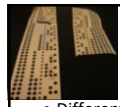
The Mechanical Monsters: Part I

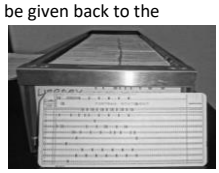
Physical computational devices from the early part of the 20th century: Konrad Zuse and his machines

James Tam



Punch Card Based Machines

- Different machines would use different forms of encoding.
- The programmer would use a machine to punch the information for a program onto card or tape.
- Typically the program would then be given to a computer operator so the program would be run.
- After a delay the results would then be given back to the programmer for analysis.



File images: James Tam

[Link to extra optional video: video of punch cards and punch tape]

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Video #1: The Use Of Computers During World War II

- Video link not available (original video could not be found)

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Mechanical Monsters: Groups

- The Zuse machines (Z1 – Z4)
- Bell Relay Computers
- The Harvard Machines
- The IBM calculators

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The Zuse Machines

- Machines:
  - Z1
  - Z2
  - Z3
  - Z4
- Originally Zuse's machine was called the V1 (Versuchsmodell-1/Experimental model-1)
- After the war it was changed to 'Z' (to avoid confusion with the weapons being developed by Wernher von Braun).

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Konrad Zuse (1910-1995)

- Born in Berlin he had childhood dreams of designing rockets that would reach the moon or planning out great cities.
- He trained as a civil engineer.
  - As a student he became very aware of the labor needed in the calculations in his field.

= (x * y) / (z +(a1 + b))

Image: http://www.konrad-zuse.net

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Konrad Zuse (1910-1995): 2

- Zuse was the first person "…to construct an automatically controlled calculating machine." – "A history of modern computing" (Williams)
  - Not electronic
  - Didn't have a stored program in memory (instructions came from external tape).
  - His first machine, the Z1, was completed in 1938.
    - Don't believe it if you have read that the ENIAC was the first 'programmable' computer (partly working in 1944 and it was hardwired).
- Many of his earlier machines were personally financed or funded by friends and family (limited $$$).
- After finishing school he began work in the aircraft industry.

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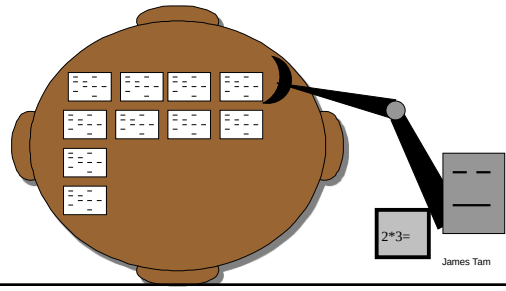
Zuse: Early Designs

- In order to automate the process of performing calculations Zuse envisioned a mechanical machine.



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Zuse: Early Designs

- Based on this early design Zuse came up with a design that included only three parts:
  - Control
  - Memory
  - Calculator

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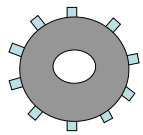
Z1: Origins

- Zuse was not familiar with the design of other mechanical computers.
  - This was a good thing!
  - Zuse had to largely build his design from scratch

Current technology (10)



Zuse's approach (2)

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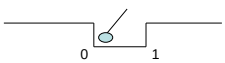
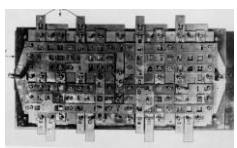
Z1: Memory (Completed 1936[1])

- Memory consisted of strips of metal with slots cut into them.
- A pin would rest on one side of the slot





http://www.techbites.com/

2: Bauer, Friedrich Ludwig (2009-11-05). **Origins and Foundations of Computing: In Cooperation with Heinz Nixdorf Museums Forum**. Springer Science & Business Media. p. 78

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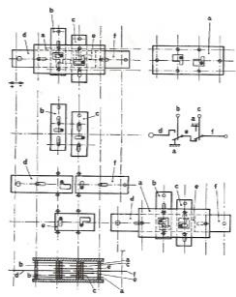
Z1 Memory

- The plates would shift and move (mechanical memory).



