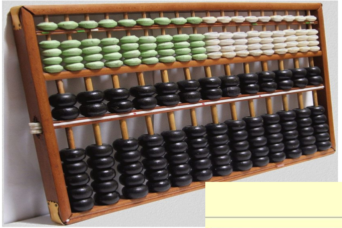
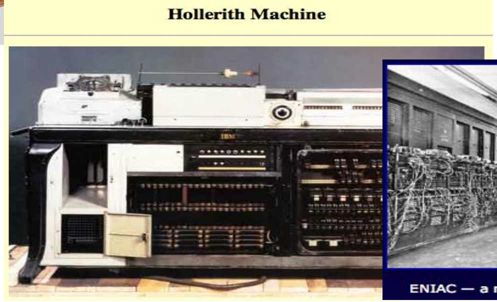
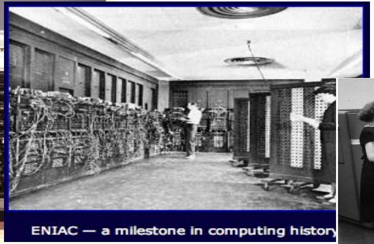
The History of Computer Science
From ancient times to the present







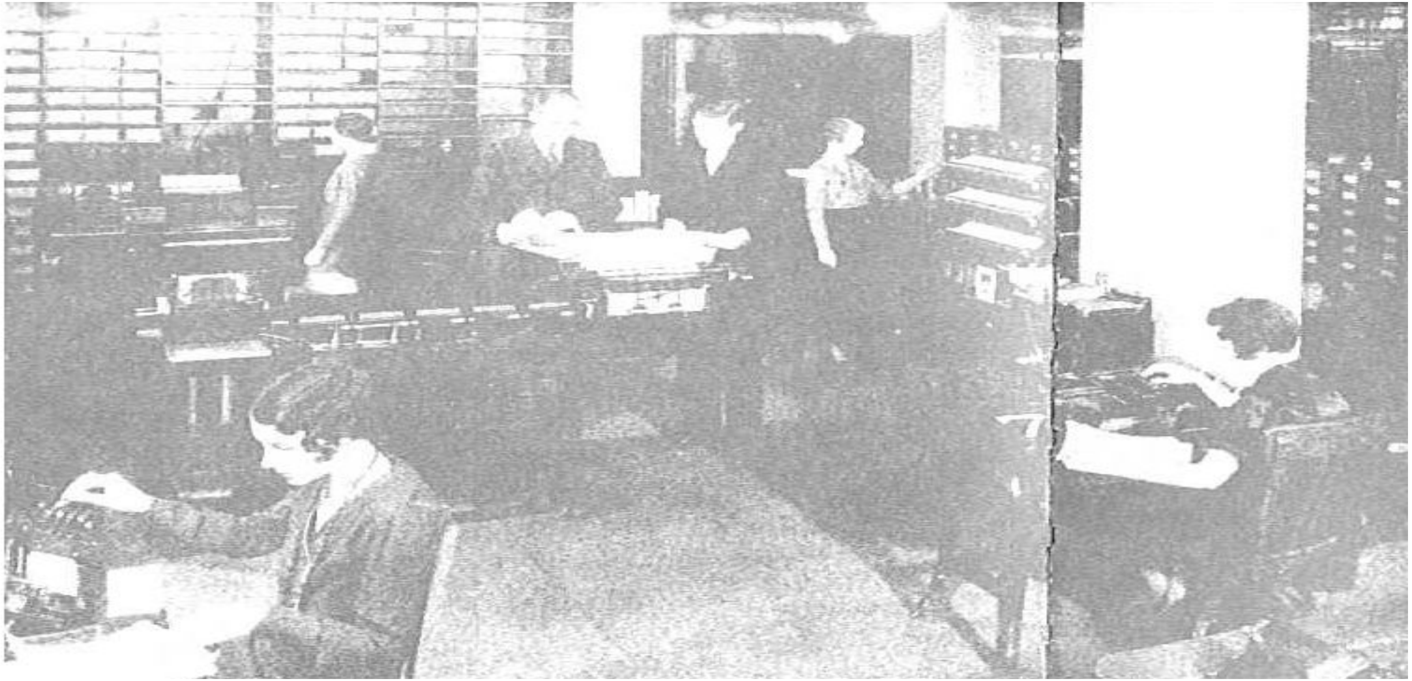

Operating a 1950s-era mainframe computer to process Social Security records.

Updated: 12/5/2019

This presentation owes much of its content and images to the following documents:
1) "An Illustrated History of Computer Science"Found online at:
http://www.computersciencelab.com/ComputerHistory/History.htm
2) "The Wonderful World of Early Computing
http://www.neatorama.com/2008/01/25/the-wonderful-world-of-early-computing/#!nIS0z

The First Computers Were People

The term "**computer**", in use from the early 17th century (the first known written reference dates from 1613), meant "one who computes": a person performing mathematical calculations.



