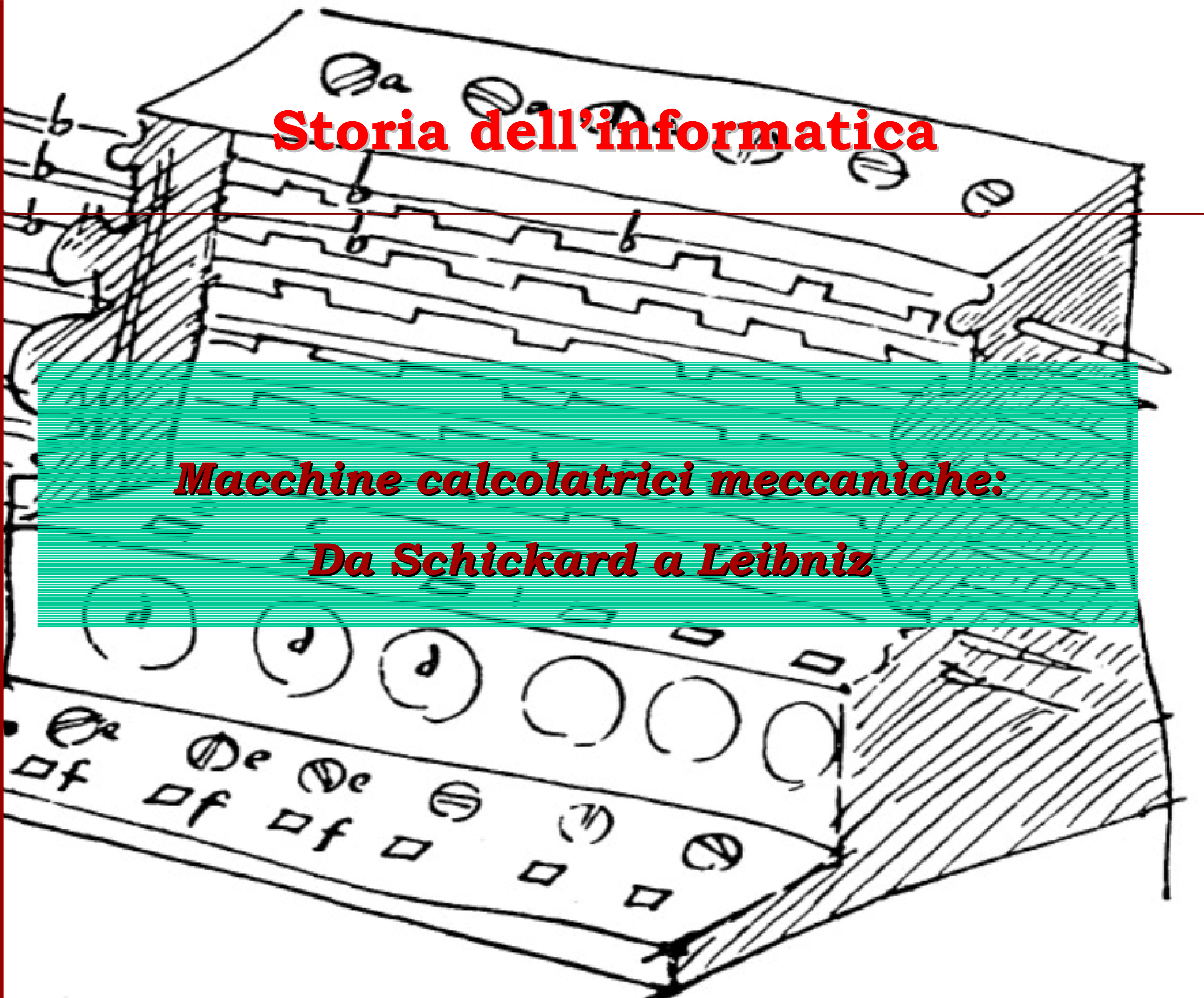
Storia dell'informatica



Macchine calcolatrici meccaniche:

Da Schickard a Leibniz

Summary

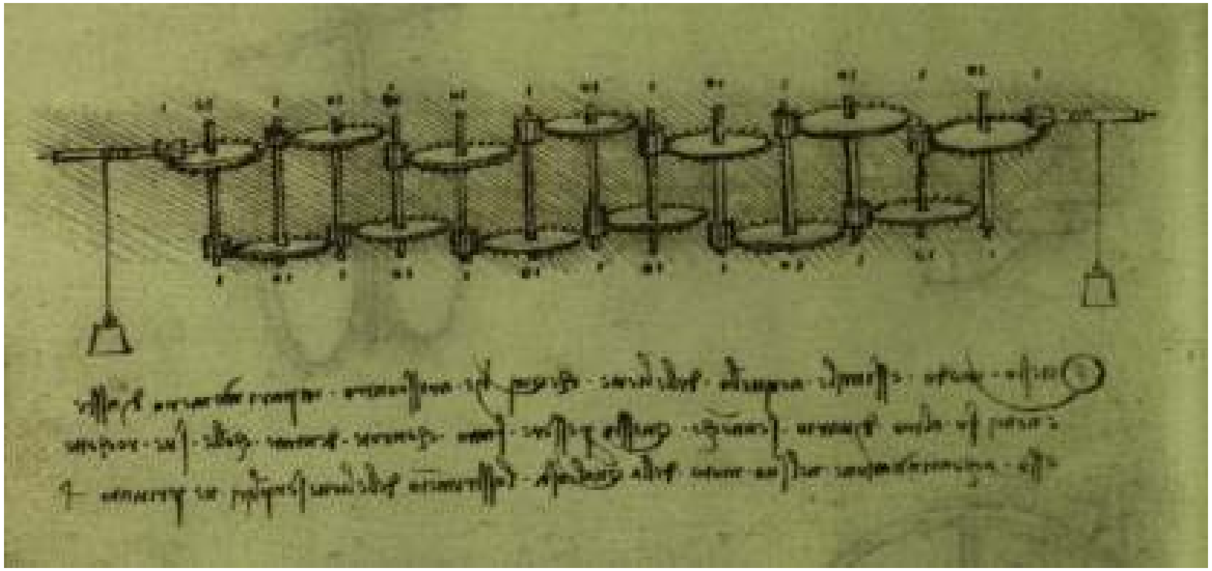
- Prologue: The story of Leonardo's "calculating machine"
- Schickard and his "calculating clock"
- Pascal's "Pascaline"
- Leibniz and his "reckoner"

Prologue

The story of Leonardo's "calculating machine"

The Codex Madrid

On February 13th 1967 an amazing discovery was made by American researchers working in the National Library of Spain, Madrid. They had stumbled upon 2 unknown works of Leonardo da Vinci know as the "Codex Madrid".



There was much excitement regarding this discovery and the public officials stated that the manuscripts "weren't lost, but just misplaced".

Guatelli and his replica

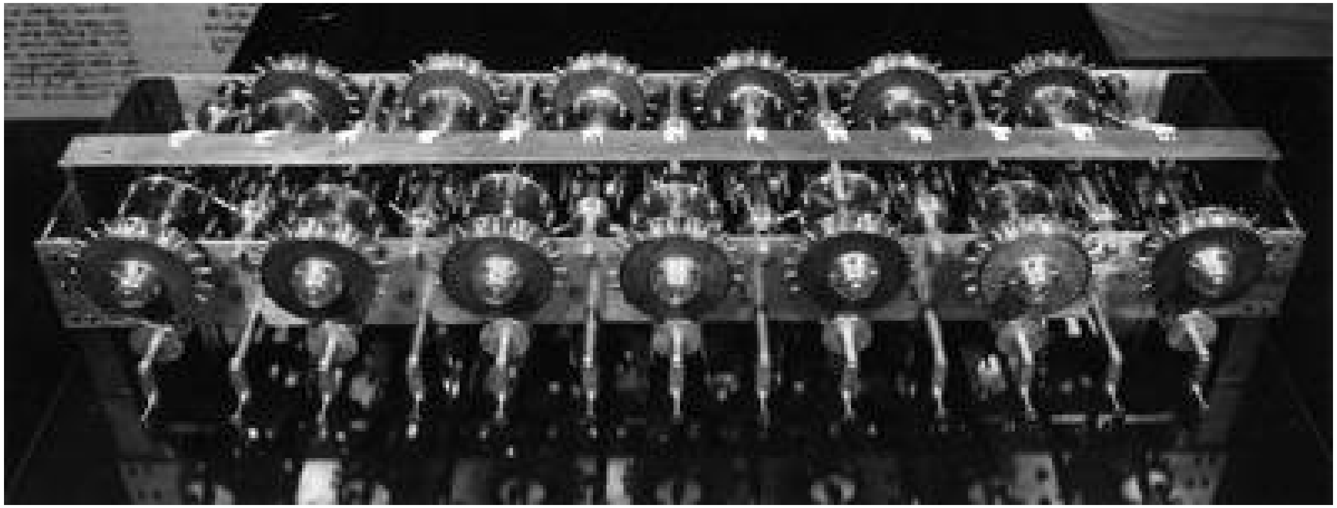
Dr. Roberto Guatelli was a renowned world expert of Leonardo da Vinci. He specialized in building working replicas of da Vinci. He had built countless such replicas with four assistants, including his chief aid, stepson Joe Mirabella.

Early in 1951 IBM hired Dr. Guatelli to continue building such replicas. They had organized a traveling tour of the machines, which was displayed at schools, offices, labs, museums and galleries.
In 1961 Dr. Guatelli left IBM and set up his own work shop in New York.

In 1967, shortly after the discovery of the "Codex Madrid", Dr. Guatelli flew to the Massachusetts university to examine its copy. When seeing the page with the calculator he remembered seeing a similar drawing in the "Codex Atlanticus".

Putting the two drawings together Dr. Guatelli built the replica later in 1968.

The replica at the IBM exhibition



Device for Calculation: An early version of today's complicated calculator, Leonardo's mechanism maintains a constant ratio of ten to one in each of its 13 digit-registering wheels. For each complete revolution of the first handle, the unit wheel is turned slightly to register a new digit ranging from zero to nine. Consistent with the ten to one ratio, the tenth revolution of the first handle causes the unit wheel to complete its first revolution and register zero, which in turn drives the decimal wheel from zero to one. Each additional wheel marking hundreds, thousands, etc., operates on the same ratio. Slight refinements were made on Leonardo's original sketch to give the viewer a clearer picture of how each of the 13 wheels can be independently operated and yet maintain the ten to one ratio. Leonardo's sketch shows weights to demonstrate the equability of the machine.

The controversy

After a year the controversy regarding the replica had grown and an Academic trial was then held at the Massachusetts university in order to ascertain the reliability of the replica.

Amongst others were present Prof. I. Bernard Cohen consultant for the IBM collection and Dr. Bern Dibner a leading Leonardo scholar.

The objectors claimed that Leonardo's drawing was not of a calculator but represented a *ratio machine*. One revolution of the first shaft would give rise to 10 revolutions of the second shaft and 10 to the power of 13 at the last shaft. Such a machine could not be built due to the enormous amount of friction which would result.

