Early Mechanical Computers: Part 1

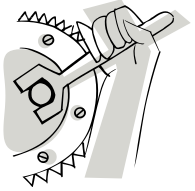
This section covers mechanical (physical rather than electronic) calculating devices

James Tam

What Is A Mechanic?

- Modern usage

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



James Tam

Copyrights unknown

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)

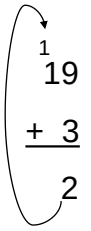
James Tam

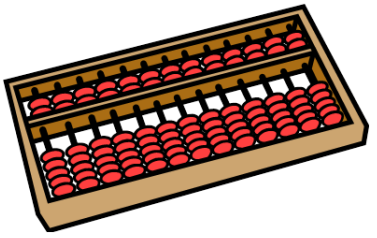
Video: The Importance Of Good Design And Precise Implementation:

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

James Tam

Propagating The Carry





- 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)

James Tam

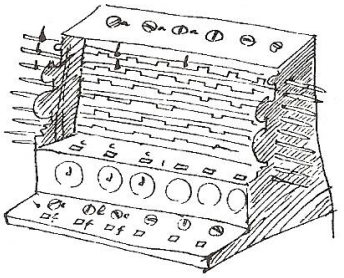
Wilhelm Schickard (1592 – 1635)

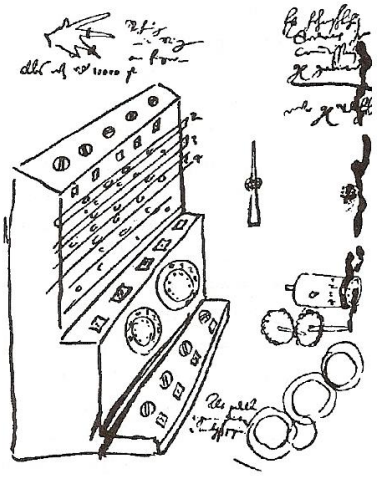
- A well-rounded 'Renaissance man' often compared to da Vinci:
  - Professor of: Hebrew, Oriental languages, Mathematics, Astronomy, Geography.
  - 'Spare time' hobbies: painting, mechanic, engraver.
- Developed the first true adding machine which could handle a carry? (Bruno von Freytag Loringhoff)?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

James Tam

Image : www.computerhistory.org

Wilhelm Schickard (1592 – 1635): 2



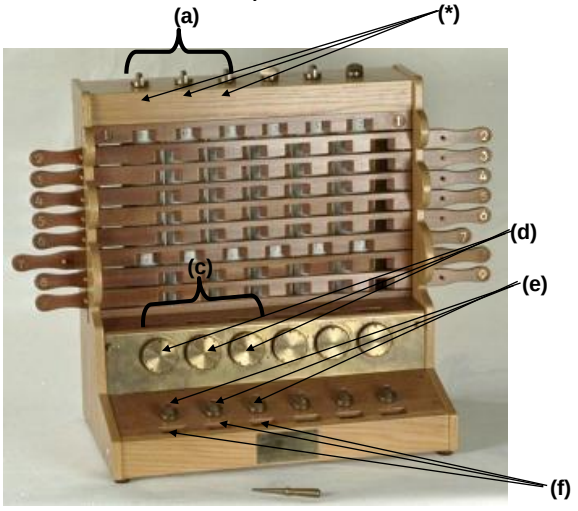


James Tam

"A History of Computing Technology" (Williams)

Re-Creation Of Schickard's Calculating Machine

- Reconstructed by Professor Bruno Baron von Freytag:



Associations:

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

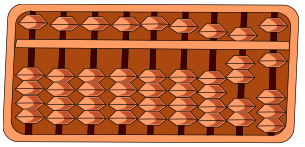
James Tam

Image: http://www.numericana.com

Schickard Carry Mechanism

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

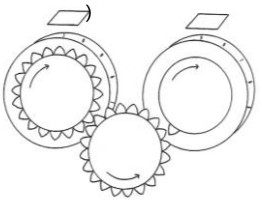
00	10
01	11
02	12
03	13
04	14
05	15
06	16
07	17
08	18
09	19
10	20



Previous approaches: manually performed

Solution: Single toothed gear

Figure 3-4
The Schickard carry mechanism. •(Williams



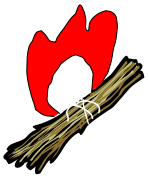
Schickard's calculator: automated

James Tam

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



James Tam

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

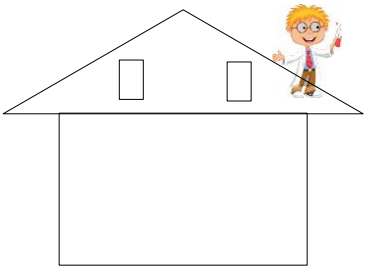
  - Why "no cost"? Recall your algorithm analysis courses.
  - Application of Pascal's wager in modern times.
  - Critiques of Pascal's wager (assumes "there is only one").

James Tam

Blaise Pascal (1623 – 1662)

Copyright unknown

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

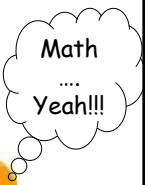


Clipart: colourbox.com

James Tam

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.