The first computers were people! That is, electronic computers (and the earlier mechanical computers) were given this name because they performed the work that had previously been assigned to people

"Computer" was originally a job title: it was used to describe those human beings (predominantly women) whose job it was to perform the repetitive calculations required to compute such things as navigational tables, tide charts, and planetary positions for astronomical almanacs.

Imagine you had a job where hour after hour, day after day, you were to do nothing but compute multiplications. Boredom would quickly set in, leading to carelessness, leading to mistakes. And even on your best days you wouldn't be producing answers very fast. Therefore, inventors have been searching for hundreds of years for a way to mechanize (that is, find a mechanism that can perform) this task.

National Advisory Committee for Aeronautics (NACA)

High Speed Flight Station "Computer Room" Notice there are people here, not machines.

Gertrude Blanch

February 2, 1897 - January 1, 1996

In the not-so-distant past, engineers, scientists and mathematicians routinely consulted tables of numbers for the answers to questions that they could not solve analytically. `sin(.4)`? No problem: look it up in the Sine Table.

These tables were prepared by teams of people called computers who typically had only rudimentary math skills. The computers were overseen by more knowledgeable mathematicians, who designed the algorithms and supervised their work.

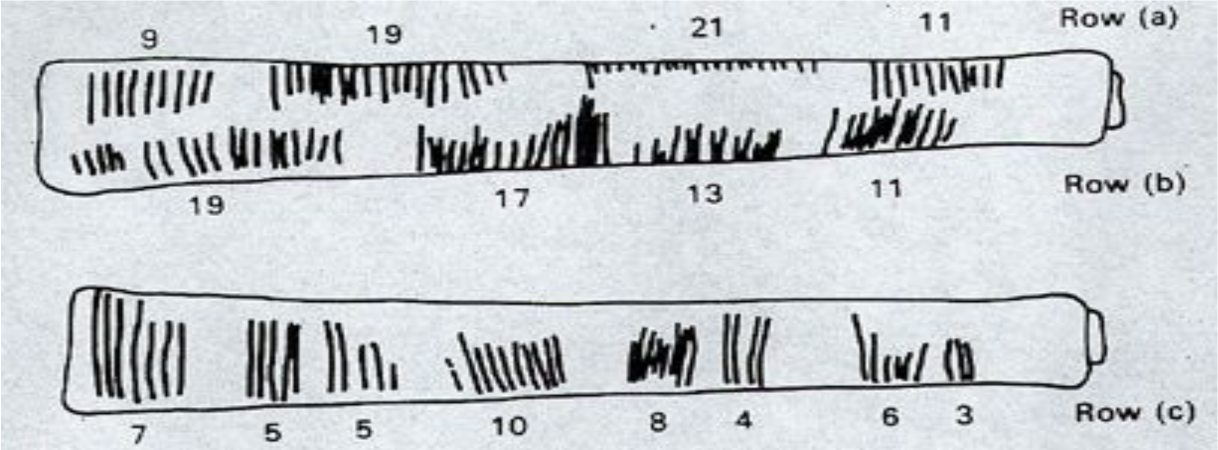
The most important of these teams was the **Mathematical Tables Project**, organized by the **Work Projects Administration** in the United States during the Great Depression. WPA rules required the hiring of people with virtually no skills, so much of the definitive work of the Mathematical Tables Project was computed by people who had mastered only addition. They were not authorized to subtract, let alone delve into the mysteries of multiplication or division. The algorithmic steps assigned to them sometimes produced negative numbers, and it goes almost without saying that these computers had no idea what these were or how to handle them. **Gertrude Blanch**, the mathematician who oversaw their work, had devised a scheme whereby positive numbers would be written in black, negative numbers in red. On the wall in front of her human computers hung a poster that encapsulates much of the era of human computing. It read:

Black plus black is black
Red plus red is red
Black plus red or red plus black, hand the sheets to team 2

35,000 Years Ago: The Lebombo Bone

The Lebombo bone is a 35,000-year-old baboon fibula discovered in a cave in the Lebombo mountains in Swaziland.

The bone has a series of 29 notches that were deliberately cut to help ancient bushmen calculate numbers and perhaps also measure the passage of time. It is considered the oldest known mathematical artifact.