It was said that Dr. Guatelli "had used his own intuition and imagination to go beyond the statements of Leonardo."

The vote was a tie, none the less IBM decided to remove the controversial replica from its display.

Epilogue

- Dr. Guatelli passed away on September 1993, at the age of 89.
- The whereabouts of the replica today is unknown. Possibly it is somewhere in one of IBM's storages.
- Joseph Mirabella still owns the work shop in New York, with many of the replicas at hand.

Part I

Schickard and his “calculating clock”

Wilhelm Schickard (1592-1635)

Wilhelm Schickard was Professor of Hebrew, Oriental languages, mathematics, astronomy, geography, and, in his spare time, a protestant minister in the German town of Tubingen during the early 1600s. He has been compared to Leonardo da Vinci in that they both had far-ranging interests and enquiring minds.

Besides being an excellent mathematician, with some of his mathematical methods being in use until the later part of the nineteenth century, he was a good painter, a good enough mechanic to construct his own astronomical instruments, and a skilled enough engraver to provide some of the copper plates used to illustrate Kepler's great work *Harmonices Mundi*.

September 20, 1623: Schickard writes to Kepler

«What you have done in a logistical way (i.e., by calculation), I have just tried to do by mechanics. I have constructed a machine consisting of eleven complete and six incomplete (actually "mutilated") sprocket wheels which can calculate. You would burst out laughing if you were present to see how it carries by itself from one column of tens to the next or borrows from them during subtraction.»

The lost drawings…

Kepler must have written back asking for a copy of the machine for himself because…

on February 25, 1624, Schickard again wrote to Kepler giving a careful description of the use of the machine together with several drawings showing its construction.

He also told Kepler that a second machine, which was being made for his use, had been accidentally destroyed when a fire leveled the house of a workman Schickard had hired to do the final construction.

Their two letters, both of which were found in Kepler's papers, give evidence that Schickard actually constructed such a machine.

The drawings of the machine had been lost and no one had the slightest idea of what the machine looked like or how it performed its arithmetic.

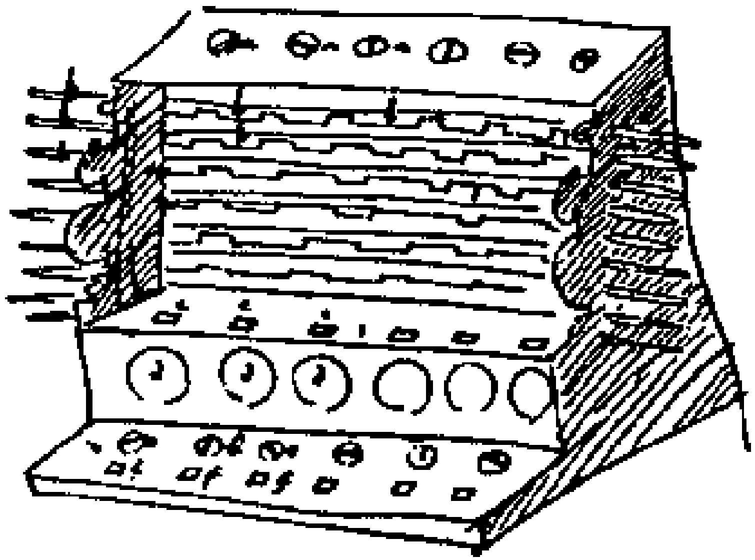
… eventually found!

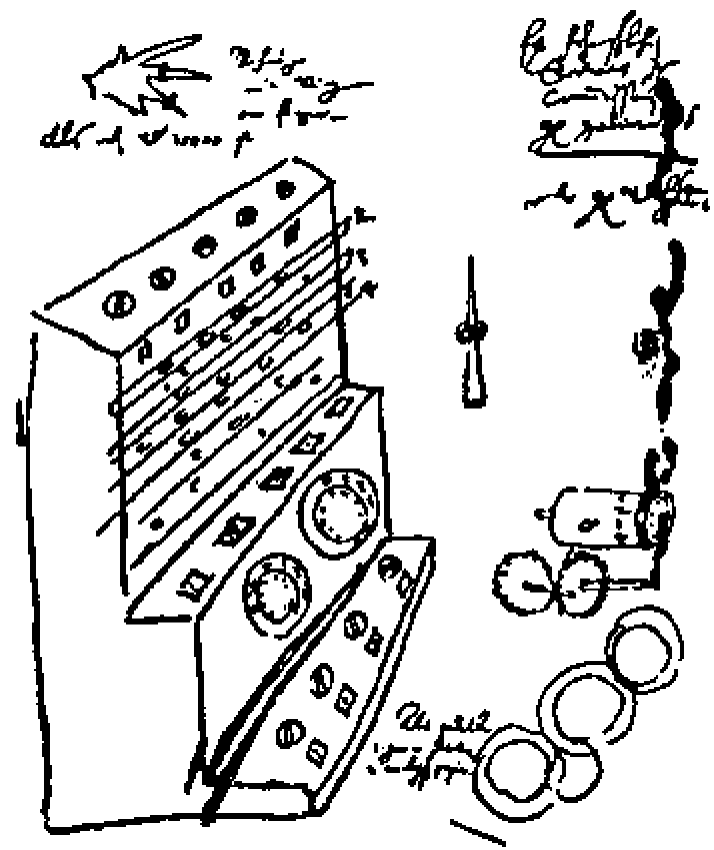
Some scholars, attempting to put together a complete collection of Kepler's works, were investigating the library of the Pulkovo Observatory near Leningrad.

While searching through a copy of Kepler's Rudolphine Tables they found a slip of paper that had seemingly been used as a book mark.

It was this slip of paper that contained Schickard's original drawings of the machine!

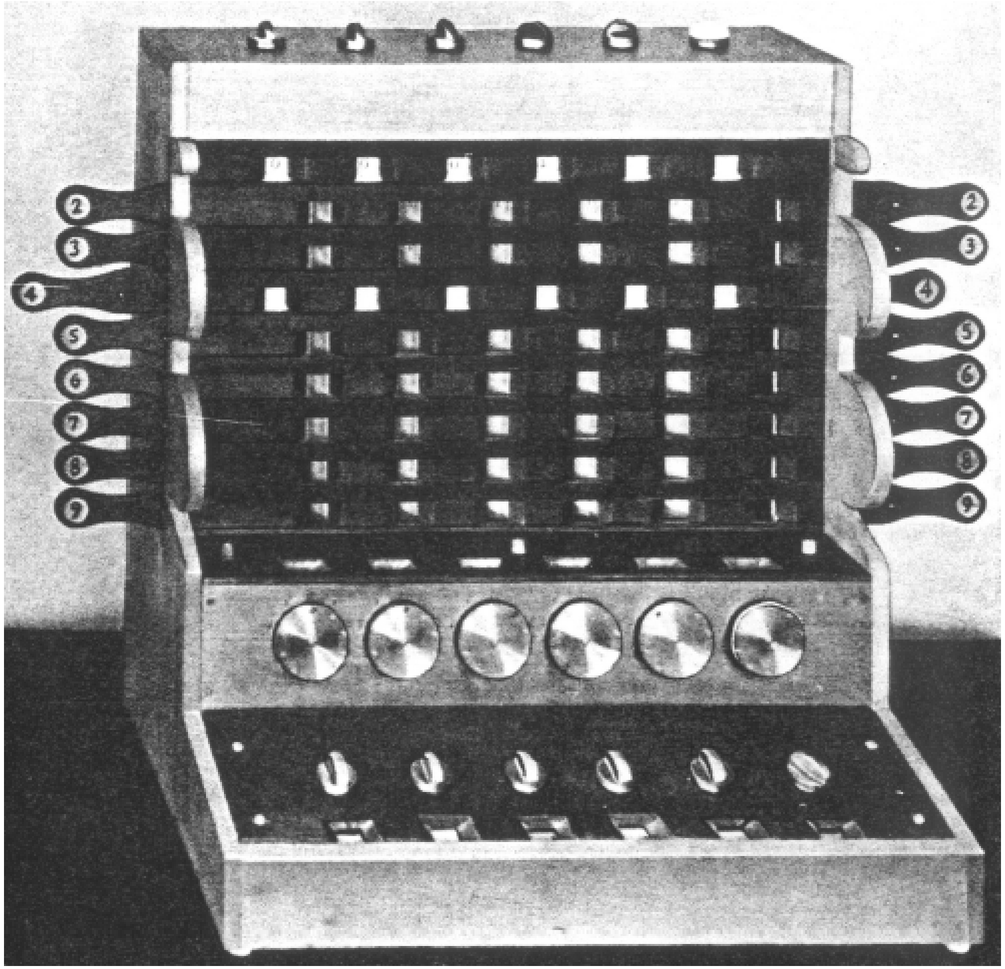
Schickard’s Drawings

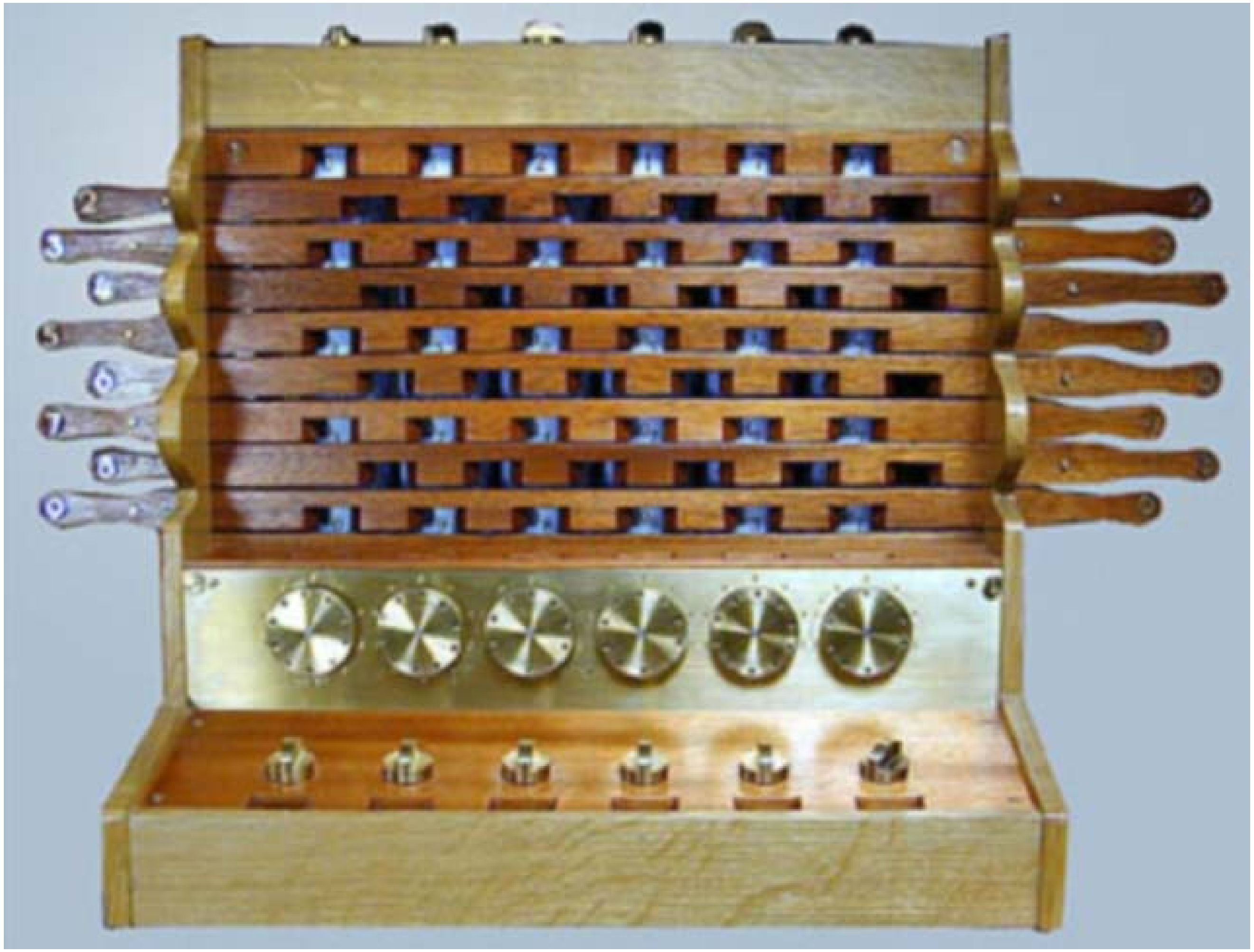




Little detail can be seen, but with the hints given in the letters it became possible to reconstruct the machine.

