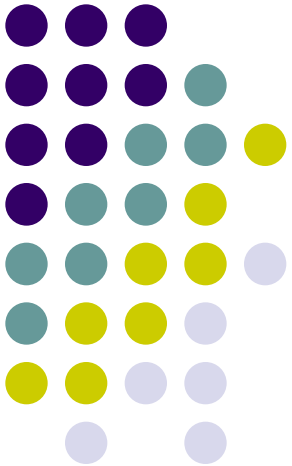
CSE 301
History of Computing

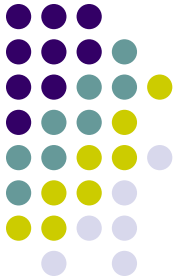
Electromechanical & Analog Computing



The typewriter

- First practical typewriter invented by Christopher Latham Sholes in 1867
  - Soon sold by Remington
- One historian of manufacturing has noted, the "typewriter was the most complex mechanism mass produced by American industry, … , in the 19th century"
- Pioneered 3 key features of the office machine industry (and thus later the computer industry)
  1. The perfection of the product & low-cost manufacture
  2. A sales organization to sell the product
  3. A training organization to enable workers to use the technology

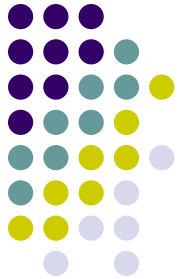
Other office technologies



- Adding Machine
  - Arithmometer by Thomas de Colmar of Alsace (1820)
    - impractical, slow to manufacture
  - Comptometer by Dorr E. Felt (1880s)
    - first “practical” adding machine
  - Burroughs Adding Machine by William Burroughs
    - Printed results, was commercially successful

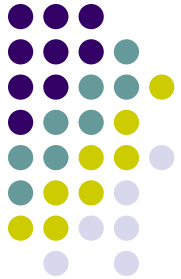
- Cash Register
  - Invented by restaurateur James Ritty in 1879
    - Sold only one machine – to John H. Patterson
  - Patterson, “an aggressive, egotistical crank”, ran with Ritty’s invention
    - bought and then renamed Ritty’s company to the National Cash Register Company (NCR)
    - innovated sales techniques

Thomas J. Watson, Sr.



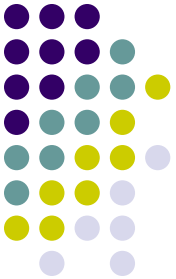
- Born in Campbell, New York, in 1874
- Worked as salesman for NCR
  - moved up quickly in the company
    - he was a sales fanatic
  - worked on “secret project” for Patterson
    - helped him move up through company ranks
  - after success, he was abruptly fired in 1911
  - Hired by C T R (Computing-Tabulating-Recording Company) in 1914
    - CTR was a firm created by Charles Flint that had merged 3 others, including Hollerith’s
    - Watson combined NCR sales techniques with Hollerith’s technology
    - renamed the company International Business Machines in 1924
    - Watson helped “Big Blue” grow rapidly
- Gave aid to Nazis during WWII?

Big Blue's Rise



- Hollerith was smart to rent machines rather than sell them
- Watson took advantage of this
  - resisted business & government pressure to sell machines
  - punched cards were sold for huge profit margins
- "rent and refill" nature of the punched-card business made IBM virtually recession proof
  - steady year-after-year income
    - even during the Great Depression
  - rarely lost customers
  - necessary accuracy of punched cards made competition nearly impossible
- Government contracts also helped
  - The government never goes out of business
  - FDR's New Deal gave IBM a lot of business
    - Watson's political support for the New Deal helped IBM get even more
- Another factor that kept IBM on top: technical innovation
  - more on this as the semester progresses

Analog Computers

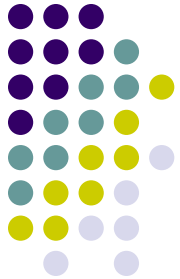


- Instead of computing with numbers, one builds a physical model (an analog) of the system to be investigated
- Used when a system could not be readily investigated mathematically
- Special purpose instruments
- Their heyday was between WW I & WW II
  - Scaled models of dam projects, electrical grids, the Zuider Zee, California irrigation projects, British weather (yikes)