20,000 Years Ago: The Ishango Bone

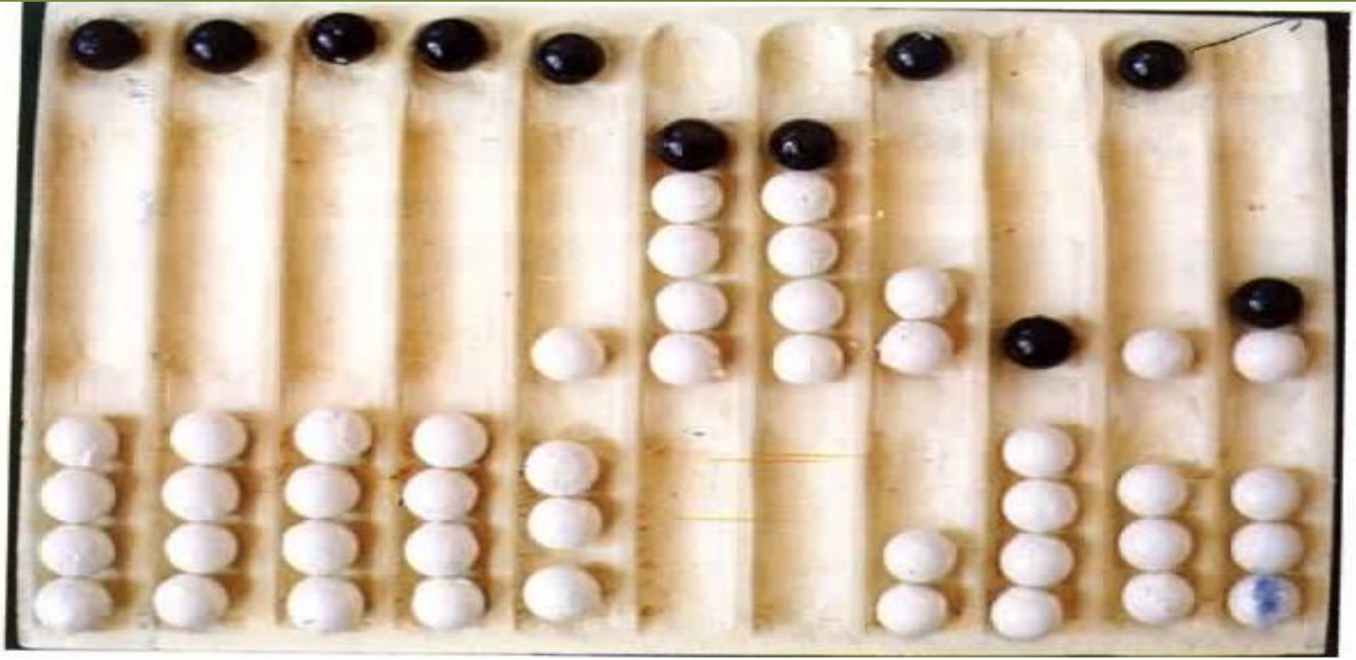
The unusual groupings of the notches on the Ishango bone (see below), discovered in what was then the Belgian Congo, suggested that it was some sort of a stone age calculation tool. The 20,000-year-old bone revealed that early civilization had mastered arithmetic series and even the concept of prime numbers.

Ishango bone

At Least 2,400 BC: The Abacus

The abacus was an early aid for mathematical computations. Its only value is that it aids the memory of the human performing the calculation.

A skilled abacus operator can work on addition and subtraction problems at the speed of a person equipped with a hand calculator



A very old abacus

(multiplication and division are slower). The abacus is often wrongly attributed to China. In fact, the oldest surviving abacus was used in 300 B.C. by the Babylonians. The abacus is still in use today, principally in the far east. A modern abacus consists of rings that slide over rods, but the older one pictured above dates from the time when pebbles were used for counting (the word "calculus" comes from the Latin word for pebble).

Today, abacus is mostly synonymous with the Chinese *suanpan*version, but in actuality it had been used in Babylon as early as 2400 BC. The abacus was also found in ancient Egypt, Greece, and Rome. Even the Aztecs had their own version.

The Roman pocket abacus was the first portable calculating device, presumably invented to help tax collectors do math while on the go!

Reproduction of a
Roman pocket abacus

A more modern abacus. Note how the abacus is really just a representation of the human fingers: the 5 lower rings on each rod represent the 5 fingers and the 2 upper rings represent the 2 hands.

ONLINE DEMO (5 min): http://www.youtube.com/watch?v=CvsnftXXKdw

Japanese Children doing abacus really fast (2 min):
https://www.youtube.com/watch?v=wIiDomlEjJw

100 BC: Antikythera Mechanism

In 1900, a Greek sponge diver spotted a shipwreck off the coast of the tiny island of Antikythera. Little did he know that amongst the jewelry and statues recovered from the wreck, the most precious item would be a lump of green rock with gears sticking out of it. The "rock" turned out to be the earliest example of analog computer: an intricate mechanism with more than 30 gears and writings that scientists thought was used to calculate the motion of the sun and the moon against a background of fixed stars.

The Antikythera Mechanism, as the device was named, was dated from around 100 BC. It would take about another 1,000 years for the appearance of similar levels of technical sophistication in the West. Who built the machine and why the technology was lost remained a mystery.