The replica





Schickard's Mechanical Calculator

In the stamp illustration, the upper part of the machine is set to show the number 100722 being multiplied by 4.

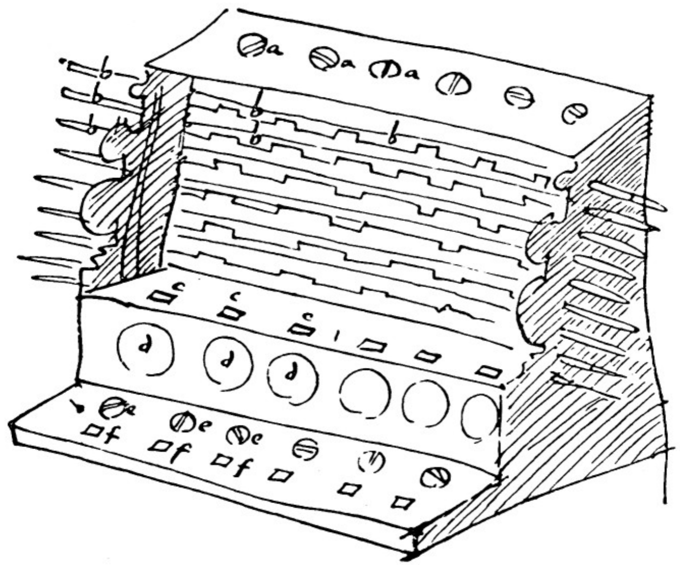
The result of this multiplication is added to the accumulator using the lower portion of the machine.

Structure of Schickard's Machine

The upper part is simply a set of Napier's bones drawn on cylinders in such a way that any particular "bone" may be selected by turning the small dials (a).

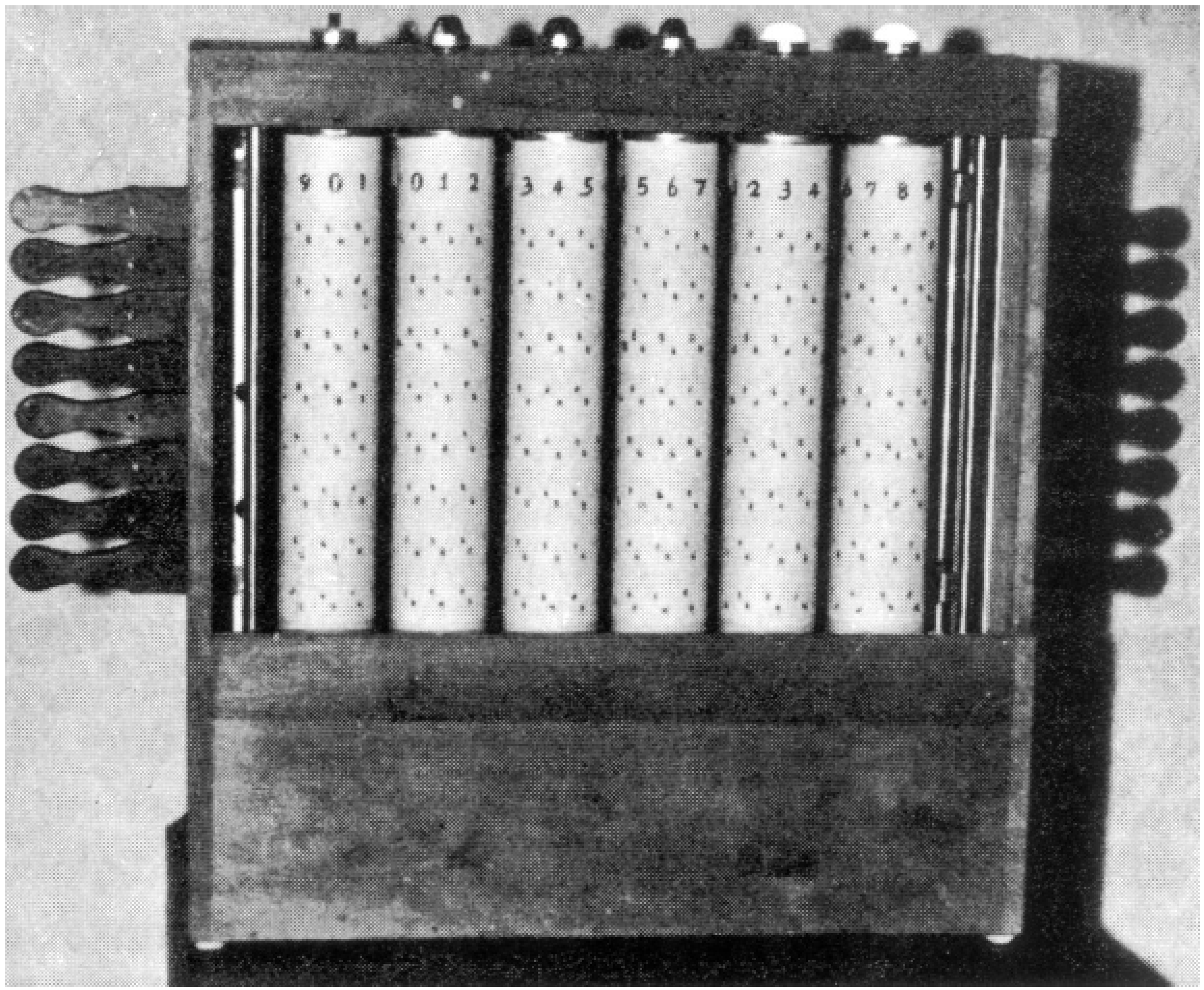
Moving the horizontal slides exposes different sections of the "bones" to show any single digit multiple of the selected number.

This result can then be added to the accumulator by turning the large knobs (d) and the results appear in the small windows just above (c).

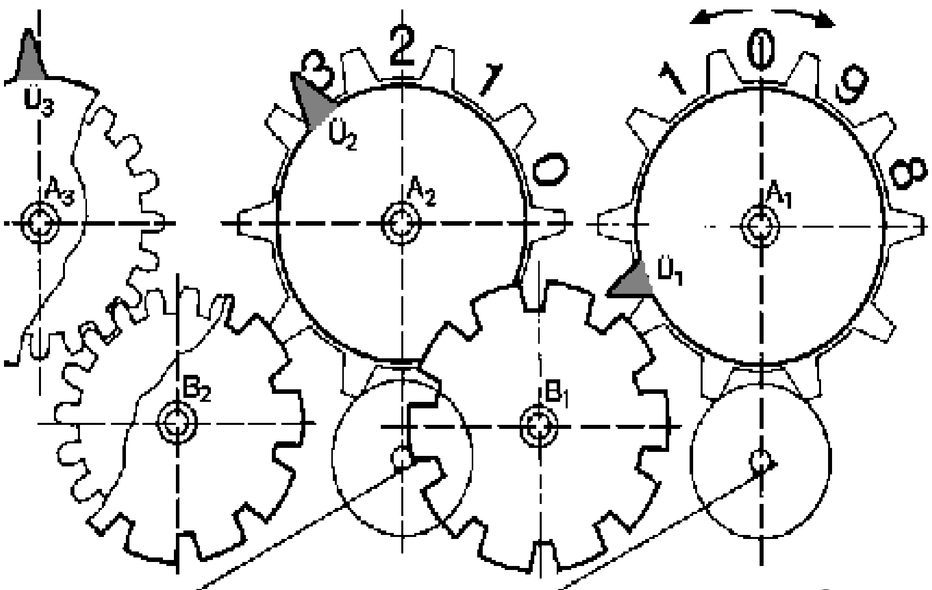


The very bottom of the machine contains a simple aide-memoire. By turning the small knobs (e) it was possible to make any number appear through the little windows (f).

This avoided the necessity of having pen, ink, and paper handy to note down any intermediate results for use at some later time in the computation.



Schickard's Carry Mechanism

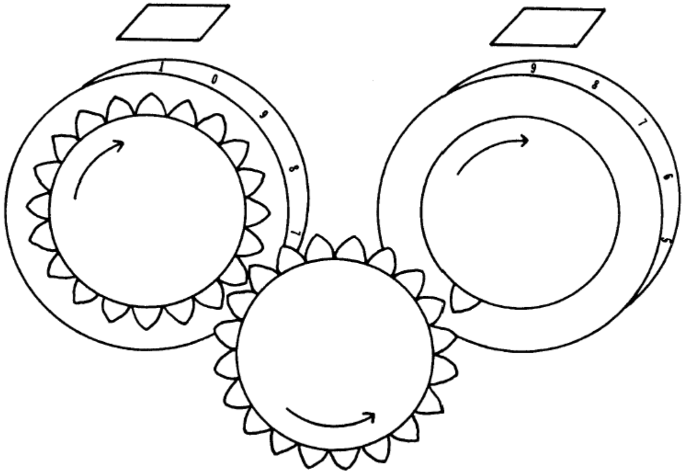


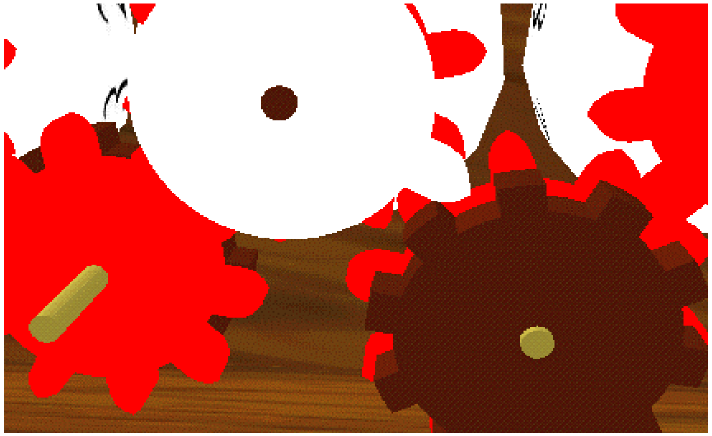
When the first wheel A_1 pass from 9 to 0, the teeth U_1 causes the intermediate wheel B_1 to rotate, which in turn to make A_2 to rotate by 36 degree, and so on.

