

## Early Mechanical Computers: Part 1

This section covers mechanical (physical rather than electronic) calculating devices

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### What Is A Mechanic?

- Modern usage



- Usage in this section of notes (~1500 – 1800s AD)



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### Common Attributes Of Early Mechanical Computers/Computing Devices

- Almost all the mechanical calculators were composed of these basic elements in some form.
  - Set up:
    - Allows the number to be entered
  - Selector:
    - Determines the type of operation (addition, subtraction)
  - Registering mechanism:
    - Indicates the value of a stored number (result)
  - Carry Mechanism:
    - Determines that any carries are handled properly
  - Control mechanism:
    - Ensures that the gears are properly aligned at the end of each operation (avoid false results and jamming)
  - Erasing mechanism:
    - Reset the result register between operations
  - The 6 parts weren't always separate but one part could implement multiple operations
    - These operations were needed in a usable machine (automated or manual)

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## Video: The Importance Of Good Design And Precise Implementation:

– [https://pages.cpsc.ucalgary.ca/~tamj/2020/409F/videos/Extra\\_video\\_challenge\\_of\\_device\\_manufacture.mp4](https://pages.cpsc.ucalgary.ca/~tamj/2020/409F/videos/Extra_video_challenge_of_device_manufacture.mp4)

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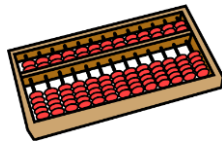
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## Propagating The Carry

$$\begin{array}{r} 19 \\ + 3 \\ \hline 2 \end{array}$$



- This was a major challenge that was overcome with varying degrees of success (?) in the earliest of the calculating machines (Schickard – Grillet).
  - (It was a non-issue for the 3 commercially produced devices because the problem had been long solved)

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## Wilhelm Schickard (1592 – 1635)

- A well-rounded 'Renaissance man' often compared to da Vinci:
  - Professor of: Hebrew, Oriental languages, Mathematics, Astronomy, Geography.
  - 'Spare time' hobbies: painting, mechanic, engraver.
- Developed the first true adding machine which could handle a carry? (Bruno von Freytag Loringhoff)?
- Evidence of the machine:
  - Letter to sent to/from Johannes Kepler (mechanical equivalent of his manual calculations).



Image : [www.computerhistory.org](http://www.computerhistory.org)

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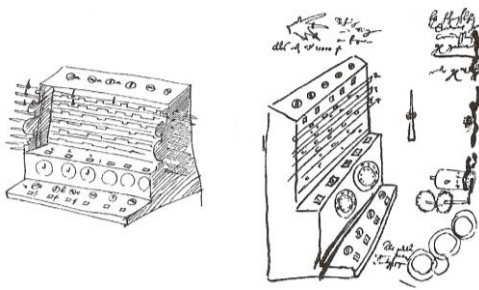
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## Wilhelm Schickard (1592 – 1635): 2



"A History of Computing Technology" (Williams)

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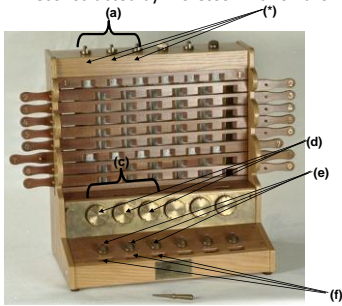
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## Re-Creation Of Schickard's Calculating Machine

- Reconstructed by Professor Bruno Baron von Freytag:



### Associations:

- (a) & (\*)
- (c) & (d)
- (e) & (f)

Image: <http://www.numericana.com>

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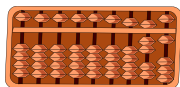
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## Schickard Carry Mechanism

- Result of additions to a previous common passed in next column

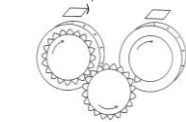
00 → 10  
01 → 11  
02 → 12  
03 → 13  
04 → 14  
05 → 15  
06 → 16  
07 → 17  
08 → 18  
09 → 19  
10 → 20



Previous approaches:  
manually performed

Solution: Single toothed gear

Figure 4-4  
Reconstructed carry mechanism



•(Williams  
Schickard's  
calculator:  
automated

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## Fate Of Schickard's Calculators

- There were two
  - One was made for Kepler



- It's unknown what happened to Schickard's copy.
- It was believed that Schickard's family was wiped out in a plague and the was unceremoniously disposed of



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## The Influence Of Pascal On Today's World

- Pascal's wager

|                    | Exists        | Does not exist      |
|--------------------|---------------|---------------------|
| You believe        | Infinite win  | No cost/finite cost |
| You do not believe | Infinite loss | No cost/finite cost |

- Why “no cost”? Recall your algorithm analysis courses.
- Application of Pascal's wager in modern times.
- Critiques of Pascal's wager (assumes “there is only one”).

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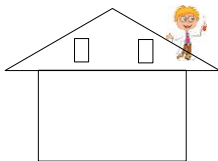
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## Blaise Pascal (1623 – 1662)

- Born in Southern (Clermont) France
- Because of his many accomplishments some of the stories about his life were (greatly) exaggerated.



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Clipart:  
colourbox.com

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## Blaise Pascal (2)

- Credited as the next major attempt to produce a calculating machine.
  - Initially he was credited as building the first mechanical calculator but this was disproved by Bruno Baron von Freytag Loringhoff.
- 'Home schooled' in the basics of reading and writing by his father Etienne Pascal.
- After learning the basics: Blaise was left to learn from reading the library of his father.