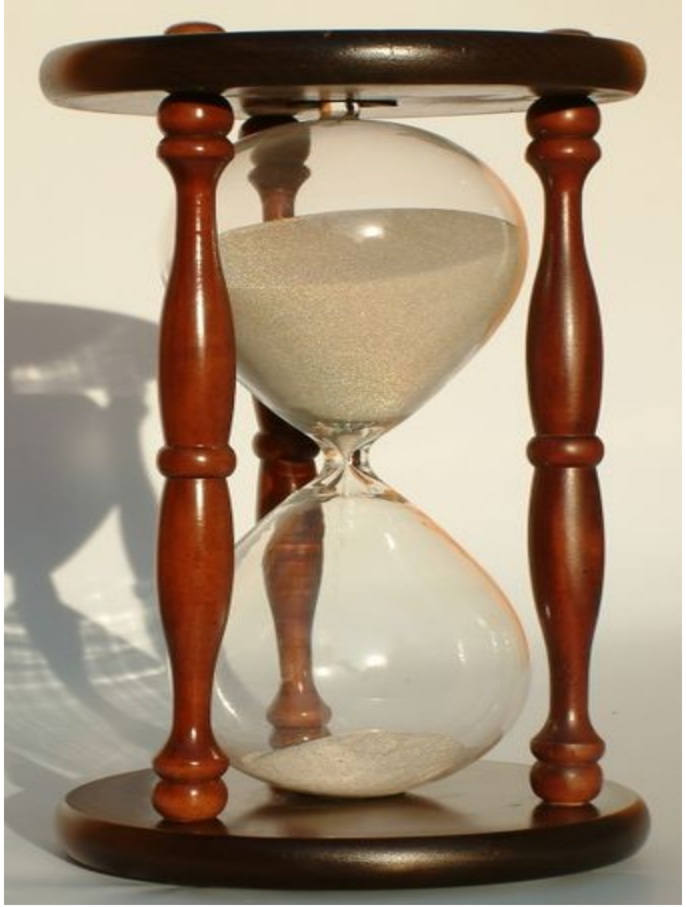
Lego Antikythera Mechanism (really cool!):
https://www.youtube.com/watch?time_continue=1&v=RLPVCJjTNgk
VIDEO (7 min)
http://www.youtube.com/watch?v=UpLcnAIpVRA

COMPUTING'S "DARK AGE"

Computing's Dark Age (400AD-1000AD in Europe)

During this period few technical advances were made, due to the collapse of the Roman Empire and the Han empire in China. In China, computing machines were re-discovered in the early 1100s, but were wiped out during the Mongol Invasion led by Gehngis Khan.

1,100's: Hour Glass



Since the hourglass was one of the few reliable methods of measuring time at sea, it has been speculated that it was in use as far back as the 11th century, where it would have complemented the magnetic compass as an aid to navigation. However, it is not until the 14th century that evidence of their existence was found, appearing in a painting by Ambrogio Lorenzetti 1328. The earliest written records come from the same period and appear in lists of ships stores. From the 15th century onwards they were being used in a wide range of applications at sea, in the church, in industry and in cookery. They were the first dependable, reusable and reasonably accurate measure of time. During the voyage of Ferdinand Magellan around the globe, his vessels kept 18 hourglasses per ship. It was the job of a ship's page to turn the hourglasses and thus provide the times for the ship's log. Noon was the reference time for navigation, which did not depend on the glass, as the sun would be at its zenith.

The Astrolabe

The astrolabe is a very ancient astronomical computer for solving problems relating to time and the position of the Sun and stars in the sky.

The **history of the astrolabe** begins more than two thousand years ago. The principles of the astrolabe projection were known before 150 B.C., and true astrolabes were made before A.D. 400. The astrolabe was highly developed in the Islamic world by 800 and was introduced to Europe from Islamic Spain (al-Andalus) in the early 12th century. It was the most popular astronomical instrument until about 1650, when it was replaced by more specialized and accurate instruments. Astrolabes are still appreciated for their unique capabilities and their value for astronomy education.

Typical uses of the astrolabe include finding the time during the day or night, finding the time of a celestial event such as sunrise or sunset and as a handy reference of celestial positions.

The Astrolabe

Telling Time -- With Your Amazing Astrolabe

Did you lose your smartphone? No worries, just pull out your astrolabe to find the time of day or night. During the day, you would base your calculations on the altitude of the sun. At night, you would use the altitude of a visible star.

