Early Mechanical Computers: Part 1

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

James Tam

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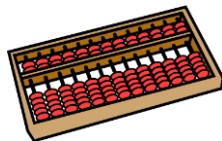
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Video: The Importance Of Good Design And Precise Implementation:

– https://pages.cpsc.ucalgary.ca/~tamj/2020/409F/videos/Extra_video_challenge_of_device_manufacture.mp4

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Propagating The Carry

$$\begin{array}{r} 1 \\ 19 \\ +\ 3 \\ \hline 2 \end{array}$$

• 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)
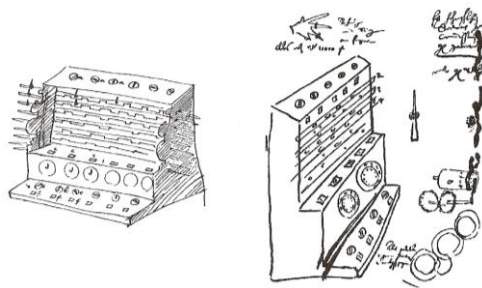
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Wilhelm Schickard (1592 – 1635)

• 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).
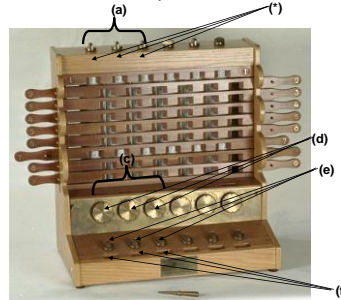
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Wilhelm Schickard (1592 – 1635): 2

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Re-Creation Of Schickard's Calculating Machine

• Reconstructed by Professor Bruno Baron von Freytag:
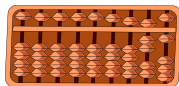

Associations:
• (a) & (*)
• (c) & (d)
• (e) & (f)

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Schickard Carry Mechanism

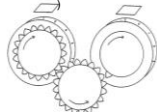• Result of additions to a previous common passed in next column

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 2-6
The Schickard 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").
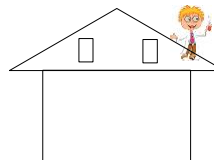
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Blaise Pascal (1623 – 1662)

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

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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.

Math ..... Yeah!!!

Math

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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
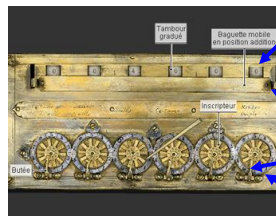- He trained at other vocations

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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')

Result: add

Mode selector

Result: subtract

'Stopping' device

Data entry

Tambour gradué

Baguette mobile en position addition

inscripteur

Butée

https://en.wikipedia.org/wiki/Rotary_dia

http://www.laurentdumeix.fr/book-html

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External Extra Videos: Pascaline

- Basic operations, Pascaline video #1:
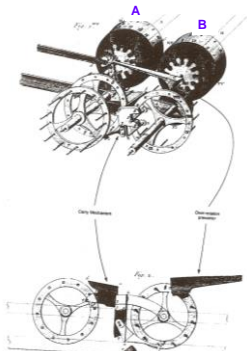 https://www.youtube.com/watch?v=CvKLM_O1Wx0

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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
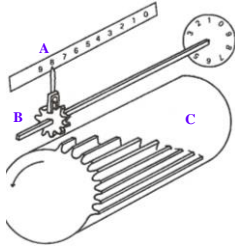
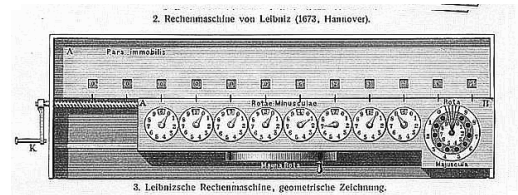• Luckily Leibniz enlisted the aid of M. Oliver

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Leibniz's Calculating Machine

It used a 'stepped drum':

Leibniz's Calculating Machine (2)

2. Rechenmaschine von Leibniz (1673, Hannover).

3. Leibnizsche Rechenmaschine, geometrische Zeichnung.

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

Image: http://www.rechnerlexikon.de

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.

External Extra Videos: Leibniz Stepped-Drum

• https://www.youtube.com/watch?v=klLB5k3LkwU

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

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

• Pope Sylvester II (946 – 1003)?

•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
  o 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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