Sail Out to Sea with the Women of Computing
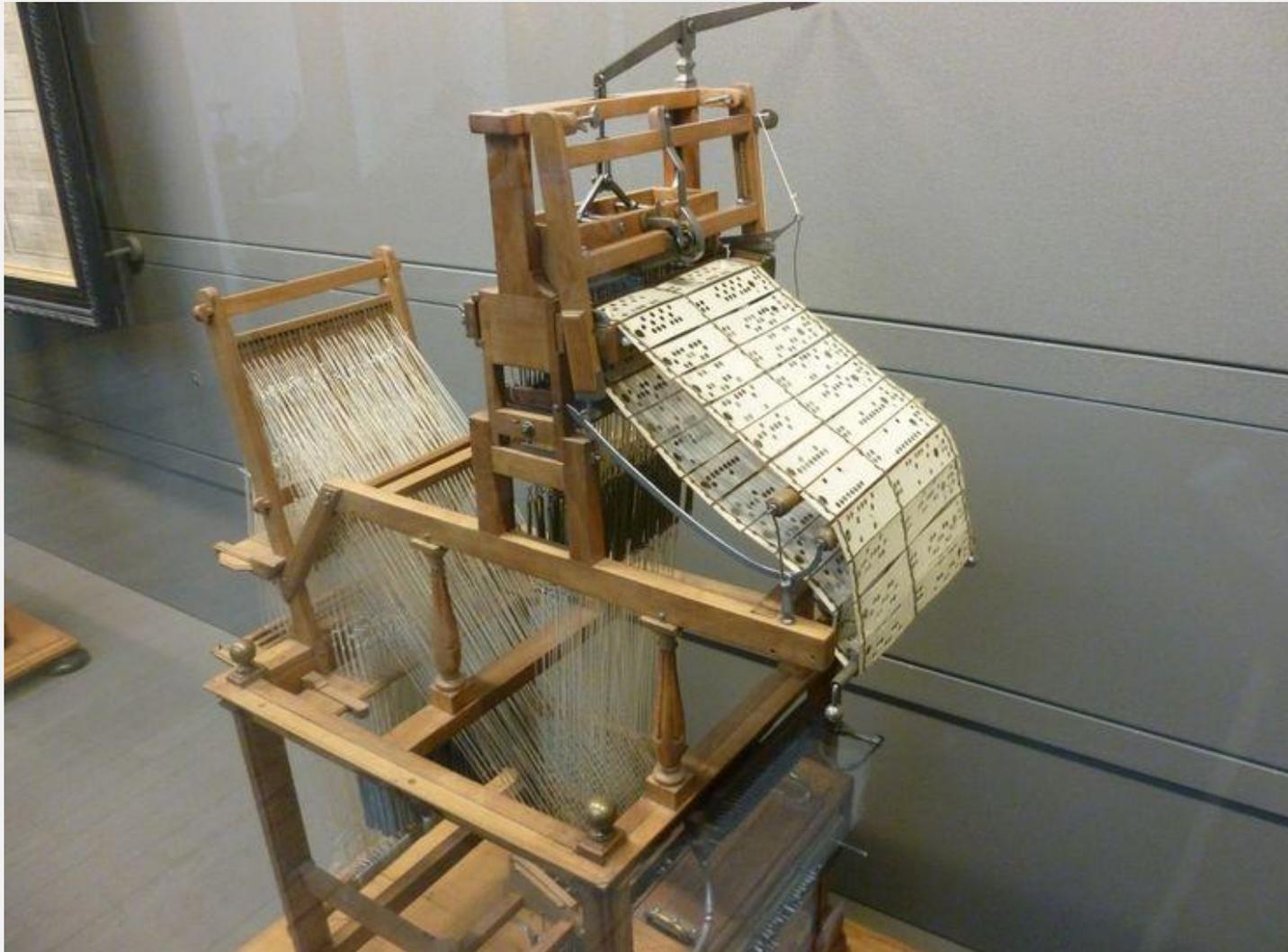
Dr. Pete Sanderson