With a few twists and turns of your astrolabe, you can tell time. Relax. It's not as hard as you think once you get the hang of it. iStockphoto/Thinkstock

The Astrolabe

http://www.ted.com/talks/tom_wujec_demos_the_13th_century_astrolabe?language=en

The Astrolabe

Using an Astrolabe to tell the time

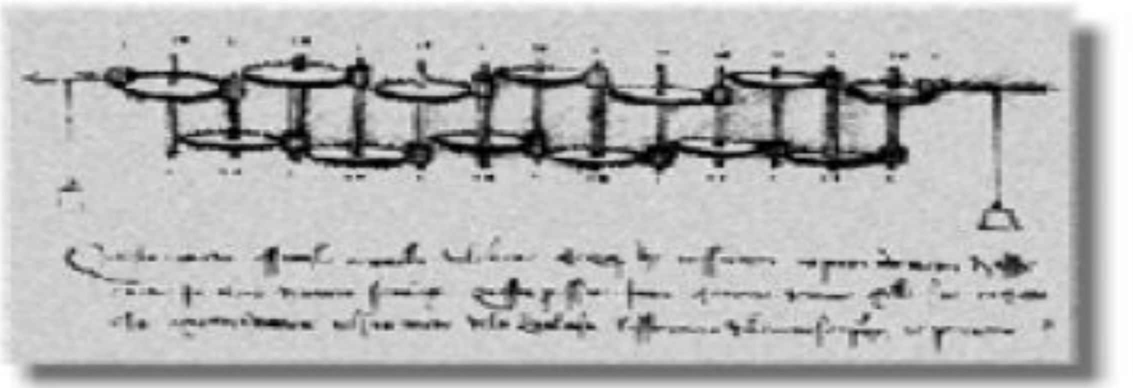
Illustration: Admiral Jurien de la Gravière's *Derniers jours de la Marine à Rames* (1885).

At night people used astrolabes to measure star positions and calculate the time.

Next >

http://www.mhs.ox.ac.uk/exhibits/using-an-astrolabe-1/

Late 1400s: Leonardo da Vinci



A Leonardo da Vinci drawing showing gears arranged for computing

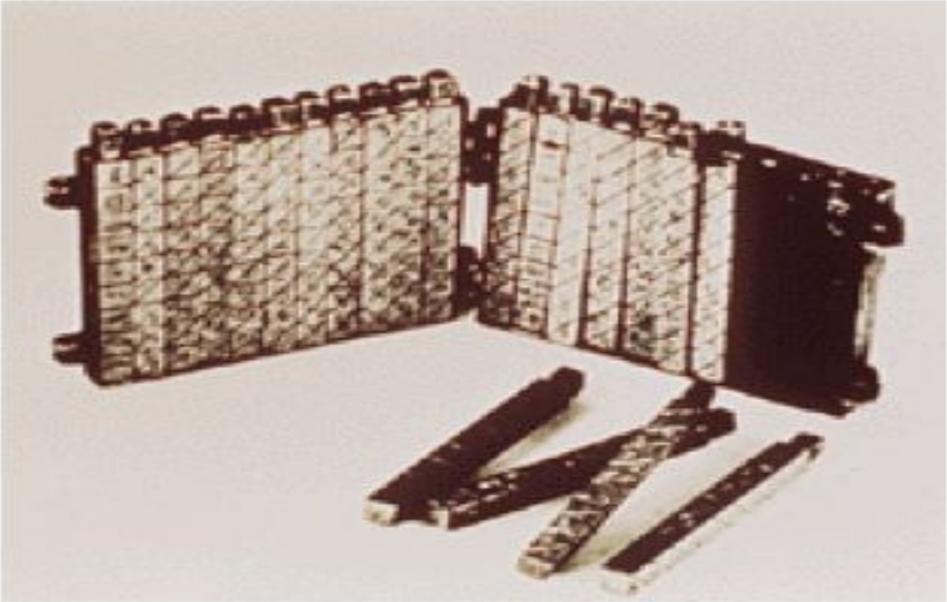
Leonardo da Vinci (1452-1519) made drawings of gear-driven calculating machines but apparently never built any.

However, modern scientists have built one, and it does work!

Working model of da Vinci's device.