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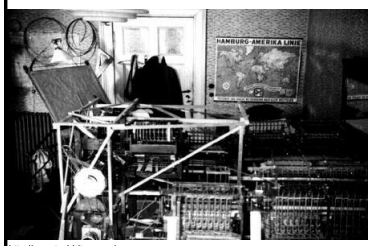
The Mechanical Monsters

Z1: Development 'Lab' 1936



http://www.techbites.com/

Mr. and Mrs. Zuse

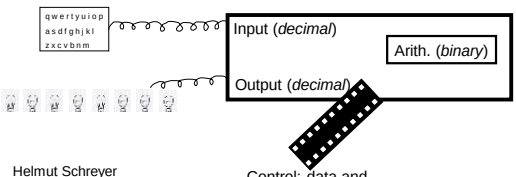
Z1: Specifications

- Storage capability:
  - Memory 64 x 22 bit locations (Source: Interational Federation for Information Processing (IFIP 2013) Horst Zuse: pp 287 – 296)
- Clock speed:
  - 1 MHz (Source: "Giants of Computing" by Gerard: pp 281 – 284 (Springer-Verlag London 2013)
- Completed in 1938[1]:
  - Memory technology already completed in 1936.
  - By this year the accumulator was also complete.

1: Bauer, Friedrich Ludwig (2009-11-05). **Origins and Foundations of Computing: In Cooperation with Heinz Nixdorf Museums Forum**. Springer Science & Business Media. p. 78

The Z1 (2)

- Overview of the architecture



Helmut Schreyer

www.atariaarchives.org

Control: data and instructions (35 mm tape)

The Z1 Memory

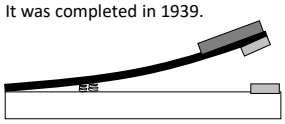
- The memory worked well but the complex routing of the ALU made the transport of information between the parts of the machine problematic:

Memory: Sheets of metal

Location: Cramped Berlin apartment (corners?): Image courtesy of James Tam

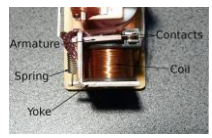
The Z2

- Designed to overcome the signal routing and reliability problems of the mechanical memory by using relays
- It was completed in 1939.



Actual Relays

Telegraph relay: http://www.sparkmuseum.com



Computer relay: http://en.wikipedia.org/wiki/Relay (public domain)

Relay Memory

- The relay based memory was more reliable than the mechanical metal sheets.
- And the resources were easier to obtain than vacuum tubes.
- The initial design was to entirely use relays but was unfeasible:
  - $2/relay * thousands of relays
  - Rebuilt second hand relays were used instead
- However even the Z2 was not reliable enough to be put into actual use
- It's one major contribution was to get funding from to allow for further work (Z3)

Z2: Alternate Memory

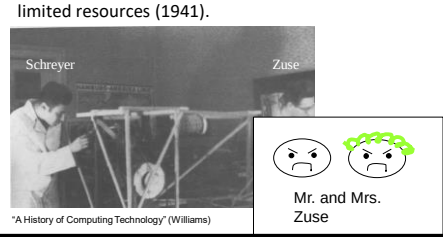
- Schreyer wanted to build the Z2 with vacuum tube memory
  - A demo of a portion of the computer did use vacuum tubes
  - But during the war the tubes were scarce and the Z2 would have needed 1000 tubes
  - The military wouldn't provide the tubes because of the development time needed.

Z2 Spec

- It was very similar to the Z1
- (Source: "Giants of Computing" by Gerard: pp 281 – 284 (Springer-Verlag London 2013)
  - Clock speed: 3 MHz
  - Memory: 64 memory locations (each 16 bits in size)

The Z3

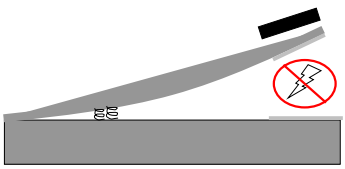
- Although the work was funded by the German Aeronautical Research Institute, Zuse was not provided with a workspace or technical staff.
- As was the case with the Z1, he completed his work with limited resources (1941).