Professor Emeritus of Computer Science
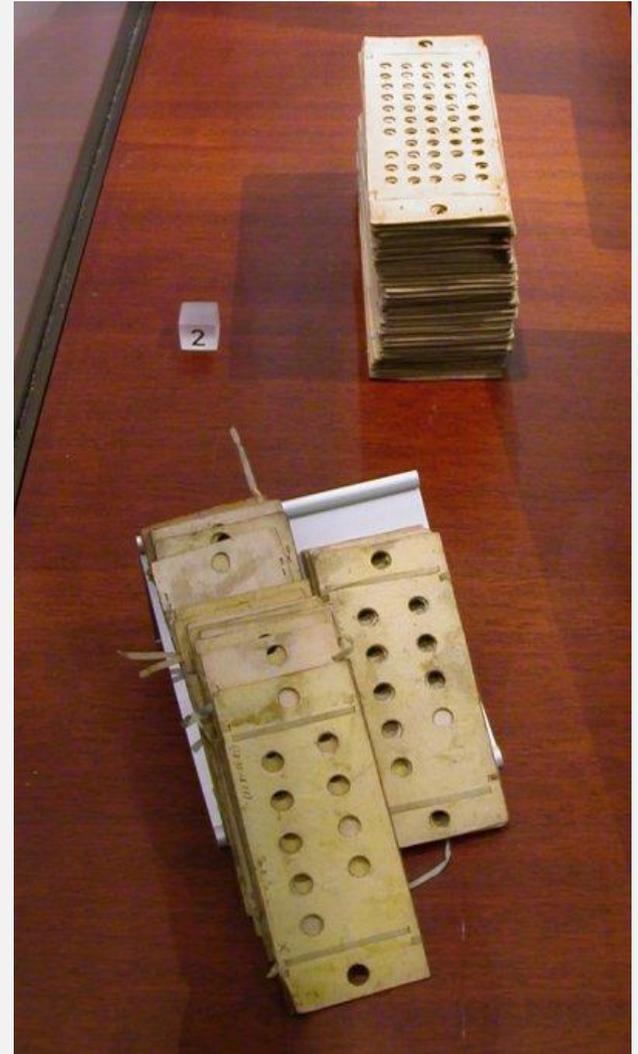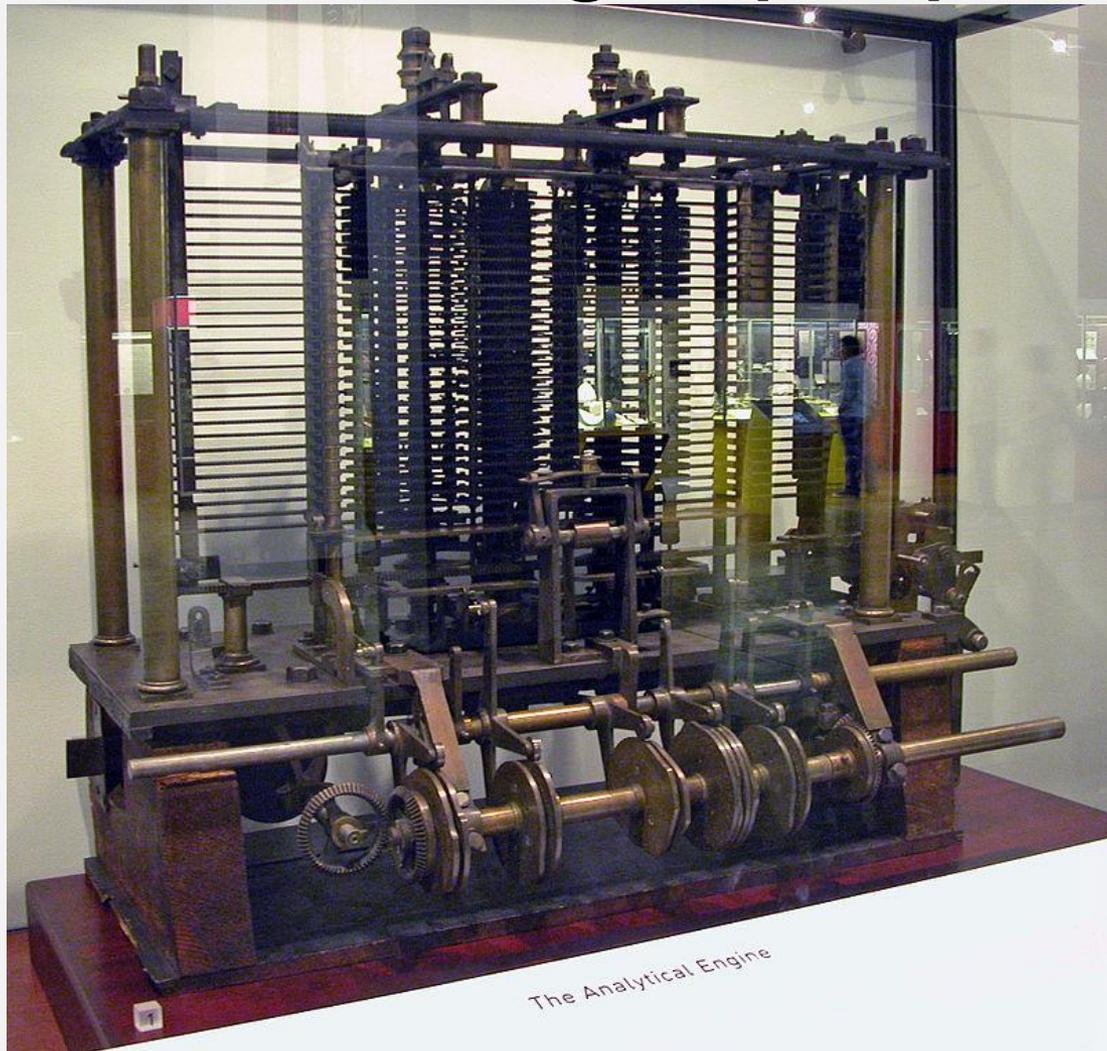
Otterbein University

26 March 2025

Jacquard Loom, invented 1801

Analytical Engine, Charles Babbage, proposed 1837

The Analytical Engine

Ada Lovelace

- Born 1815, daughter of Lord Byron

- Mother promoted her interest in mathematics

- Met Charles Babbage in 1833

- Married William King, Earl of Lovelace, in 1835

- Communicated and Collaborated with Babbage

Ada's Translation and Note

- In 1843, Babbage hired Ada to translate an article about the Analytical Engine.

