Main Memory Prior to Semiconductors Being Practical

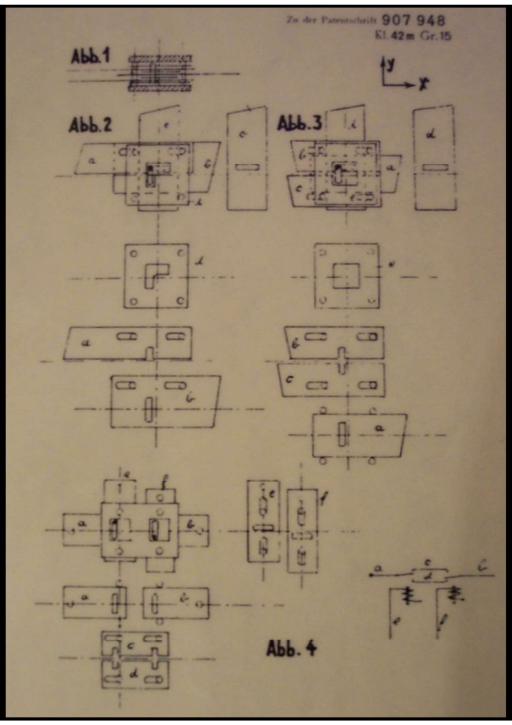
Delay Lines, Williams Tubes, Magnetic Drums, and Magnetic Core

John Haldeman – Hackforge – August 2017

Main Memory

What is meant by memory or main memory in this presentation:
- Memory that the processor interacts with – Reading data/instructions and writing it back
- Not necessarily memory for long term storage – Hard Disks and tape for instance are a separate subject

1938



Various computing machines, if they needed or used memory that was processed used mechanical mechanisms

This eventually culminated in Konrad Zuse's machines such as the Z1 memory mechanism shown above. Later machines Zuse built used relays instead and eventually drum memory (discussed later).

Mechanical mechanisms for memory we too slow to be used for many purposes – especially when computing machins became electronic and needed faster access to the memory

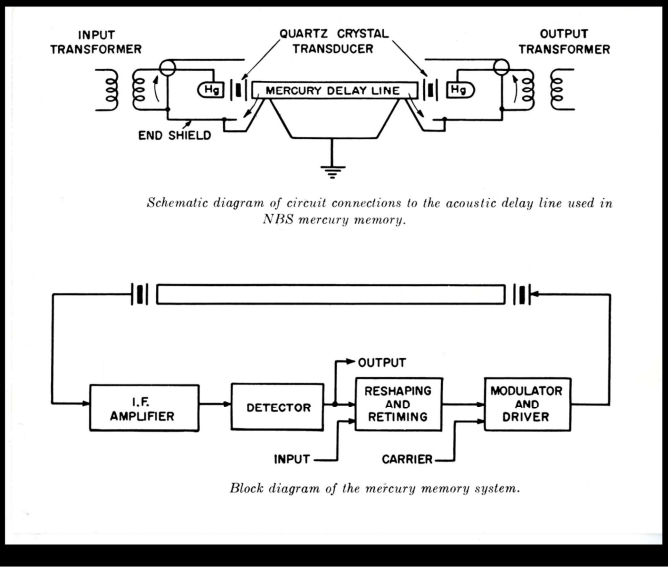
RADAR

A lot of computing technology and computer engineers originated from work on RADAR during World War 2.

A problem with RADAR:

- Send a signal and detect the beam being bounced back to a receiver
- You pick up both moving targets (an aircraft) and stationary targets (a mountain)
- Solution – point the RADAR above the stationary objects on the ground – Problem: Flying under the RADAR and difficulty calibrating mobile RADAR
- Subtractive RADAR – Take two readings and subtract the first reading from the second – Removes stationary objects and gives you moving objects – Problem: You need a way to remember the first reading – You need a memory

Delay Lines



Schematic diagram of circuit connections to the acoustic delay line used in NBS mercury memory.

Block diagram of the mercury memory system.

Mercury delay lines were originally used in RADAR equipment to capture the original readings in memory that were subtracted from new readings.

They were also used in computing. The idea is you transmit a sound wave through the mercury and receive it on the other end (mercury was used due to a similar acoustic impedance to quartz).