Courtesy of IBM

1617: Napier's Bones

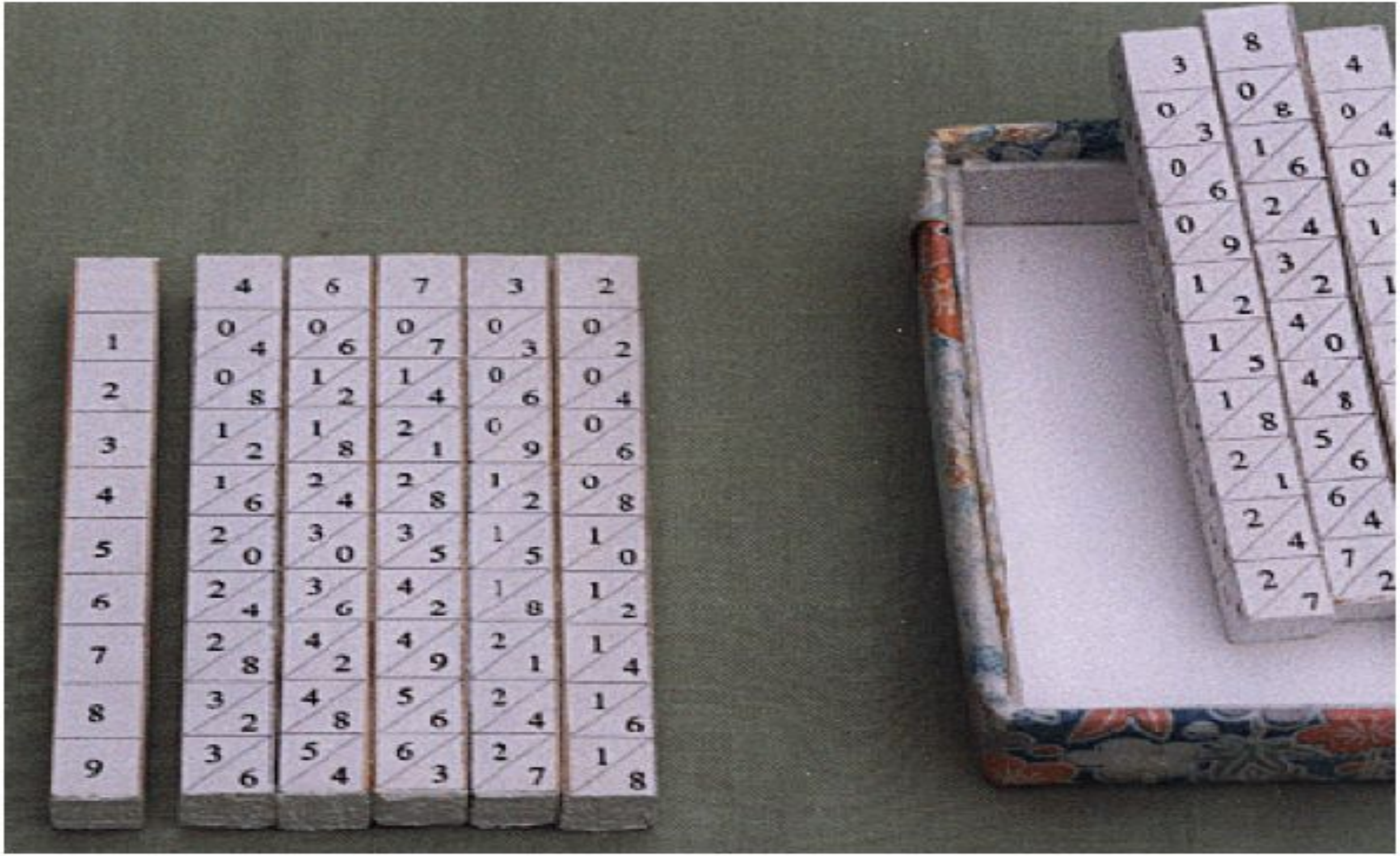


An original set of Napier's Bones [photo courtesy IBM]

VIDEO DEMO (1 min)