- Article was written in French for a Swiss journal

- Ada supplemented the 8,000-word translation with a 20,000-word "note"

Quotes from the Translation

The various parts of the machine may be distinguished into two principal classes:

First, that relative to the *Operations*.
Secondly, that relative to the *Variables*.

When two numbers (Variables) are to be combined together, the machine

… transfers the numbers to the mill …

… the required Operation is effected …

… the result is transferred to the column of Variables …

Today's equivalent

Addition using machine language of a modern computer.
A, B and C are variables located in memory (the "store");
R1, R2 and R3 are registers located in the CPU (the "mill")

```
Load R1,A          Load contents of A into R1
Load R2,B          Load contents of B into R2
Add R1,R2,R3       Add contents of R1 & R2, result to R3
Store R3,C         Store contents of R3 to C
```

Ada's Note and Algorithm

- "The Analytical Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves."

- "The engine might compose elaborate and scientific pieces of music…"

- Note G included an algorithm for computing the Bernoulli series.

- This is considered the world's first published computer program!

Algorithm detail from Note G

Number of Operation	Nature of Operation	Variables acted upon	Variables receiving results	Indication of change in the value on any Variable		Statement of Results
1	$\times$	${}^1V_2 \times {}^1V_3$	${}^1V_4, {}^1V_5, {}^1V_6$	$\begin{cases} {}^1V_2 &= {}^1V_2 \\ {}^1V_3 &= {}^1V_3 \end{cases}$		$= 2n$ ....
2	$-$	${}^1V_4 - {}^1V_1$	${}^2V_4$	$\begin{cases} {}^1V_4 &= {}^2V_4 \\ {}^1V_1 &= {}^1V_1 \end{cases}$		$= 2n - 1$ ....
3	$+$	${}^1V_5 + {}^1V_1$	${}^2V_5$	$\begin{cases} {}^1V_5 &= {}^2V_5 \\ {}^1V_1 &= {}^1V_1 \end{cases}$		$= 2n + 1$ ....
4	$\div$	${}^2V_5 \div {}^2V_4$	${}^1V_{11}$	$\begin{cases} {}^2V_5 &= {}^0V_5 \\ {}^2V_4 &= {}^0V_4 \end{cases}$		$= \frac{2n-1}{2n+1}$ ....
5	$\div$	${}^1V_{11} \div {}^1V_2$	${}^2V_{11}$	$\begin{cases} {}^1V_{11} &= {}^2V_{11} \\ {}^1V_2 &= {}^1V_2 \end{cases}$		$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$ ....
6	$-$	${}^0V_{13} - {}^2V_{11}$	${}^1V_{13}$	$\begin{cases} {}^2V_{11} &= {}^0V_{11} \\ {}^0V_{13} &= {}^1V_{13} \end{cases}$		$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$ ....

Ada's legacy

- Ada programming language

- Funded by US Department of Defense

- Once mandated for many DoD projects

- Developed 1977-1983

- Still in use today!

Fast-forward 100 years….

What was happening in 1943?

What was the definition of *computer*?

In December 1943, Vassar College mathematics professor **Grace Murray Hopper** joined the US Naval Reserve.

Grace Murray Hopper

US Naval Reserve, 1943-1966, 1967-1971, 1972-1986

Grace and the Mark I

- In 1944, Grace Hopper read the memoirs of Charles Babbage

- She soon joined the Mark I computer project at Harvard

- She wanted to make computers easier to program

- She designed "compilers" to translate English-like instructions into binary

COBOL

- **CO**mmon **B**usiness **O**riented **L**anguage
- Not the first language she helped develop, but the most famous.
- Developed in the 50s
- Still in use today!

COBOL Compiler Example

COBOL language to perform addition:

```
COMPUTE   C = A + B
```

COBOL compiler may translate this to:

```
Load R1,A

Load R2,B

Add R1,R2,R3

Store R3,C
```

then to its binary equivalent (01101010...)