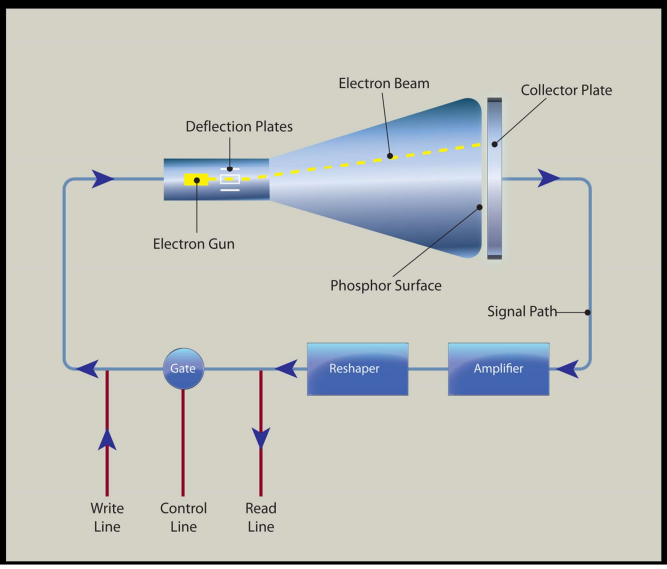
UNIVAC I Delay Lines (1951)

One computer that used mercury delay lines was the Eckert and Mauchly's UNIVAC 1 (there are many others but the UNIVAC is very notable as the first commercial general purpose computer in the US and has some of the best pictures).

There were also non-mercury based delay lines and eventually torsional delay lines that just used wire. For awhile they were used until transistors became cheap enough to use them everywhere. For example, they were used in some of the IBM terminal systems prior to the 3270.

UNIVAC 1's capacity:
1000 words of 12 characters (a decimal instead of binary machine)

Williams-Kilburn Tubes

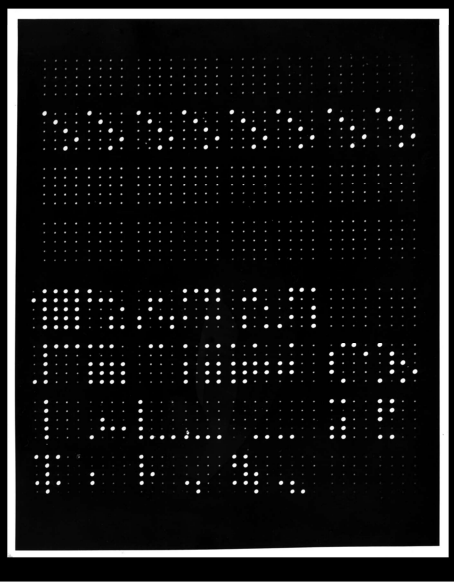


Another ingenious use of RADAR technology for memory.

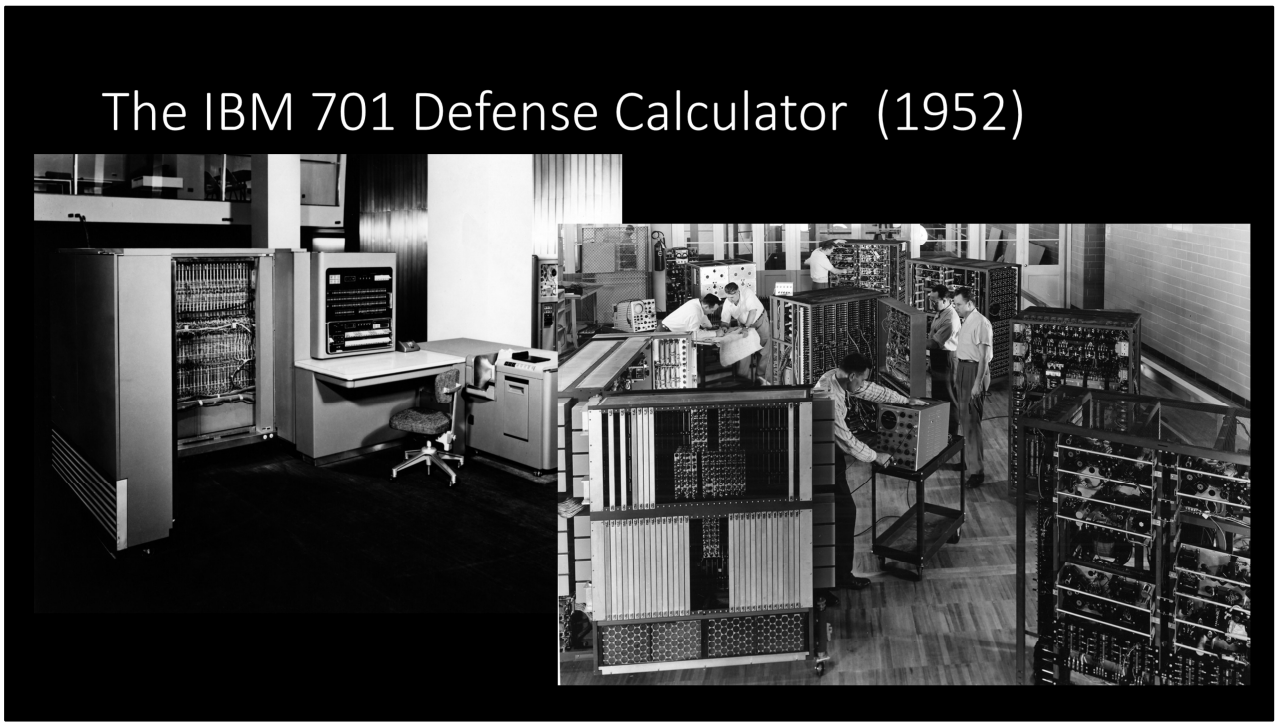
Here CRTs were used as televisions are to display RADAR information to people manning the RADAR. Long persistence phosphor was occasionally used to have the detected objects remain on the screen for a long time.