Copyrights unknown

James Tam

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

Copyrights unknown

James Tam

Pascal: Other Vocations

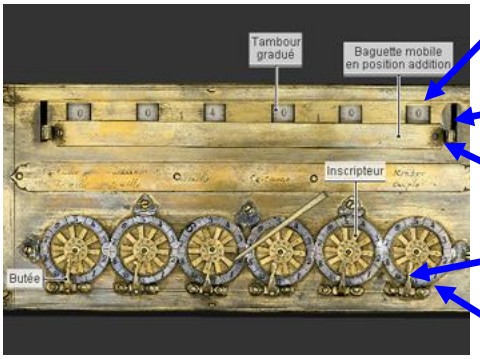
- After his failure at getting others to build his designs he realized that he would have to work as designer and the builder/implementer of the designs
- He trained at other vocations

Copyrights unknown

James Tam

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')



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

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

James Tam

External Extra Videos: Pascaline

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

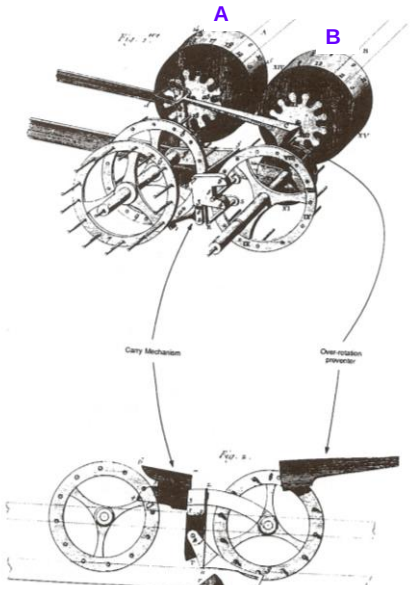
James Tam

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

James Tam

Pascal's Machine: Carry (2)



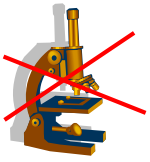
Additional details coming up in Pascaline video #2

James Tam

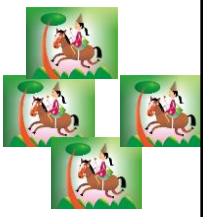
From: A history of computing technology (Williams)

Pascal's Later Life

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



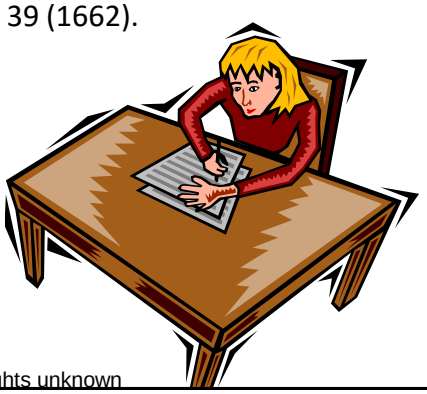



James Tam

Copyrights unknown

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).



Copyrights unknown

James Tam

Gottfried Leibniz (1646 – 1716)

"A history of computing technology" (Williams)

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

colourbox.com

- Doctorate awarded at the university of Altdorf

James Tam

Challenges Faced By Leibniz, Pascal And Others

James Tam

Copyrights unknown

Leibniz's Final Machine

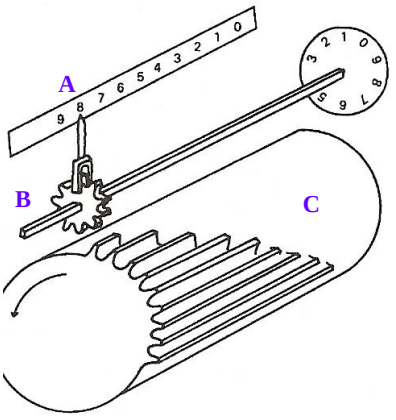
- Luckily Leibniz enlisted the aid of M. Oliver

James Tam

Copyrights unknown

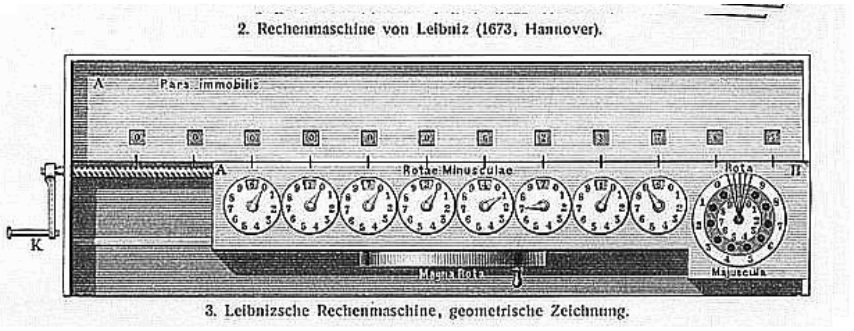
Leibniz's Calculating Machine

It used a 'stepped drum':



James Tam

Leibniz's Calculating Machine (2)



•"*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 "

James Tam

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.

James Tam

External Extra Videos: Leibniz Stepped-Drum

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

James Tam

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)

James Tam

Image copyrights unknown

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

James Tam

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)

James Tam

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

James Tam

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

James Tam

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

James Tam