The Bug
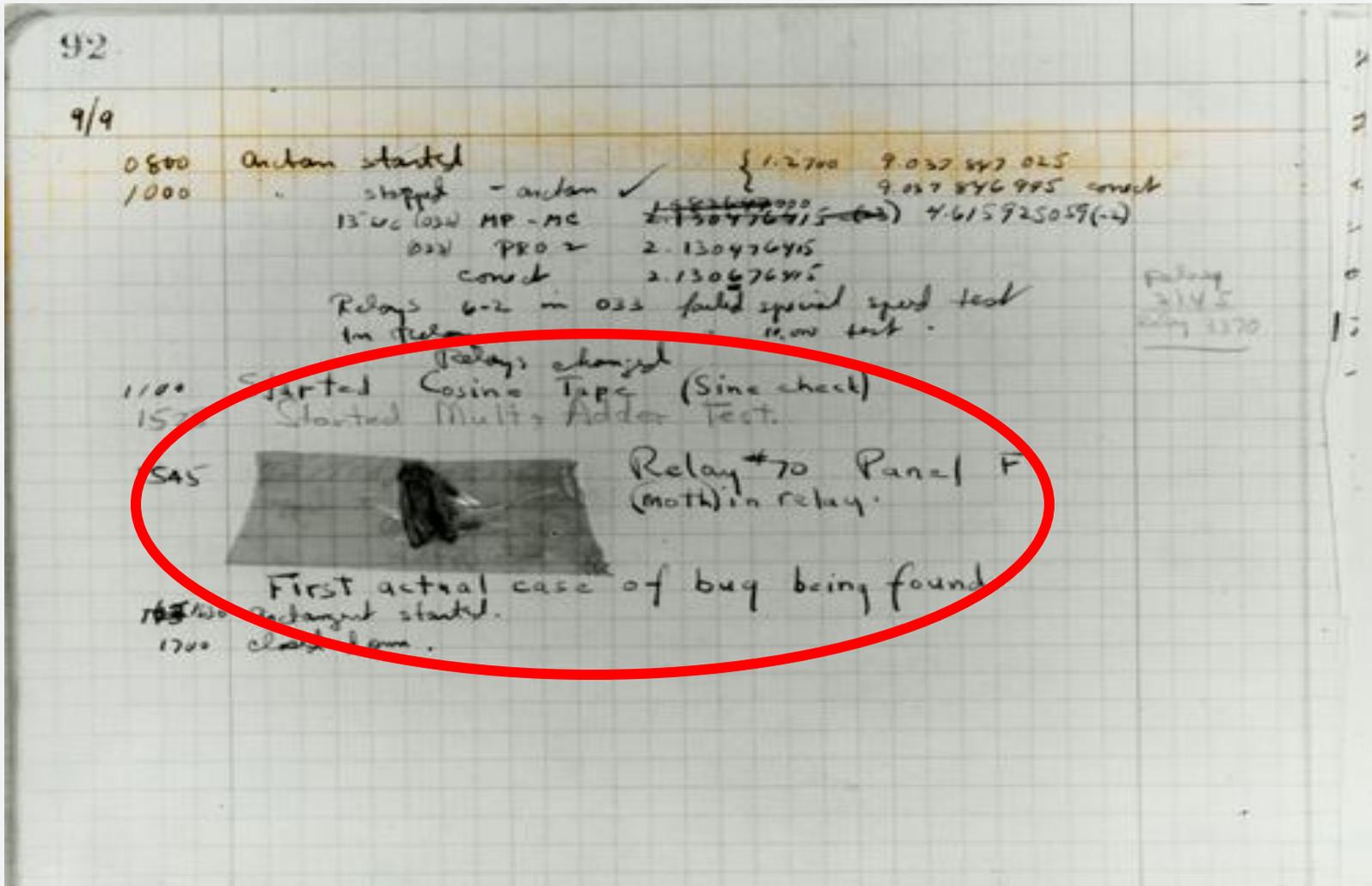
Moth that shorted a circuit in the Mark II computer

Famous Quote

"A ship in port is safe; but that is not what ships are built for. Sail out to sea and do new things."

-- Grace Hopper

* first sentence from John A. Shedd's *Salt From My Attic*

The Nanosecond

Legacy of "Amazing Grace"