Analog Computers

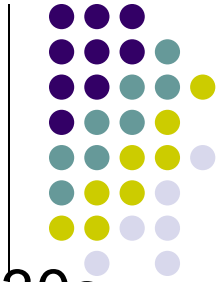
- Lord Kelvin (1824-1907) (William Thomson)
  - Father of Analog Computing
  - Invented analog tide-predicting machine (1876)
    - Used in thousands of ports throughout the world
  - Many other inventions

Vannevar Bush



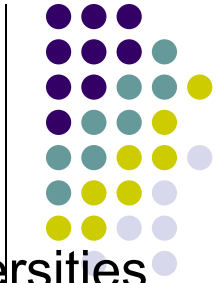
- Developed the profile tracer
  - a bicycle wheel with gadgetry for measurement
  - a one-problem analog computer
    - used to plot ground contours
- During WW II, Bush became chief scientific adviser to Rooservelt
- Another analog computer he developed was the differential analyzer

Differential Analyzer



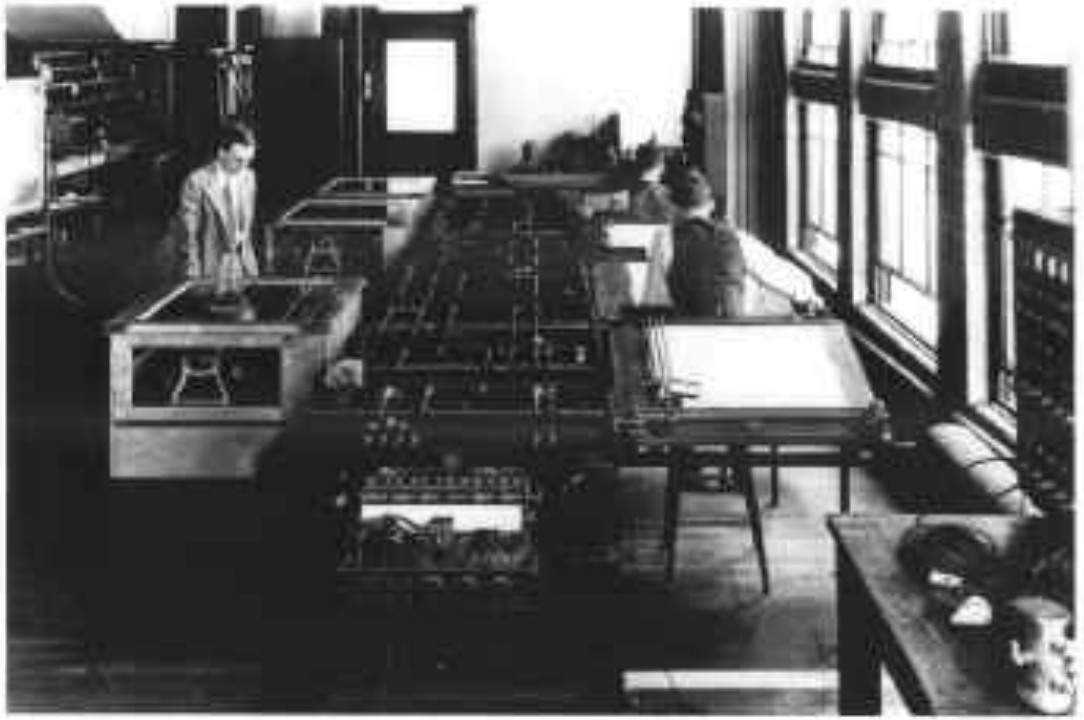
- Designed by Vannevar Bush at MIT
  - starting in the 1920s and completed in the early 1930s
- More of a general purpose computer (still limited)
  - Useful for differential equations
    - Describe many aspects of the physical environment involving rates of change
      - Accelerating projectiles
      - Oscillating electric currents

Differential Analyzer (continued)