"A History of Computing Technology" (Williams)

The Z3 (2)

- This machine was similar to the Z1 and Z2 (input, output and control)
- It overcame the reliability problems of the relay-technology



The Z3 (3): Source Williams

- It was a relatively fast machine (considering the limited resources and relative isolation of Zuse)
  - Additions: 0.25 – 0.3 seconds
  - Multiply: two numbers every 4 – 5 seconds
  - (Comparable to the speed of the Harvard Mark I which was developed two years later with much greater resources)
- It was developed on a relatively modest budget:
  - 1940s currency: 25,000 RM (~$6,500 US)
- But it wasn't practical for large scale problems (limited memory): 64 words
- 5 - 10 MHz[1]

1: Dalle calcolatrici ai computer degli anni Cinquanta
https://books.google.ca/books?id=p5GszzXR550C&pg=PA177&redir_esc=y#v=onepage&q&f=false

The Z3 (5)

- The original was destroyed by the allies in 1943-1944.
- Zuse made a copy in the 1960s which is on display in a museum.

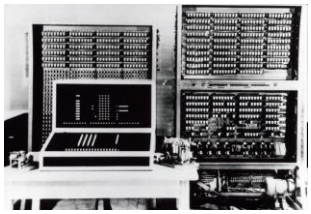


Image: www.computerhistory.org

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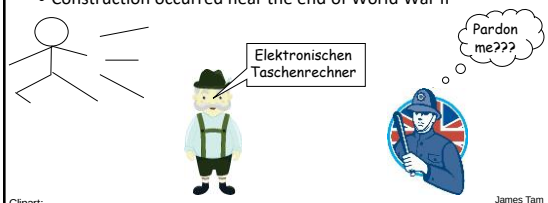
The Z4

- Essentially the same as the Z3 (save that the word size was larger).
  - Z3: 22 bits (1=sign, 14=mantissa, 7=exponent), 5 – 10 MHz
  - Z4: 32 bits, 40 MHz (Source unconfirmed)
- Construction occurred near the end of World War II



Clipart: www.colourbox.com

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The Z4

- After the war the Z4 was completed and a few upgrades were added (e.g., conditional branch).
- In 1950 it was the only operational computer in Europe and one of the few in the entire world (Williams).
- It continued to provide useful service until 1960.

James Tam

Significance Of The Zuse Machines

- The Zuse computers were the first automatically controlled calculated machines that were actually functional.
- They had comparable speeds to machines developed later (Harvard Mark I).

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Significance Of The Zuse Machines (2)

- It's also remarkable considering the working conditions:
  - Limited resources

"A History of Computing Technology" (Williams)

$$$

  - Isolation (WWII!)

James Tam

Video #2: Konrad Zuse Machine

- Workings of the Z1 from the Technikmuseum, Berlin
  - https://www.youtube.com/watch?v=RG2WLDxi6wg

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Video #3: Operation Of A Relay-Based 'Computer'

- Original video link could not be found.
- Alternate video link:
  - The 'relays' are different from computers such as the 'Z' series computing devices but you can at least see the connectivity occur between circuits.
  - Also see Video #4 to see how relays of the era operated.
  - https://www.youtube.com/watch?v=1it3kjlgocc

James Tam

After This Section (M.M. All Parts) You Should Now Know

- What were the 4 categories/families of mechanical monsters
- In each of the 4 categories:
  - What machines were created and by whom
  - What were some of their important technical specifications and the general appearance of the machine
  - How did the machines work/what technology was employed in their manufacture
  - Why was the significance of the machine/technology (some machines will have more information than others)
  - How were these machines used and what was their eventual fate (with the latter point not a great deal of information may be available for all machines)
  - (For the machines with their own custom encoding) how did the encoding system store information

James Tam

After This Section (M.M. All Parts) You Should Now Know (2)

- Who were some of the people behind the development of these machines
  - What were some of the milestones and accomplishments in their lives
  - What were some of their motivations in the design of the mechanical monsters
- Approximately when (and in what order) did milestones in the development of the mechanical monsters occur

James Tam

Source Material

- "A history of modern computing" Michael R. Williams (IEEE 1997)
- Interational Federation for Information Processing (IFIP 2013) Horst Zuse: pp 287 – 296
- "Giants of Computing" by Gerard: pp 281 – 284 (Springer-Verlag London 2013)
- Origins and Foundations of Computing: In Cooperation with Heinz Nixdorf Museums Forum. Bauer, Friedrich Ludwig. (Springer Science & Business Media 2009) p. 78

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