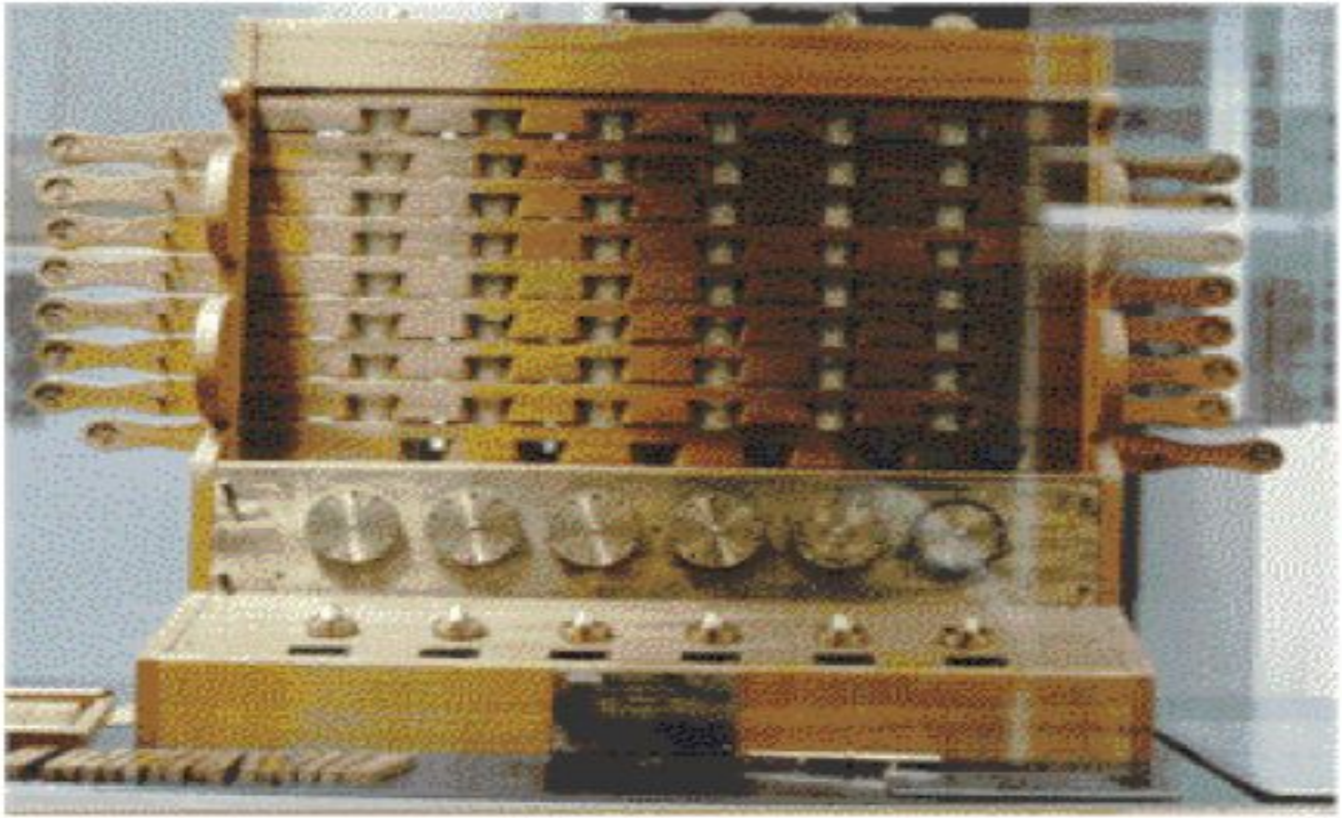
http://www.youtube.com/watch?v=3gjDfc2AF3w

In 1617 an eccentric (some say mad) Scotsman named John Napier invented logarithms, which are a technology that allows multiplication to be performed via addition. The magic ingredient is the logarithm of each operand, which was originally obtained from a printed table. But Napier also invented an alternative to tables, where the logarithm values were carved on ivory sticks which are now called Napier's Bones.



A more modern set of Napier's Bones

1623: Schickard's Calculating Clock



The first gear-driven calculating machine **to actually be built** was probably the calculating clock, so named by its inventor, the German professor Wilhelm Schickard in 1623.

This device got little publicity because Schickard died soon afterward in the bubonic plague.

1632: The Slide Rule

A slide rule

Napier's invention led directly to the slide rule, first built in England in 1632 and still in use in the 1960's by the NASA engineers of the Mercury, Gemini, and Apollo programs which landed men on the moon. While great aids, slide rules were not particularly intuitive for beginners. A 1960 Pickett manual said:

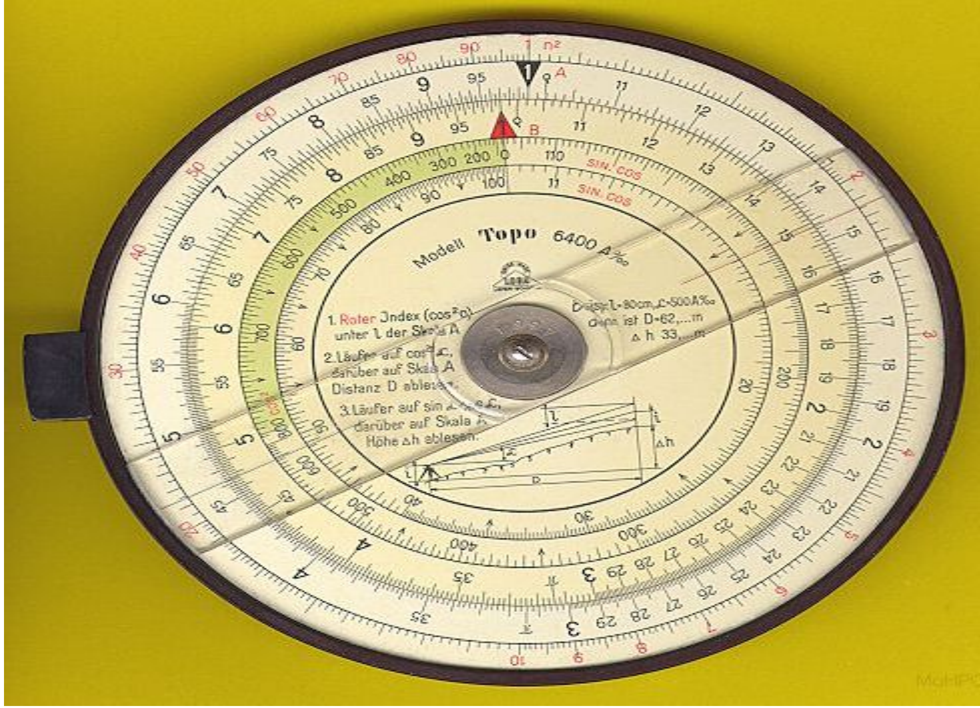
"When people have difficulty in learning to use a slide rule, usually it is not because the instrument is difficult to use. The reason is likely to be that they don't understand the mathematics on which the instrument is based, or the formulas they are trying to evaluate. Some slide rule manuals contain relatively exhaustive explanations of the theory underlying the operations. In this manual it is assumed that the theory of exponents, of logarithms, of trigonometry, and of the slide rule is known to the reader, or will be recalled or studied by reference to formal textbooks on these subjects."