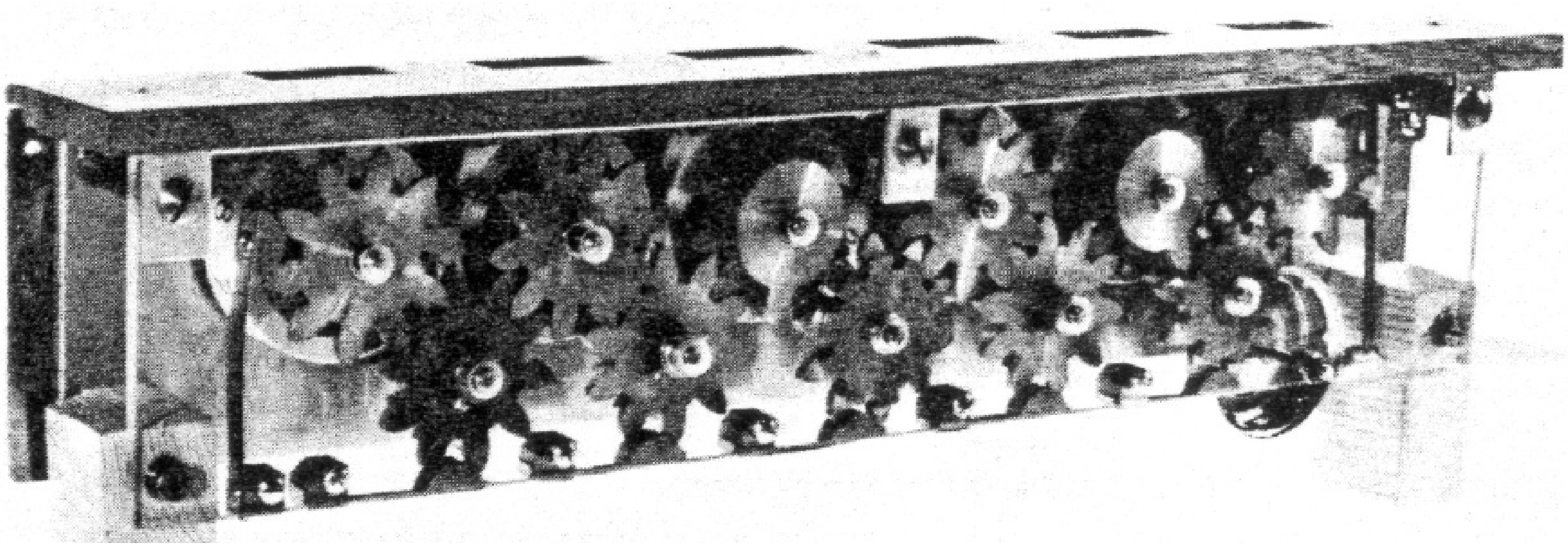
$$\begin{array}{r} 19 \\ +\ 1 \\ \hline 20 \end{array}$$

A decimal digit is represented by the position of a wheel.

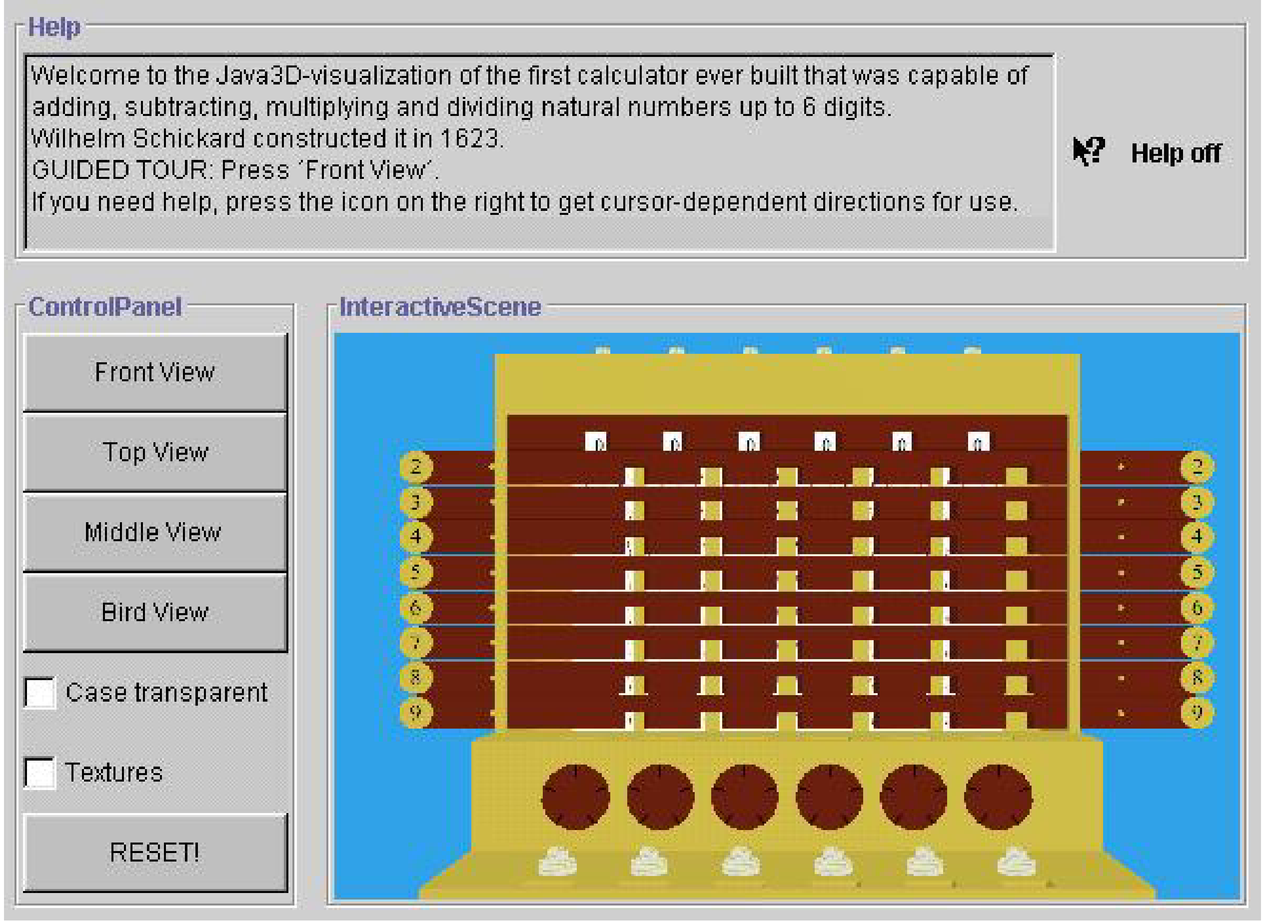
Schickard's Carry Mechanism







A Java Simulator



http://www.gris.uni-tuebingen.de/projects/studproj/schickard

Part II

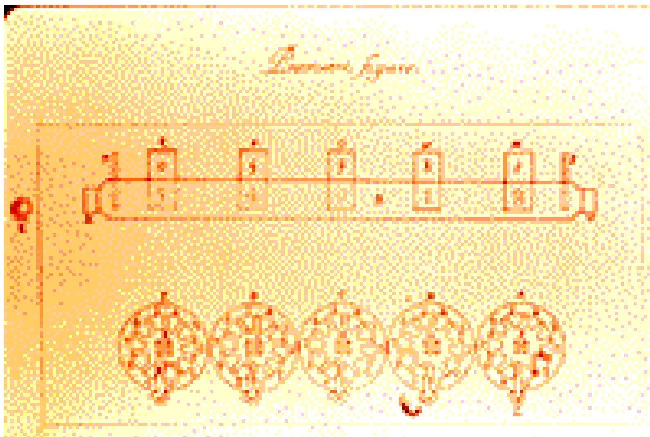
Pascal and the “Pascaline”

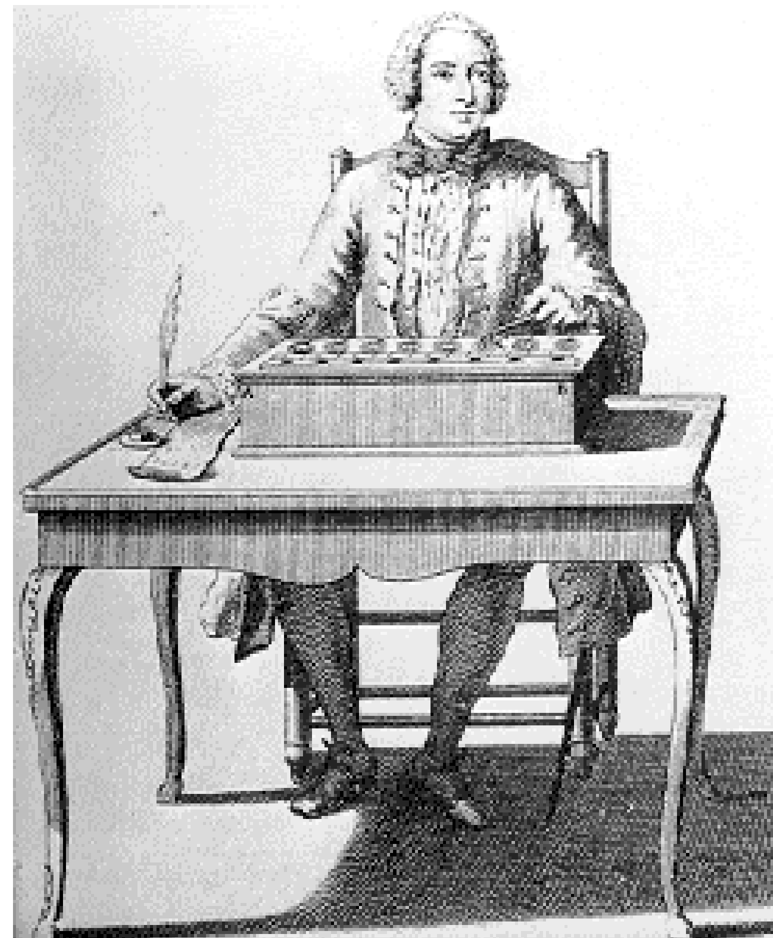
Blaise Pascal (1623-1662)