- The Annual Grace Hopper Celebration of Women in Computing

- ACM Grace Murray Hopper Award

- National Women's Hall of Fame 1994

- USS Hopper Naval destroyer 1997

- Presidential Medal of Freedom 2016

Meanwhile, over at UPenn…ENIAC
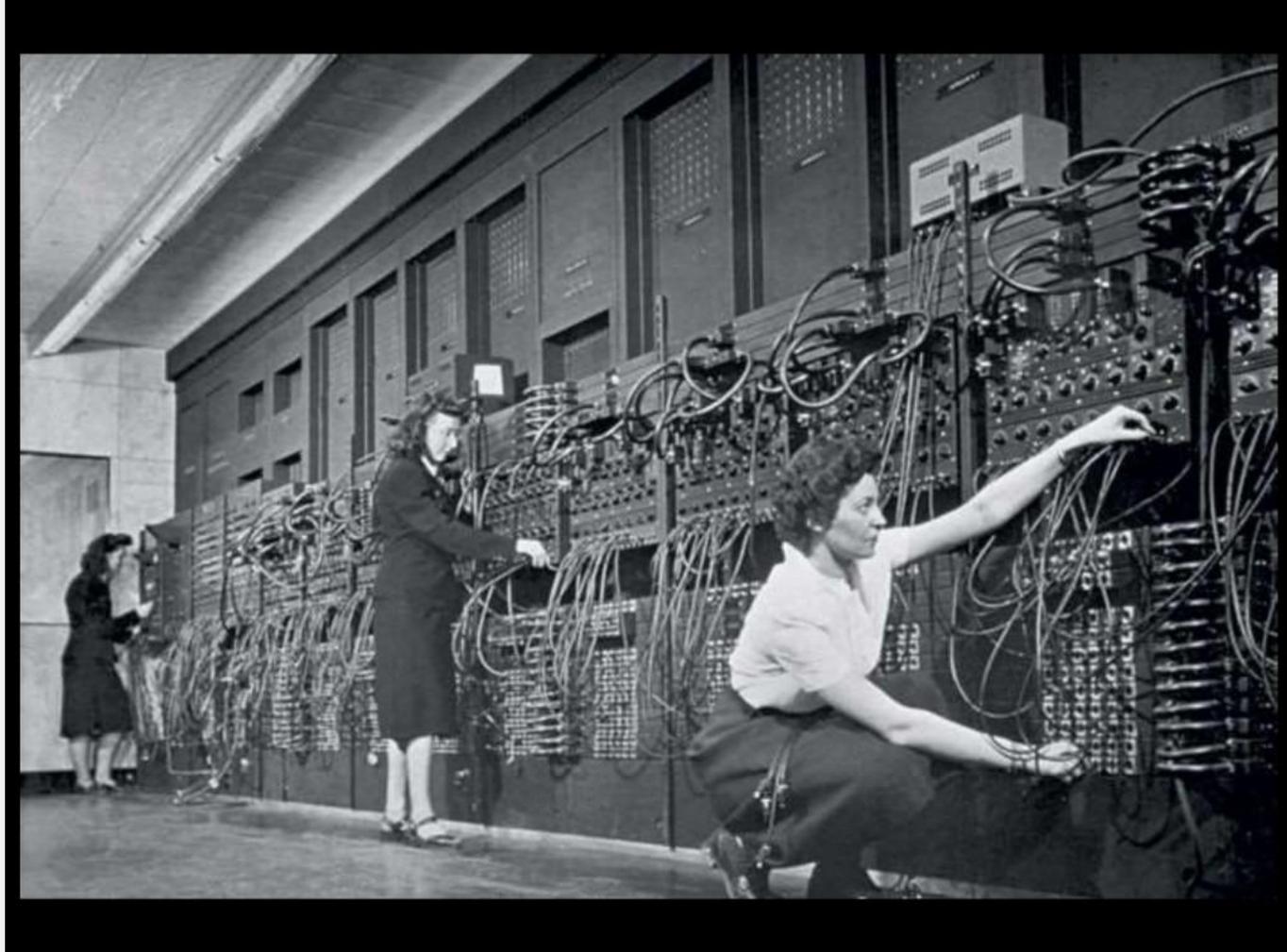
ENIAC

- **E**lectronic **N**umerical **I**ntegrator **A**nd **C**omputer

- Developed to generate artillery firing tables

- U. of Pennsylvania's Moore School of EE

- John Mauchly, J. Presper Eckert
  - After ENIAC they left to found (now) Unisys
  - Grace Hopper would join them in 1949

Programming ENIAC

- Each program required different circuit design

- This was done using modular circuits and plugboards

- Six "computers" were hired to program it
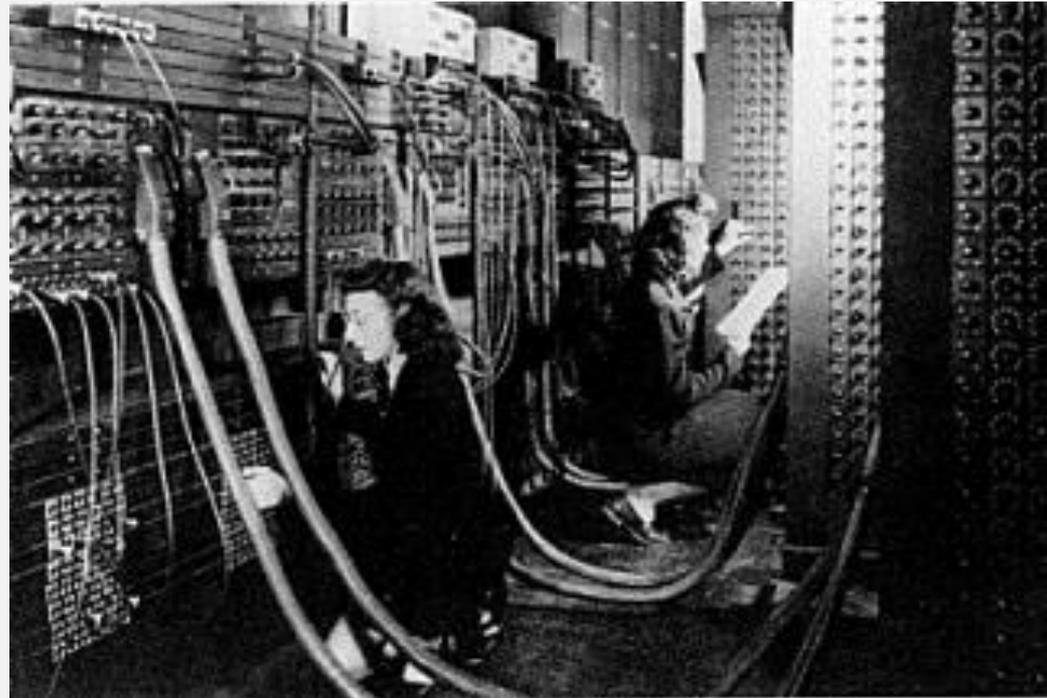
The 6 ENIAC Programmers

"Direct Programming"

- No computer! No manuals! All they had were circuit diagrams!