You can use phosphor to persist an image and use that image as storage

Williams-Kilburn Tubes

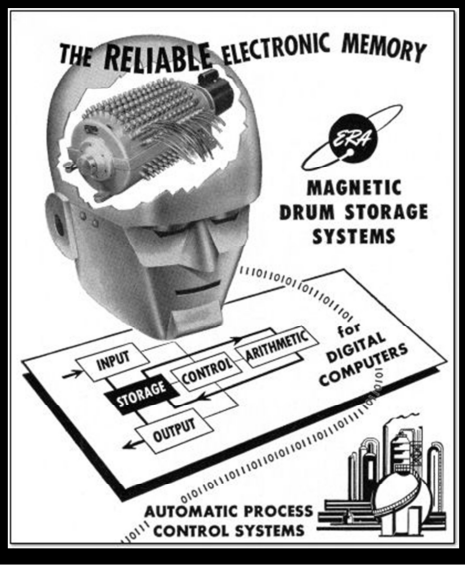


Pictures illustrating Williams Tubes



IBM 701 Defense Calculator: 2,048 36-bit words

Magnetic Drums



Magnetic drums are effectively large hard disks where instead of spinning a disk or set of disks, you spin a drum with a read head.

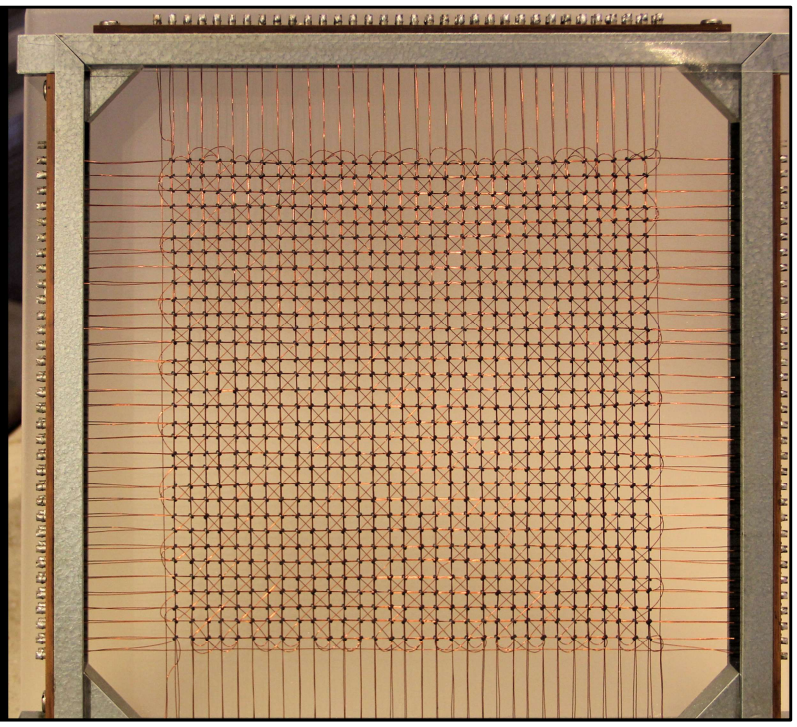
Sometimes it was effectively used as a hard disk or for swap space – a second tier storage device with a faster main memory unit (eg: Use of Williams Tube/Drum Memory combination in the Manchester Mark 1)

IBM 650

Rotating drum memory provided 1,000, 2,000, or 4,000 words of memory (a signed 10-digit number or five characters per word). Words on the drums were organized in bands around the drum, fifty words per band, and 20, 40, or 80 bands for the respective models.

Drum rotated at 12,500 rpm. non-optimized average access time was 2.5 ms. Optimization occurred by positioning instructions on the drum in such a way that they would be immediately available when needed (without waiting for the drum to rotate).

Magnetic Core



Magnetic cores are built by organizing a set of rings that can hold be magnetized in two different ways – clockwise or anticlockwise (representing 1/0). Then stringing write wires horizontally and vertically – you can change the magnetization type by running a current through those wires. Then a read wire is woven through every ring.

Reads are destructive – meaning every time you read you have to re-write the data. There were special cores that weren't write-destructive but they were expensive and only used in high speed systems.

MIT Whirlwind