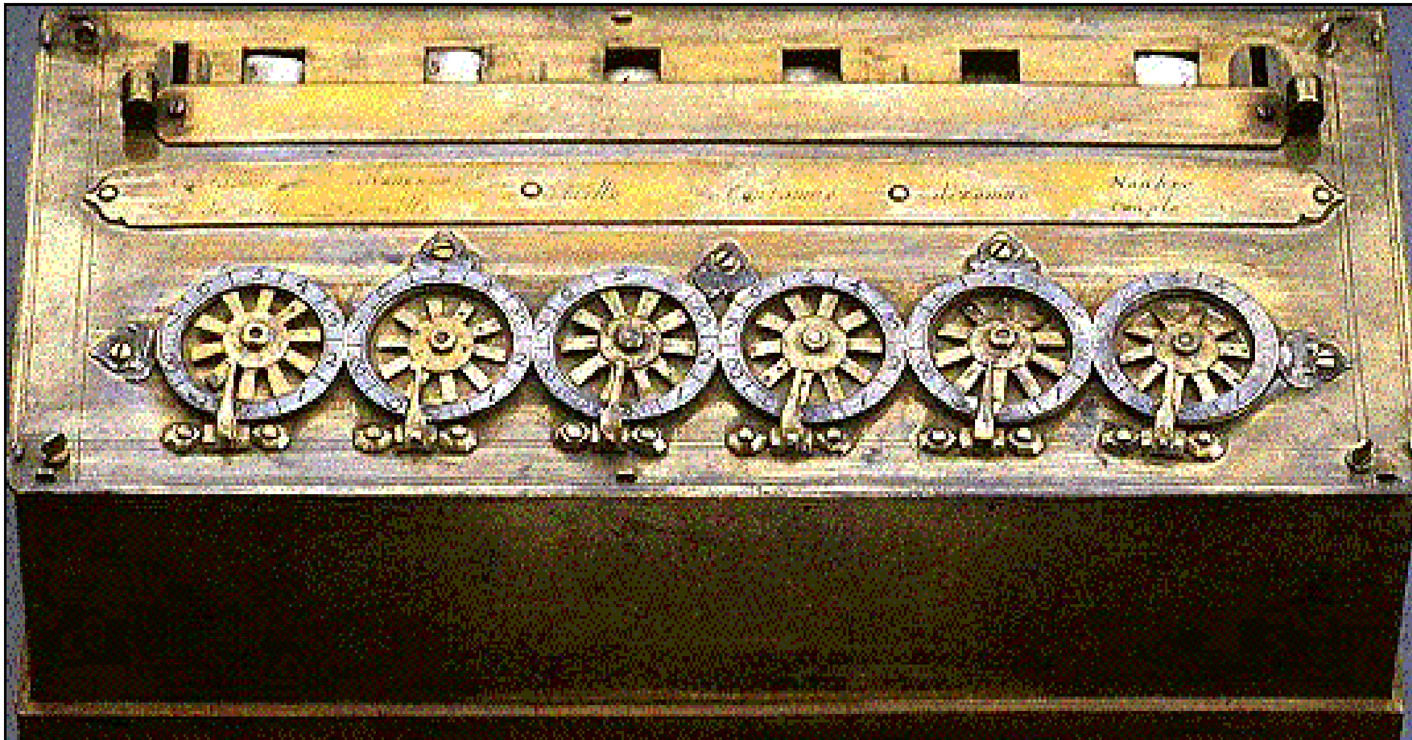
Pascal was a French mathematician, physicist, and religious philosopher.

He was a mathematician of the first order. In mathematics, Pascal helped create two major new areas of research. He wrote a significant treatise on the subject of projective geometry at the age of sixteen and corresponded with Pierre de Fermat from 1654 on probability theory, strongly influencing the development of modern economics and social science.

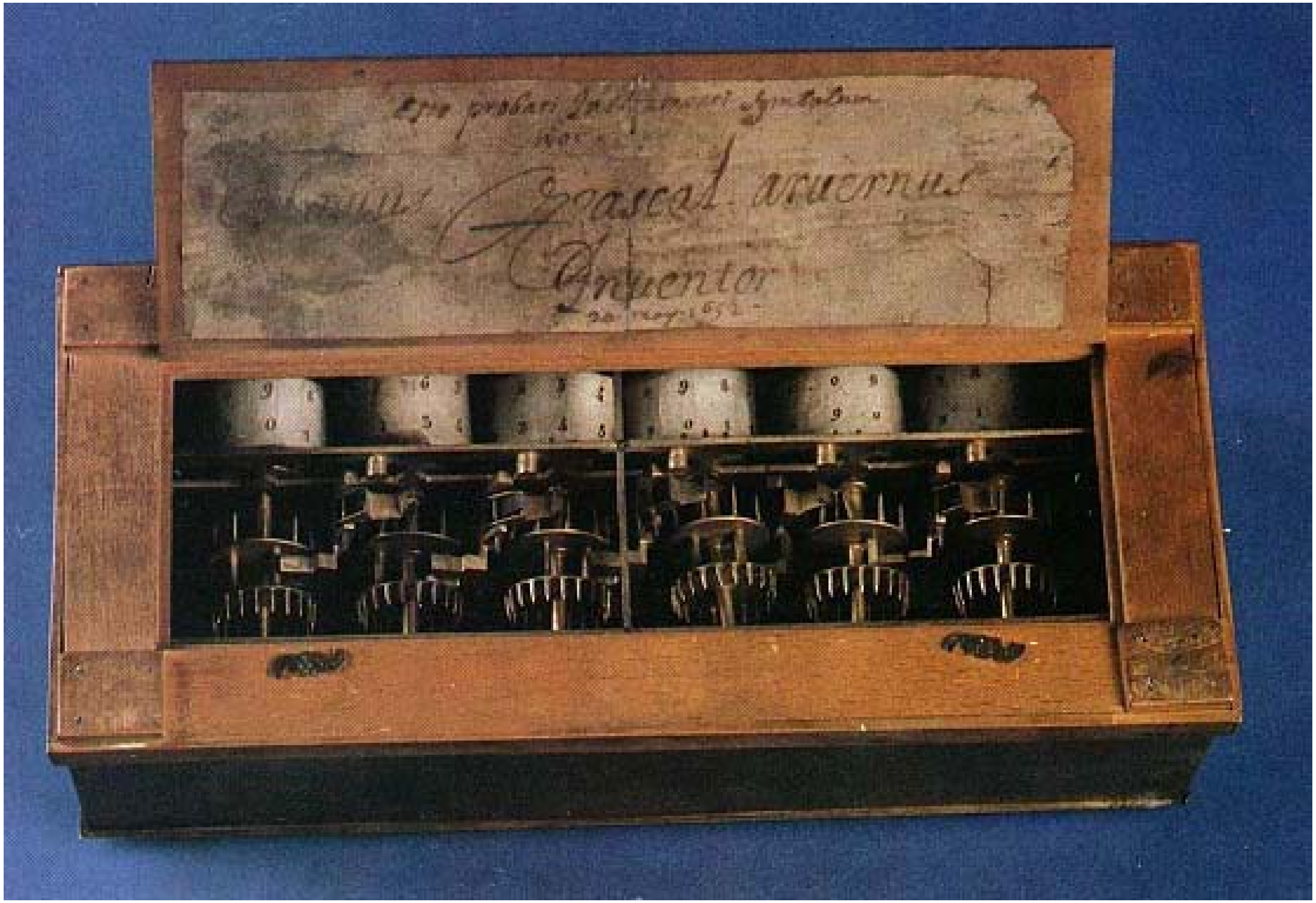
Following a mystical experience in late 1654, he left mathematics and physics and devoted himself to reflection and writing about philosophy and theology.