- ENIAC had 27 units,18,000 vacuum tubes.

- 20 units to add & store, 3 to multiply, 1 to generate "clock" pulses

- Kay discovered the *master programmer unit* could implement loops and if-then!

"Pedaling Sheet"

- Jean, Betty and Kay translated calculations step-by-step into unit activations, constructing a table similar to Ada's.

- Each row is a step, each column is a unit, each cell contains its settings.

- They called the table a "pedaling sheet" like riding a bicycle one pedal stroke at a time

Demo Day 15 Feb 1946

- All 6 wrote and debugged the trajectory program before having access to ENIAC!

- Major public demonstration February 1946, birth of the information age

- Program ran correctly, calculating trajectory in 20 seconds versus human 30-40 hours!

"One small step for (a) man..."

On 20 July 1969,
Neil Armstrong
took humankind's
first step on the moon

Ever wonder who
programmed the
Apollo 11 command module computer?

…meet Margaret Hamilton!
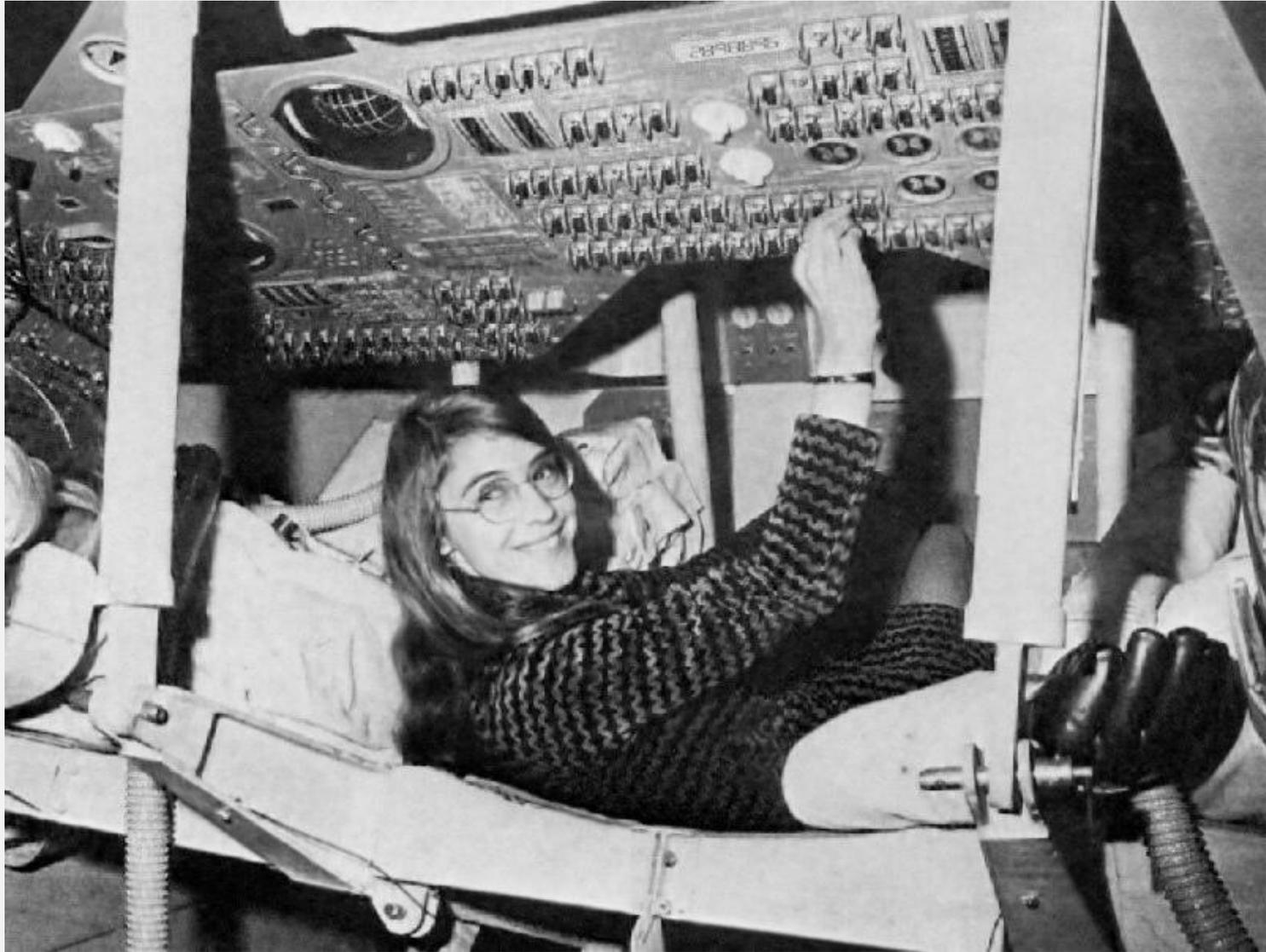
Margaret Hamilton

- Indiana native, taught high school math

- Joined MIT lab working for NASA

- Led the team that developed Apollo 11 fight control software

- Credited with coining the term *Software Engineering*

Mission Critical

Her software saved the Apollo 11 lunar landing when the on-board computer became overwhelmed with tasks.