- Useful for a wide range of science & engineering problems
  - versions built and used to advance knowledge at many Universities
    - including University of Pennsylvania, which led to the modern computer (we'll see this later)
- Rockefeller Differential Analyzer completed in 1942 at MIT
  - Massive machine
    - 100-tons
    - 2000 vacuum tubes
    - 150 motors
  - Fell into secrecy during World War II
  - Emerging after WWII, the Differential Analyzer was already obsolete, being replaced by digital computers like ENIAC

Differential Analyzer

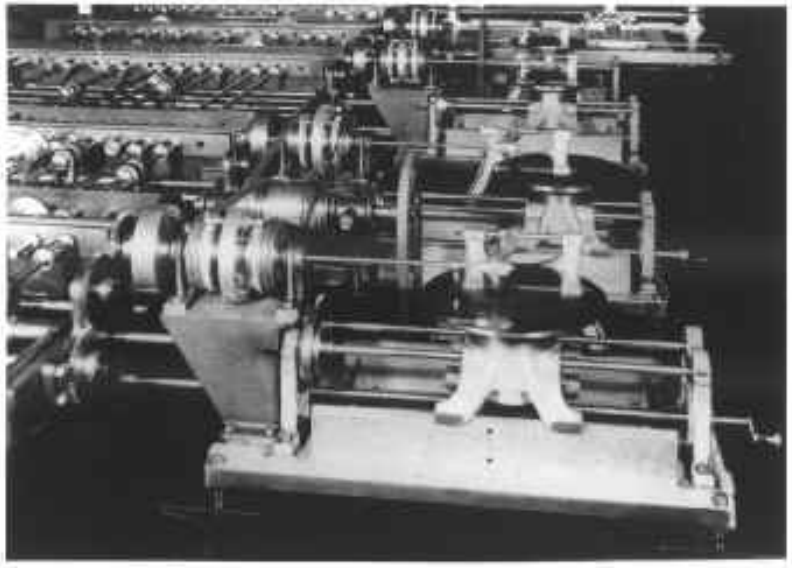


The Differential Analyzer (MIT Museum)

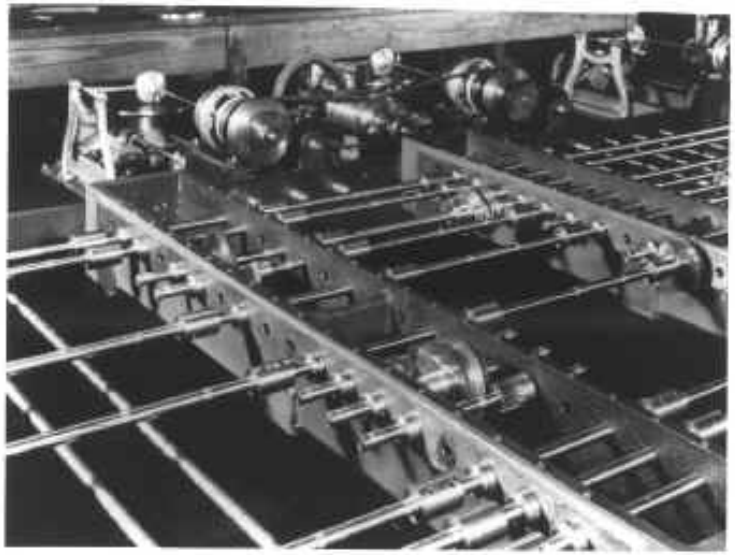
Differential Analyzer

Operator's console of the Differential Analyzer (MIT Museum)