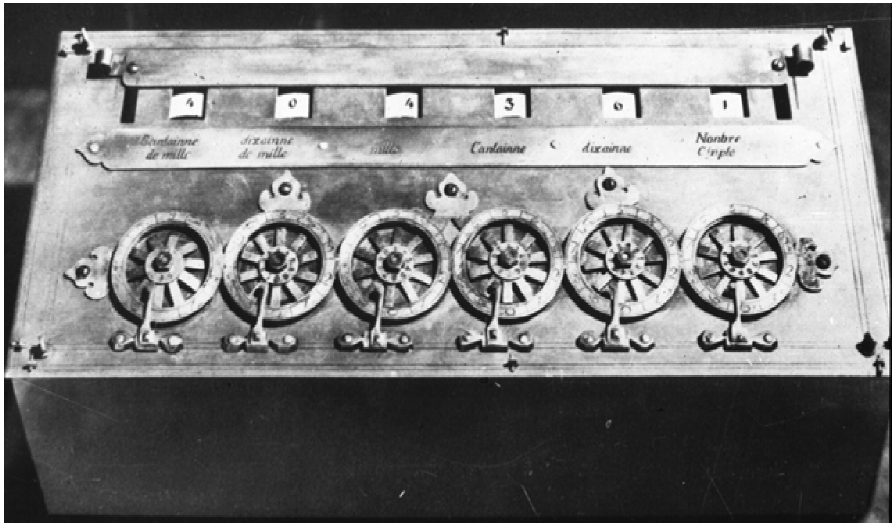


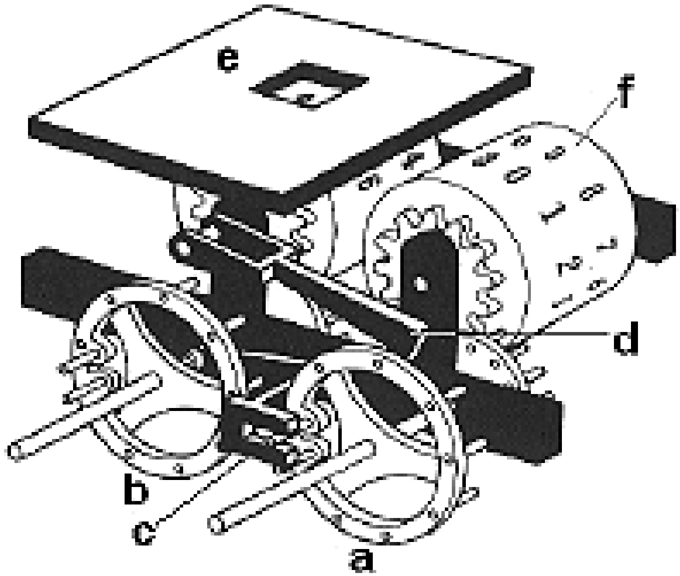


823.JPG

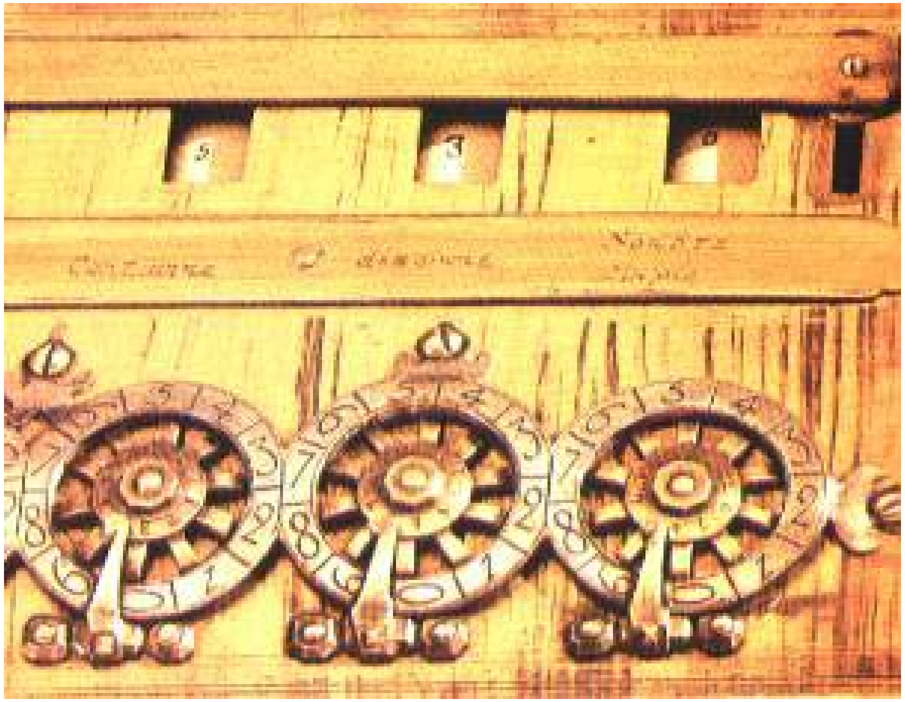


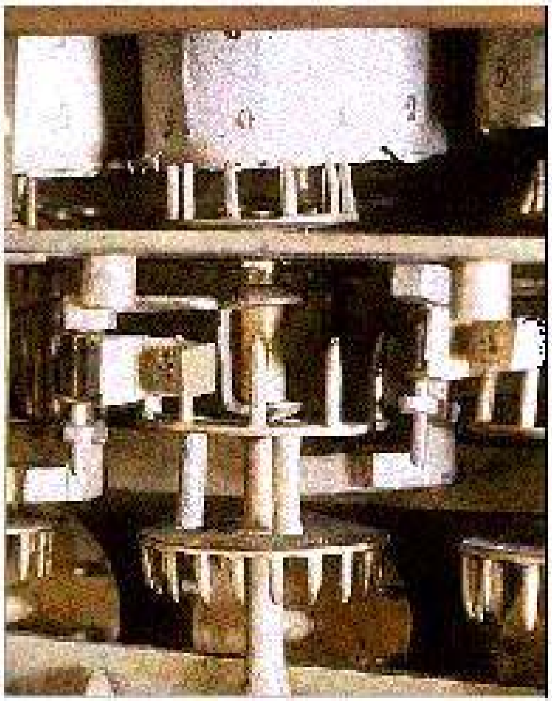
Pascal's Calculating Machine

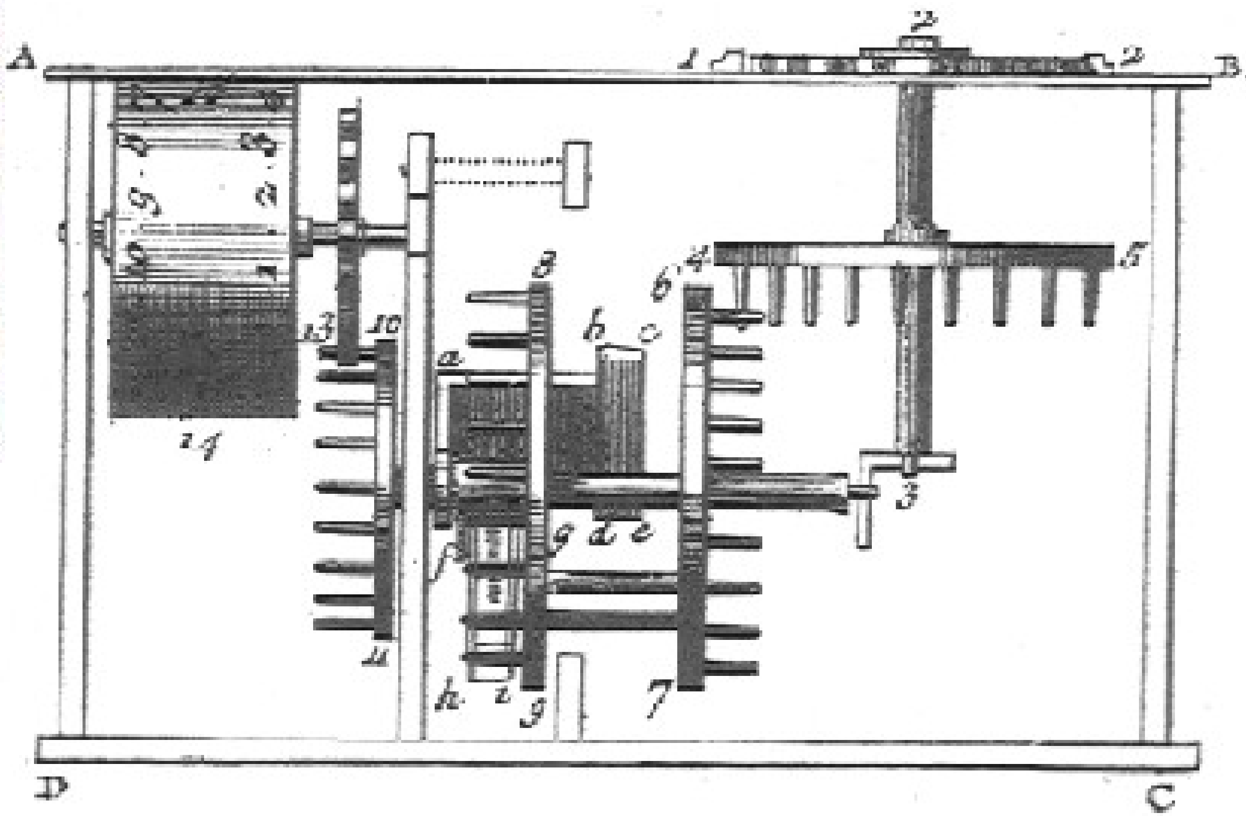




Blaise Pascal (1623-1662) invented a different carrying mechanism in his adding machine. To add a number, one dial the wheels like an old-fashioned dial-tone telephone.

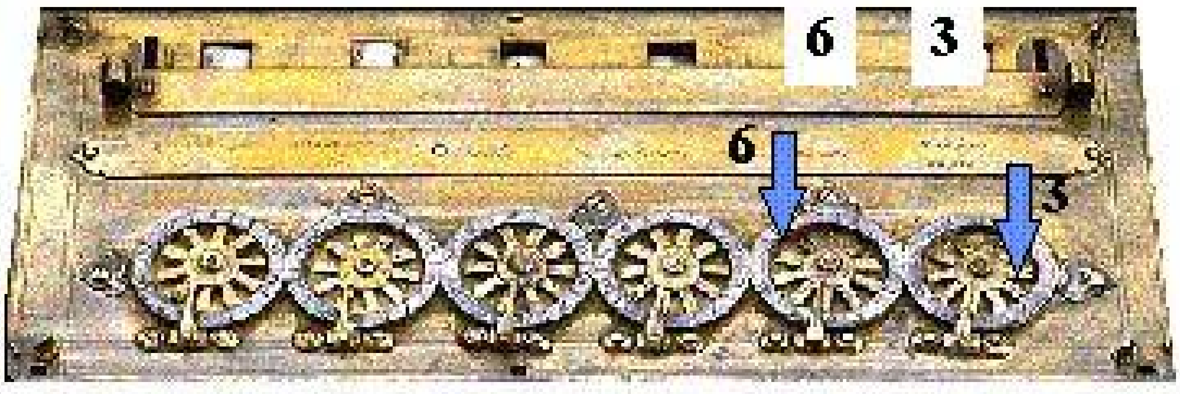


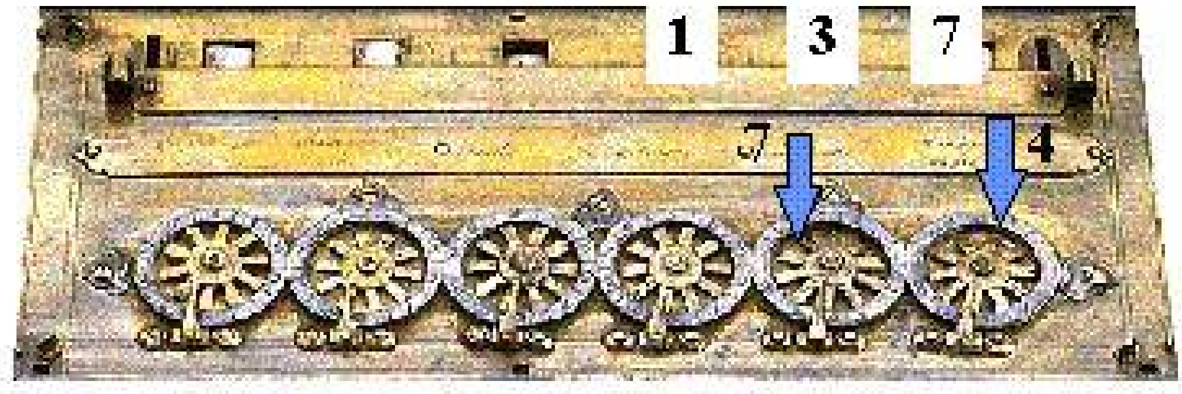




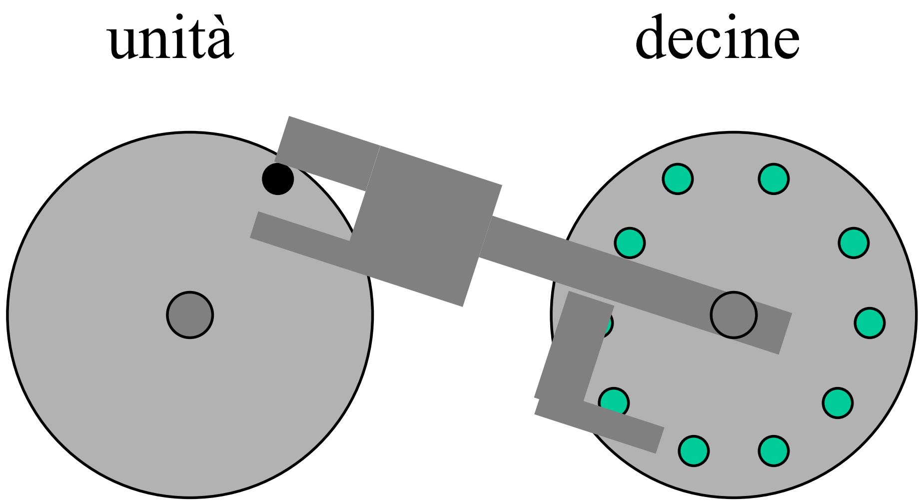
A
B
C
D
1
2
3
4
5
6
7
8
9
10
11
13
14
a
b
c
d
e
g
h
k