It correctly prioritized them in real-time.

with source code listing for Apollo Guidance Computer, 1969

Full Circle

Margaret Hamilton, still active at 88, is a recipient of the **Augusta Ada Lovelace Award** from the Association of Women in Computing

Highest Honors

On November 22, 2016 Margaret Hamilton and Grace Hopper were awarded the **Presidential Medal of Freedom**, the highest civilian award in the United States.

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Hidden Figures

Katherine Johnson

Dorothy Vaughan

Turing Awards

Francis Allen   Barbara Liskov   Shafi Goldwasser

Languages & AI

Jean Sammet   Mary Shaw   Qiheng Hu

Two of my Mentors

Joyce Statz

Mary Lou Soffa

Where are we today?

The highest percentage of female computer science graduates is 36%, when?

A. 1985

B. 2000

C. 2015

Percentage of Female Computer Science Degree Recipients, by Year
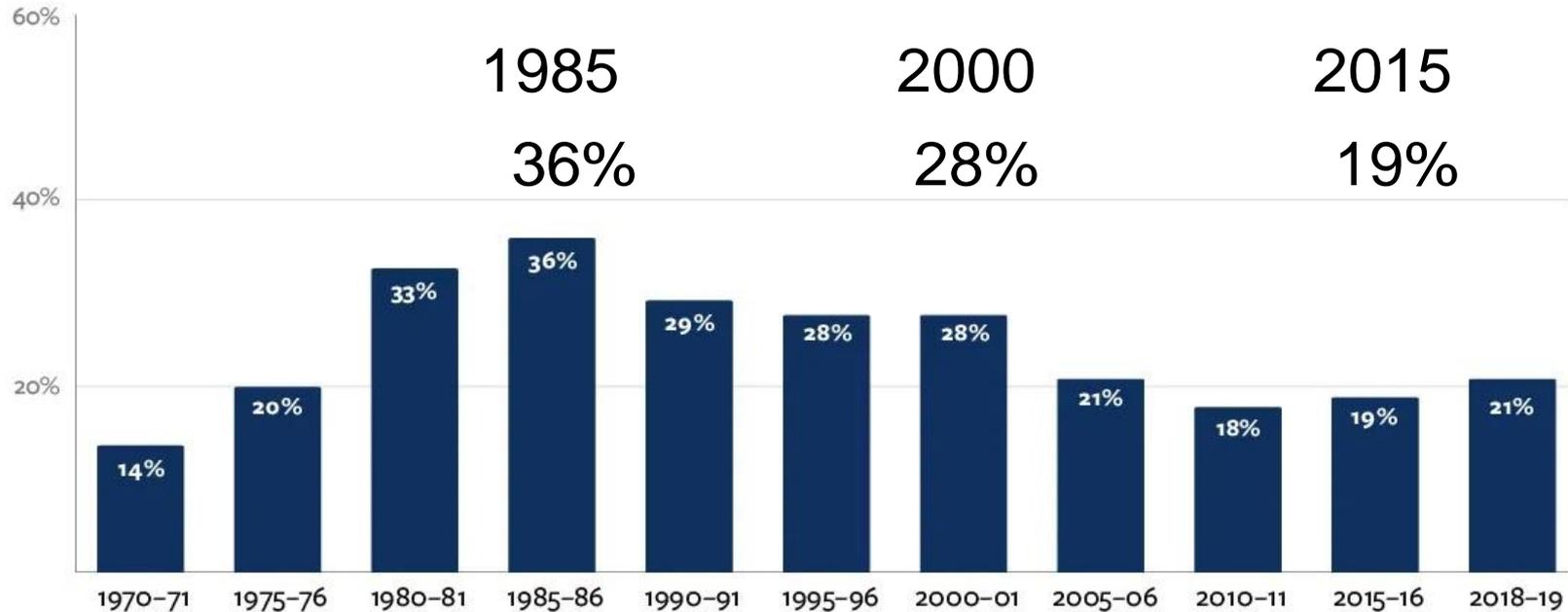
What is being done?

