K.: "Sliding Bar Calculators". *ETCetera* 11, June 1990.

[4] Otnes, Robert K.: "Small Adders" (2003).
URL http://www.rechnerlexikon.de/artikel/Small_Adders (last visit Aug. 9, 2009)

[5] Weiss, Stephan: "Multipliziereinrichtungen an Zahlenschiebern" (2009).
URL http://www.mechrech.info (section publications, last visit Aug. 9, 2009).

(Aug. 2009)
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