Differential Analyzer

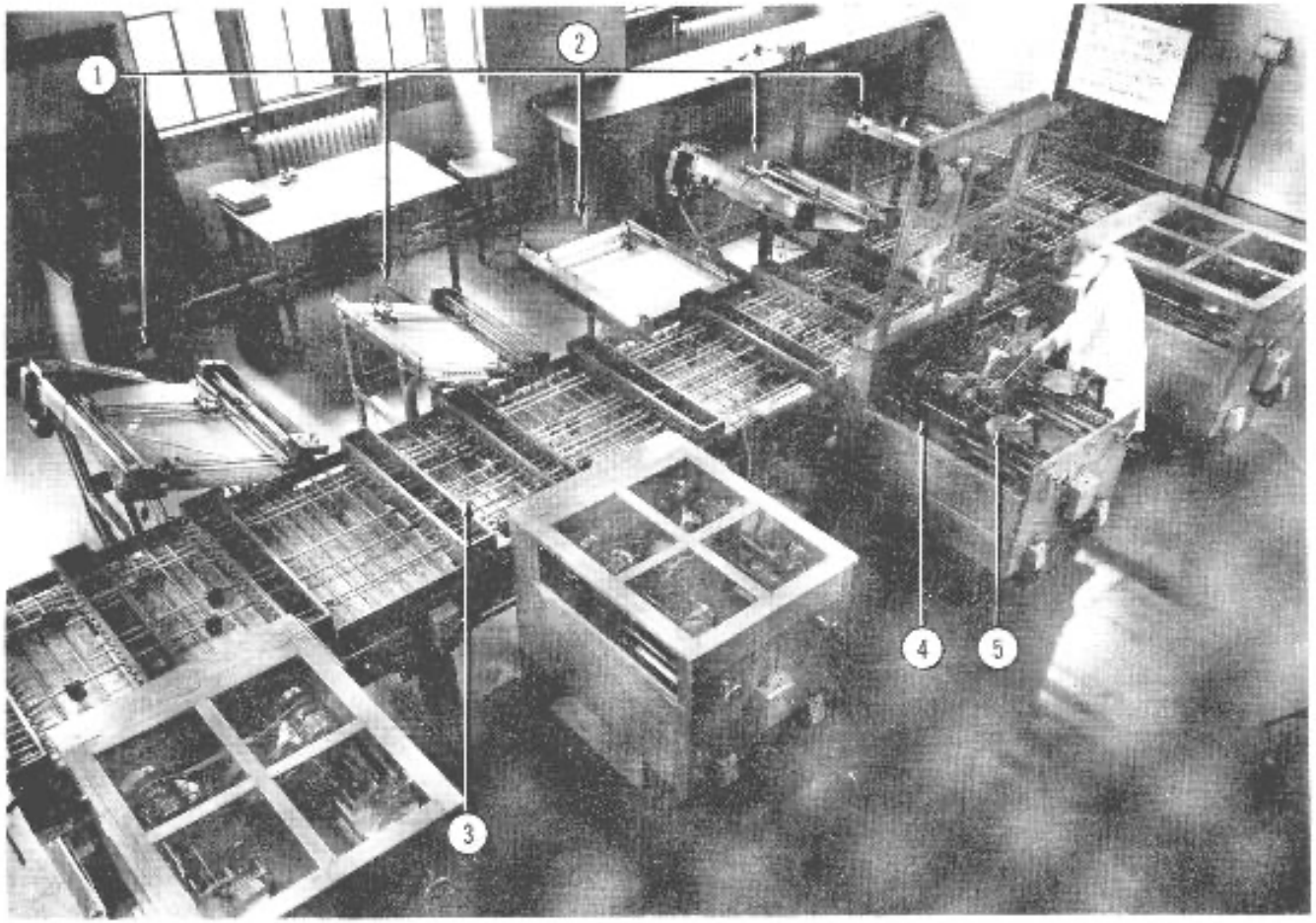


Close-up of wheel and disk integrators on the machine (MIT Museum)



Close up of bus rods which carry variables between different calculating units (MIT Museum)

Differential Analyzer

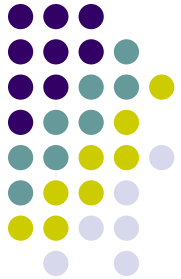


1 Input table
2 Output table
3 Shafts and gears used for interconnection
4 Torque amplifier
5 Integrator disk

FIG. 4. The differential analyzer system, showing integrators, torque amplifiers, and shafting.