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## Pascal: Motivations

- His family were government tax collectors
- The calculations required were repetitive and rather tedious



- At 19 Pascal designed his first calculating machine (1642)
  - His attempts at finding someone to implement the design was not successful



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## Pascal: Other Vocations

- After his failure at getting others to build his designs he realized that he would have to work as designer and the builder/implementer of the designs
- He trained at other vocations



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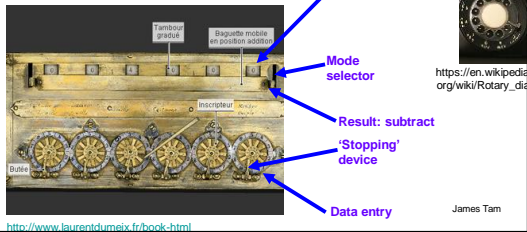
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### Pascal's First Machine: Work

- He went through nearly 50 prototypes (all based on the original design).
- In 1645 he publically presented his machine
  - Pascal's calculator (later 'Pascaline')



### External Extra Videos: Pascaline

- Basic operations, Pascaline video #1:  
[https://www.youtube.com/watch?v=CvKLM\\_Q1Wx0](https://www.youtube.com/watch?v=CvKLM_Q1Wx0)

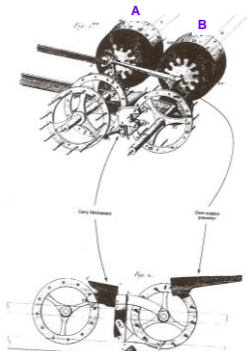
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### Pascal's Machine: Carry

- Pascal realized that the gear and tooth mechanism used by Schickard was problematic.
  - (A carry propagated for more than several digits would require force such that the gears could/would be damaged).
- Instead a complex system of falling weights was employed

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### Pascal's Machine: Carry (2)



Additional details  
coming up in Pascaline  
video #2

From: A history of computing technology (Williams)

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### Pascal's Later Life

- Later in life (1650) Pascal had a life changing dream



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### Fate Of Pascal's Machines

- Several machines were produced but sales weren't profitable
- Few survive to today.
  - They were quite delicate
- Pascal suffered from a painful illness which lead to his death at 39 (1662).



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## Gottfried Leibniz (1646 – 1716)

- Age 15: admitted to university Leipzig (law)
- Age 20: applied for his doctorate (law)
  - Declined (“Ya bother me kid...”)



colourbox.com



“A history of computing technology” (Williams)

- Doctorate awarded at the university of Altdorf

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## Challenges Faced By Leibniz, Pascal And Others



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## Leibniz’s Final Machine

- Luckily Leibniz enlisted the aid of M. Oliver



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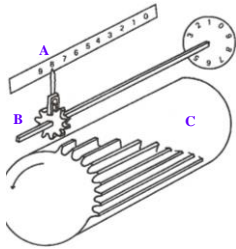
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## Leibniz's Calculating Machine

It used a 'stepped drum':



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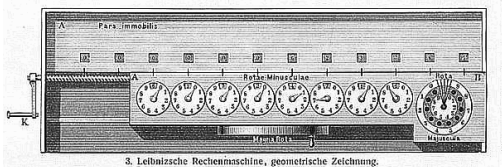
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## Leibniz's Calculating Machine (2)

2. Rechenmaschine von Leibniz (1673, Hannover).



• "eine zahl von einer ganzen Reihe  
Ziphern, sie sey so lang sie wolle (nach  
proportion der größe der Maschine)!!!" -  
Leibniz

"A number from a whole series of ciphers,  
they are as long as they want (according to  
the proportion of the size of the machine)"

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Image: <http://www.rechnerlexikon.de>

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## Leibniz's Calculating Machine (3)

- It used a gear based system (not single tooth gear) for carries.
- Carries were problematic.
- Ripple carry through several digits had to be manually propagated.

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### External Extra Videos: Leibniz Stepped-Drum

- <https://www.youtube.com/watch?v=klB5k3LkwU>

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### Leibniz: End Years

- “...he (Leibniz) holds the position, perhaps more than any other post-Renaissance figure, of a man of almost universal genius.
- People like him are often very difficult to get along with, and there was an almost audible sigh of relief from his contemporaries when he finally died.”
  - Williams (History of Computing Technology)



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### External Extra Videos: Leibniz Vs. Newton

- Leibniz-Newton feud (video mostly just for fun, caution: minor gore near the end)
- <https://www.youtube.com/watch?v=KQyIU10pD-A>

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## Who Invented (Physically Built) The First True Adding Machine?

- Pope Sylvester II (946 – 1003)?



• [www.d.umn.edu](http://www.d.umn.edu)

- No it was most certainly an abacus that was referred to
- (Delicate machining wasn't possible).
- William Schickard (first: but may have been incomplete – single toothed gear? did the carry work? - say Williams and others)
- Blaise Pascal (either second or the first complete)

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## Operations Available: Schickard, Leibniz And The Pascal Machines

- Addition (Schickard, Pascal, Leibniz)
- Addition and subtraction (Pascal & Leibniz)
- Multiplication and division (Leibniz)
  - Repeated additions and subtractions

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## After This Section You Should Now Know

- Common attributes of the early mechanical computing devices
- Who were some of the people behind the early mechanical computers and when they lived as well some of the events from their lives
- The appearance and general operation of these mechanical machines
- What were the mathematical operations implemented by the early mechanical devices
  - What was the one major challenge faced in the design of all the early calculating machines (Schickard – Grillet)
- William Schickard's calculator
  - How were Napier's bones employed
  - How did carries get propagated from one digit to another
  - What was the limit on the carry and how was it deal with
  - The eventual fate of Schickard's calculators

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### After This Section You Should Now Know (2)

- The eventual fate of Pascal and his machines
- How the stepped drum was implemented in Leibniz's calculating machine in order to perform basic mathematical operations
- Who invented the first true adding machine

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