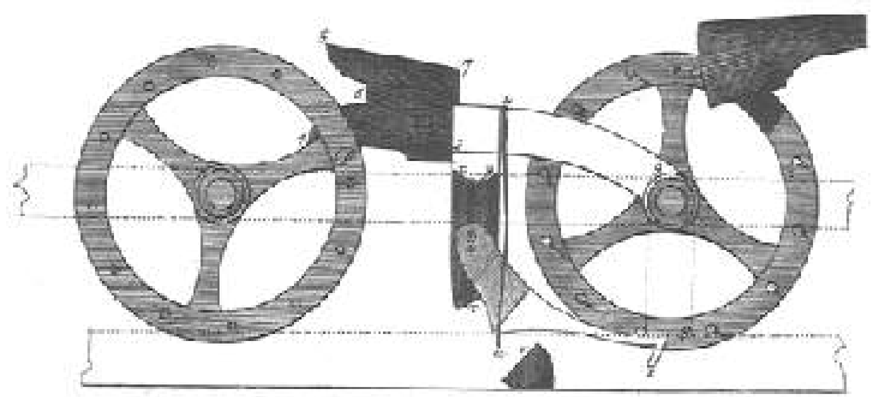
An example: 63+74

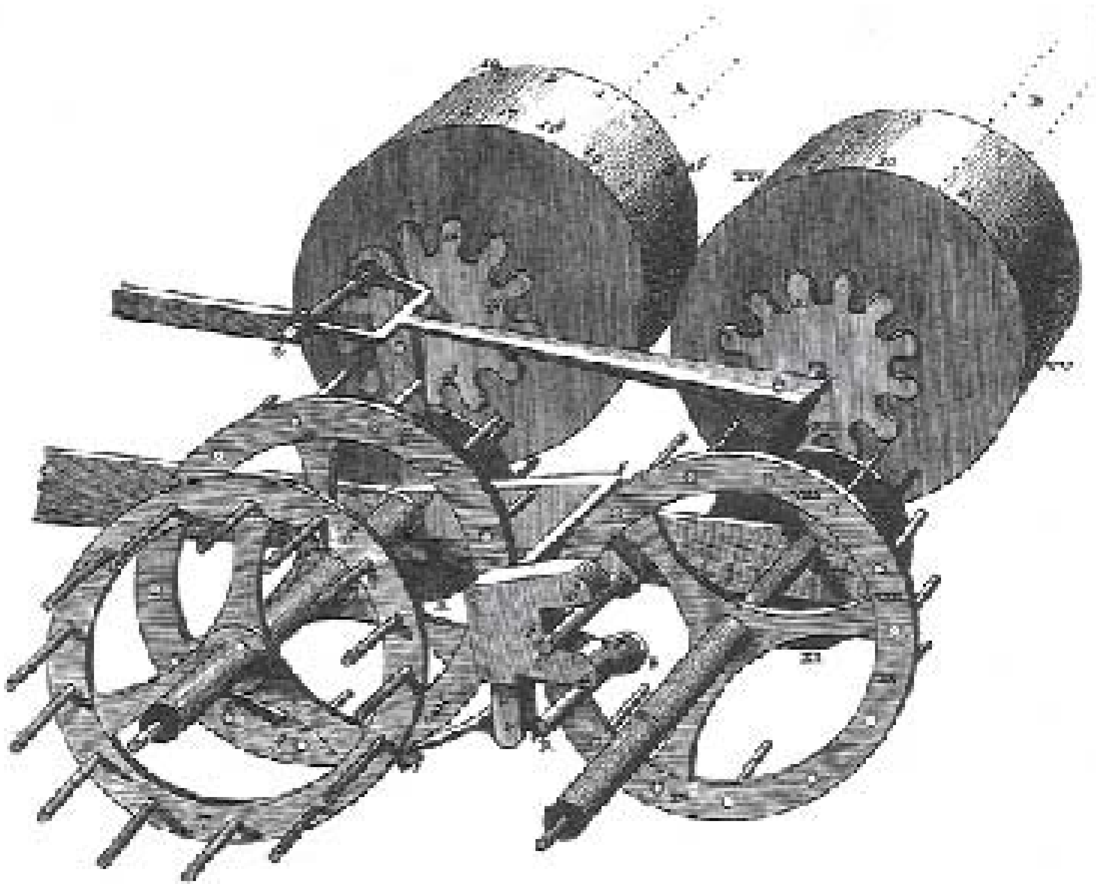




Carry propagation







Subtraction with Pascal Machine

- Due to its carrying mechanism, the wheels cannot turn backward to do subtraction.
- To subtract a number, one adds 10's complement of a number. A 10's complement of a number *n* is 1 plus a number *m* such that each digit of *n*+*m* is 9.
- E.g. consider 6-digit numbers (represented by 6 wheels), if *n* = 000124, its 10's complement is *k*=*m*+1=999875+1=999876, so that *k*+*n*=0

$$\begin{array}{r} 000124 \\ +999876 \\ \hline 1\,000000 \end{array}$$

Since there are only 6 wheels, the last carry is lost, leaving 0 as the result.

To subtract 000124 from Pascal machine, we add 999876, to get the correct answer.

Pascal attempted to put the machine into production for his own profit.

This was not a successful venture, but it did result in a large number of units surviving to the present day. They are all slightly different in that they have different numbers of digits in the accumulator or have slight differences in the internal mechanisms.

None of the surviving models functions very well, and it is doubtful if they functioned perfectly even in Pascal's day.

The mechanism, although ingenious, is rather delicate and prone to giving erroneous results when not treated with the utmost care.

Some of them will, for example, generate extra carrys in certain digits of the accumulator when they are bumped or knocked even slightly.

Part III

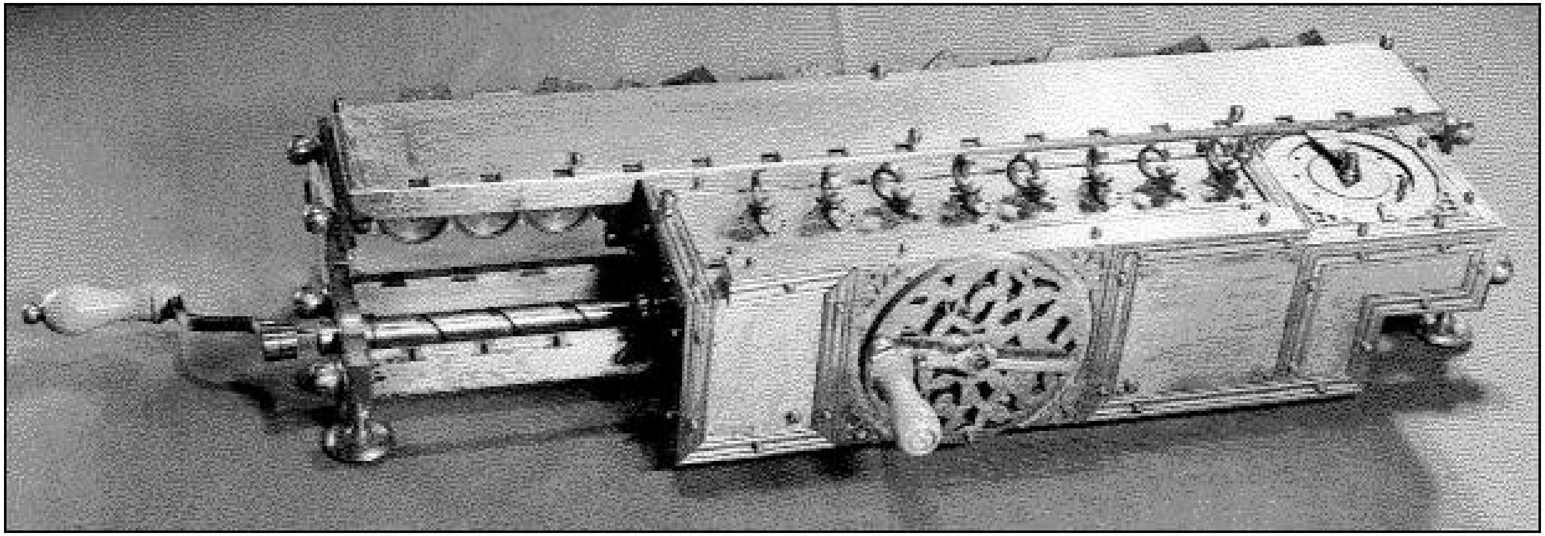
Leibniz and His “Reckoner”

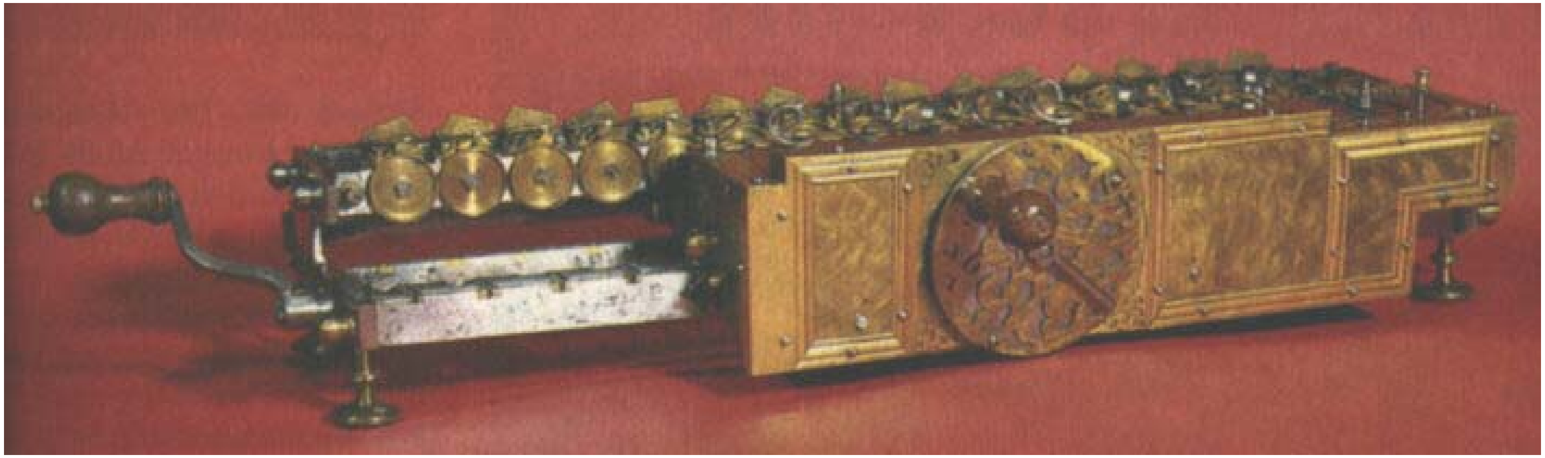
Gottfried Leibniz (1646-1716)