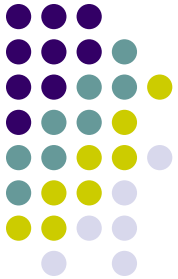
Another view

Advantages of Analog Calculation



- Ability to solve a given problem numerically even without the ability to find a formal mathematical solution
- Ability to solve even a very complex problem in a relatively short time
- Ability to explore the consequences of a wide range of hypothetical different configurations of the problem being simulated in a short period of time
- Ability to transmit information between components at very high rates

Disadvantages of Analog Calculation

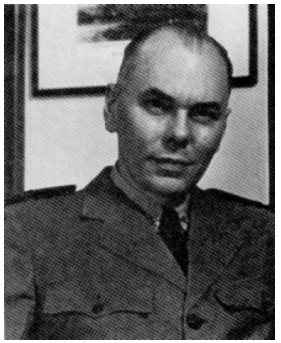


- An analog device is not universal.
  - not sufficiently general to solve an arbitrary category of problems
- It is difficult if not impossible to store information and results.
- It does not give exact results.
  - Accuracy can vary between 0.02% and 3%
- The components of an analog computer will function as required only when the magnitudes of their voltages or motions lie within certain limits.

Harvard Mark I

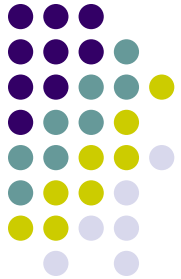
IBM Automatic Sequence Controlled Calculator

- *Digital* computer
  - Aiken's machine for "makin' numbers"
- Developed by Howard Aiken 1937-1943 at Harvard University
  - Inspired by Babbage
  - IBM funded the construction under the permission of Thomas J. Watson



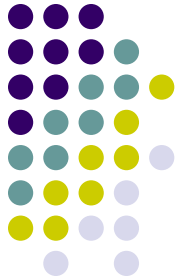
- Constructed out of switches, relays, rotating shafts and clutches
- Sounded like a "roomful of ladies knitting"

Harvard Mark I



- Contained more than 750,000 components
  - over 50 feet long
  - 8 feet tall
  - weighed approximately 5 tons
  - 750,000 parts
  - hundreds of miles of wiring
- Performance:
  - Could store just 72 numbers
  - Could perform 3 additions or subtractions per second
  - Multiplication took 6 seconds
  - Logs & trig functions took over a minute
  - Fed programs using punched tape
  - Could perform iteration (loops), not conditional branching

Aiken vs. IBM



- Watson had IBM give it a facelift against Aiken's wishes
- 1944 – started to be used for table making for the Bureau of Ships
- Intense interest from press & scientific community
  - "Harvard's Robot Superbrain" – American Weekly
- Users manual was the first digital computing publication
- 1944 Dedication Ceremony
  - Aiken took full credit for it, ignoring IBM's Engineer's contribution
  - Made Watson furious
  - Watson wanted revenge
    - not the murdering kind, the let's make a machine that puts the Mark I to shame kind
      - The Selective Sequence Electronic Calculator (later)