- Girls Who Code

- Code.org

- Systers (online forum for women in IT)

- National Center for Women & IT (NCWIT)

- Association for Women in Computing

- Anita Borg Institute for Women and Technology

- Grace Hopper Celebration of Women in Computing

- Computer Science Education Week

Book Resources
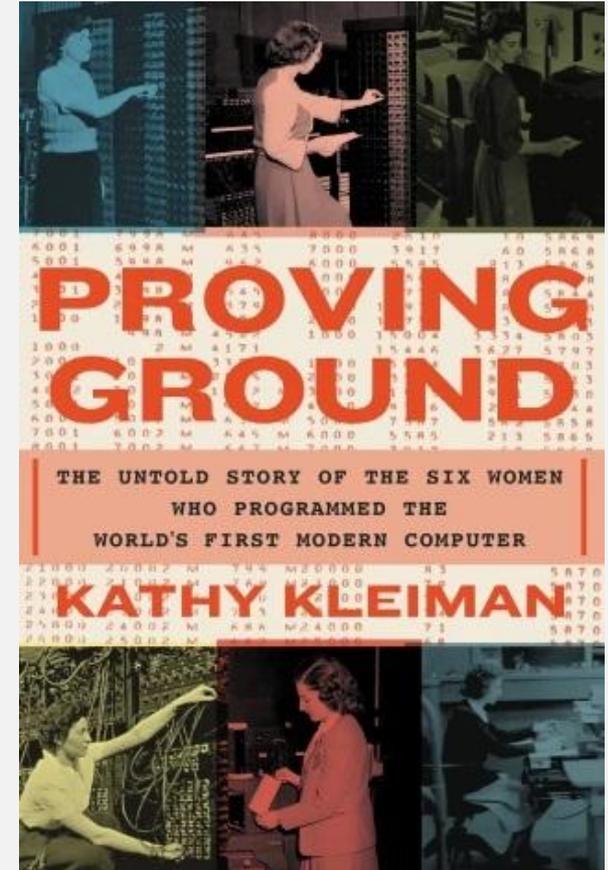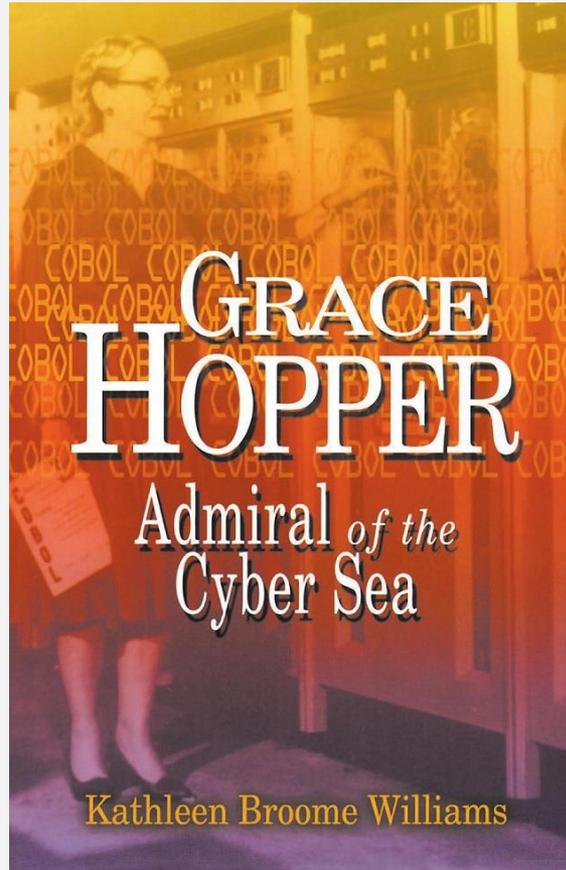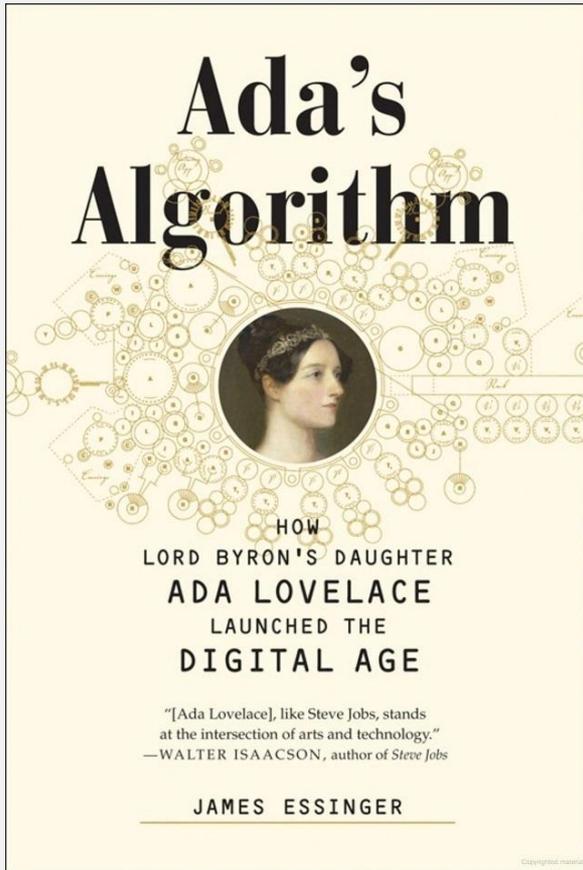
Thanks also to my Fall 2016 Software Engineering class for their research!