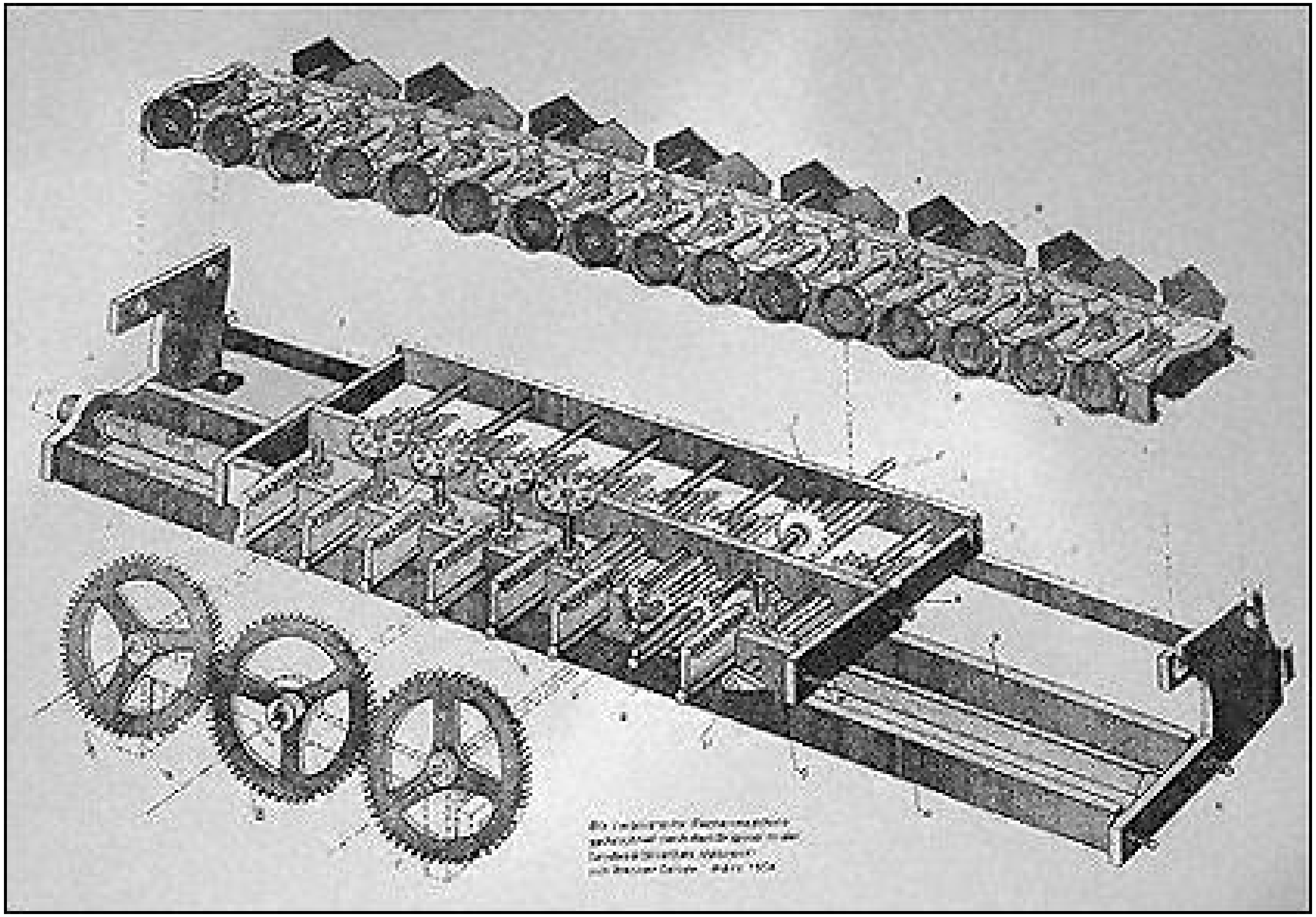
Leibniz developed, independently from Newton, the differential and integral calculus.

He also developed ideas of mechanical machine for multiplication.

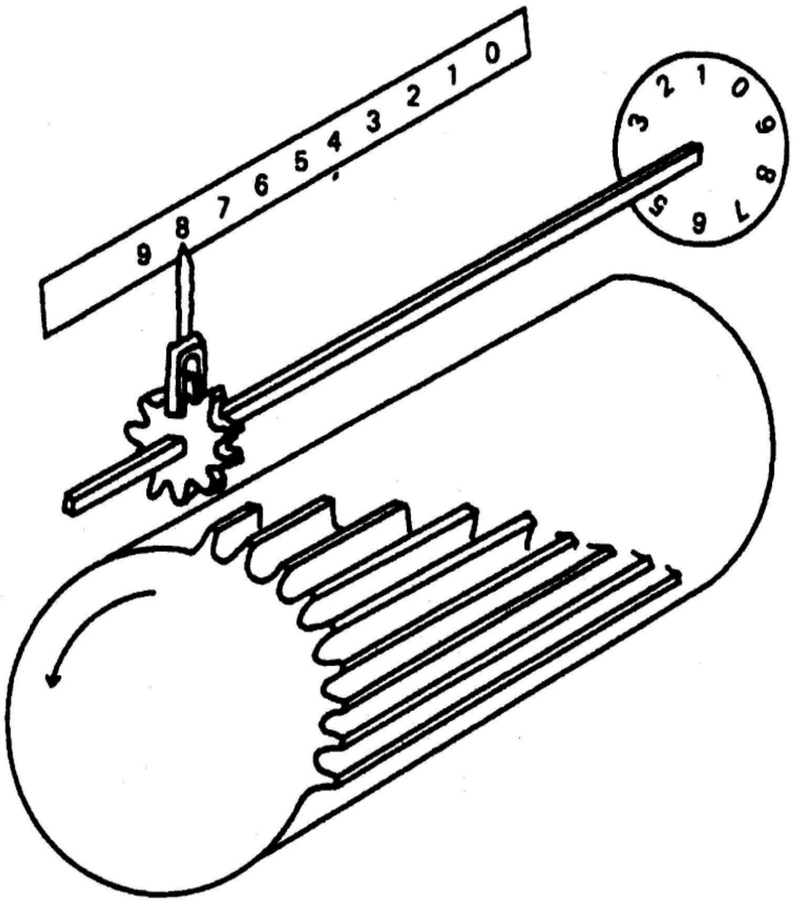
$$\int_a^b F'(x)dx = F(b) - F(a)$$







Leibniz's Stepped Drum Mechanism



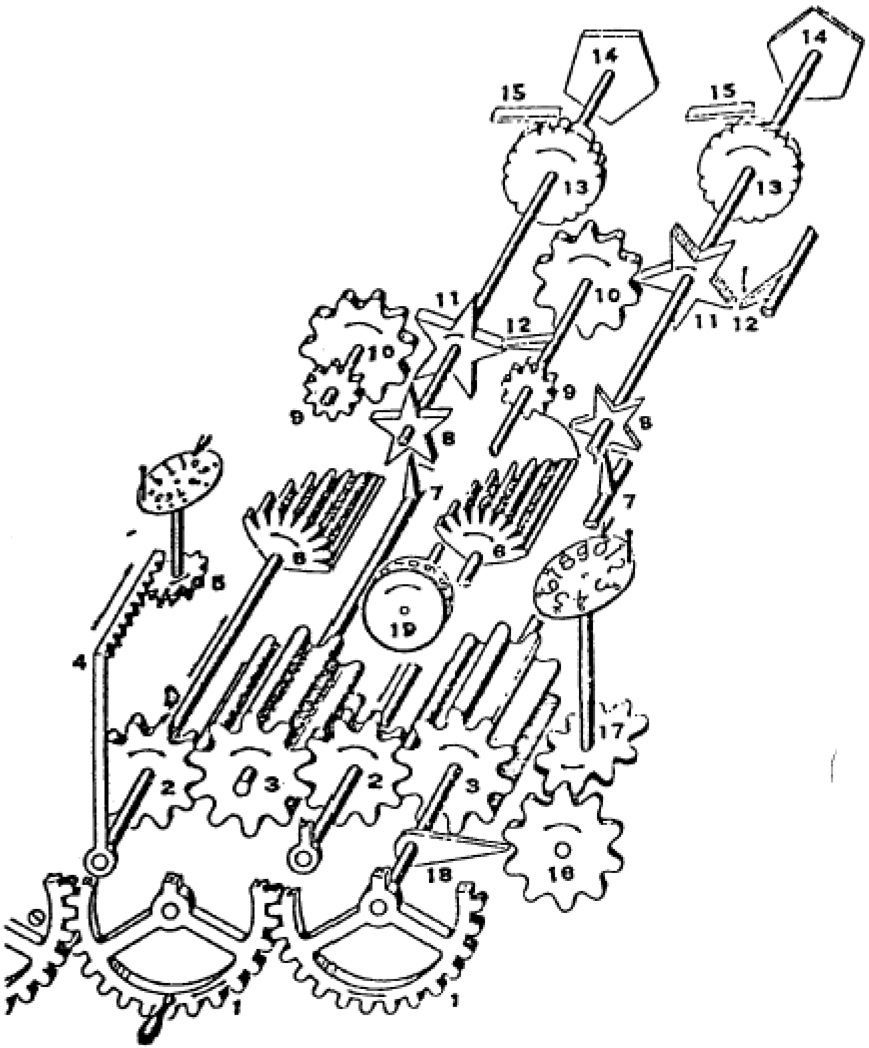
By registering a corresponding position of the square shaft, the result wheel can be turned a variable number of positions.

The carry mechanism

When a carry was needed, the small lever 7 would interact with the star wheel 8 and partially turn the shaft so that one of the points of the star 11 would assume a horizontal position

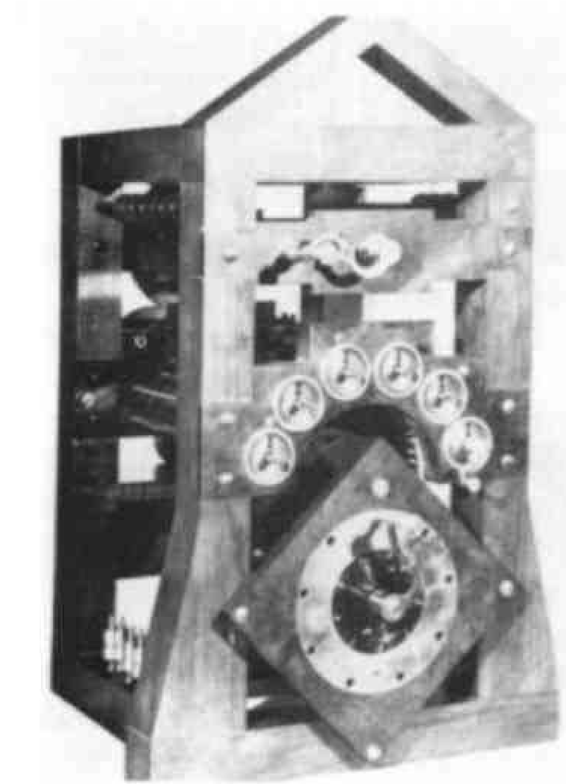
This would put it into a position in which the lever 12 could give it a little extra push to cause the result wheel to flip over to the next digit (i.e.,add the carry to the next digit).

To ripple a carry across several digits manual intervention was needed via the pentagonal disks 14.



Giovanni Poleni's machine (1709)

Giovanni Poleni Venezia 1683 - Padova 1761



References

M. R. Williams. *A History of Computing Technology.* IEEE Computer Society Press, 1997 (2nd Edition).

W. Aspray (Ed.). *Computing Before Computers*. Iowa State University Press, 1990. http://ed-thelen.org/comp-hist/CBC.html

V. Pratt. *Macchine pensanti: L'evoluzione dell'intelligenza artificiale*. Il Mulino, 1990.