Harvard Mark I

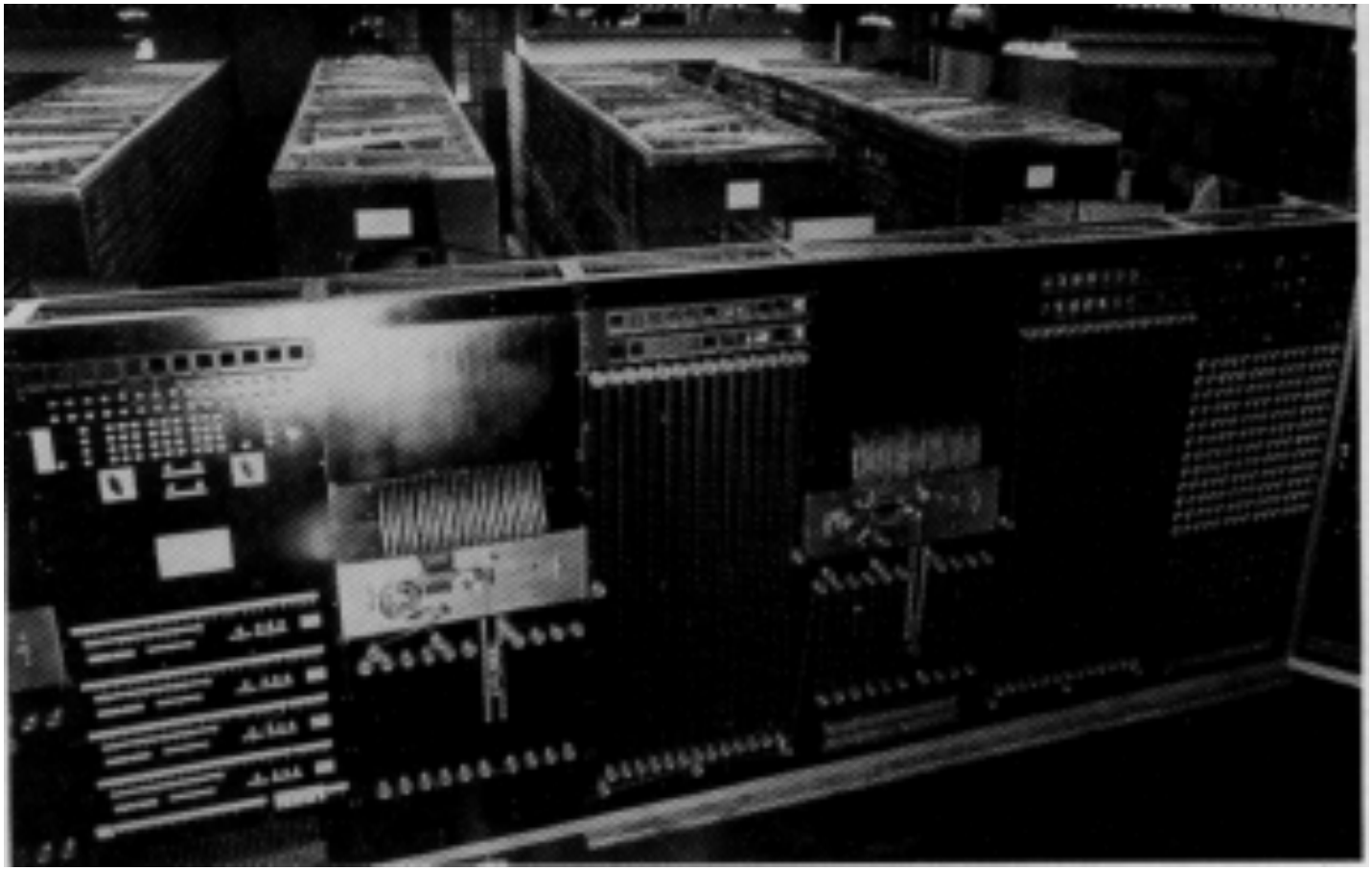
IBM Automatic Sequence Controlled Calculator

- In 1947, how many electronic digital computers did Aiken predict would be required to satisfy the computing needs of the entire U.S.?
  - Six (that's right: 6)

The Harvard Mark I

Harvard Mark I

IBM Automatic Sequence Controlled Calculator



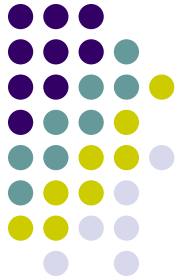
Harvard Mark II

Harvard Mark I

IBM Automatic Sequence Controlled Calculator

Harvard Mark IV

The demise of electromechanical computing



- Computers like the Mark I were quickly eclipsed by electronic machines
  - Electronic machines had no moving parts
- Mark I shortcomings
  - was brutally slow
  - our authors go so far as to say:
    - “Not only was the Harvard Mark I a technological dead end, it did not even do anything very useful in the fifteen years that it ran.”
      - the Navy might disagree slightly
  - “Babbage’s Dream Come True”?
    - ran 10 times as fast as Babbage’s Analytical Engine
    - could not perform decision making (branching)
    - within 2 years electronic machines were working 1000 times faster