A 1948 Stanley manual expressed a somewhat different opinion:

"The principles of logarithmic calculators are too well known to those likely to be interested for it to be necessary to enlarge upon the subject here, especially as it is absolutely unnecessary to have any knowledge of the subject to use the calculator."

...

"Anyone can calculate with the Fuller after a brief study of the following instructions **without any mathematical knowledge whatever.**“



A Circular Slide Rule

Another interesting quote from the same Pickett manual:

"A computer who must make many difficult calculations usually has a slide rule close at hand.“

In 1960, "computer" was still understood to be a *person* who computed.

No need to watch this unless you want to...we did not watch in class

GIANT SLIDE RULES!

Many manufacturers made large slide rules for class demonstrations and as teaching aids. Sizes ranged from 4 to 8 feet in width. **Picketts** were the most common, as they offered these giant rules for free to schools that bought at least 24 rules.

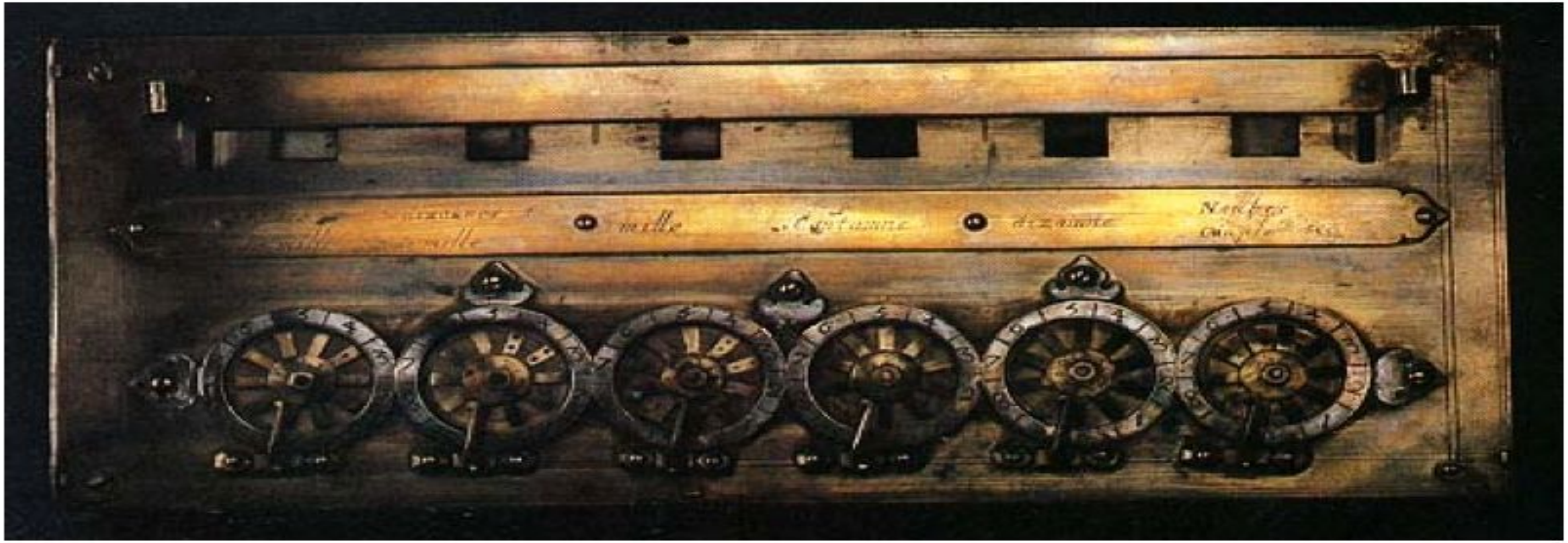
DEMO OF SLIDE RULE: http://www.youtube.com/watch?v=aj6_yYdt-Z8

1642: The Pascaline

The 8 Gear Pascaline

In 1642 Blaise Pascal, at age 19, invented the Pascaline as an aid for his father who was a tax collector.

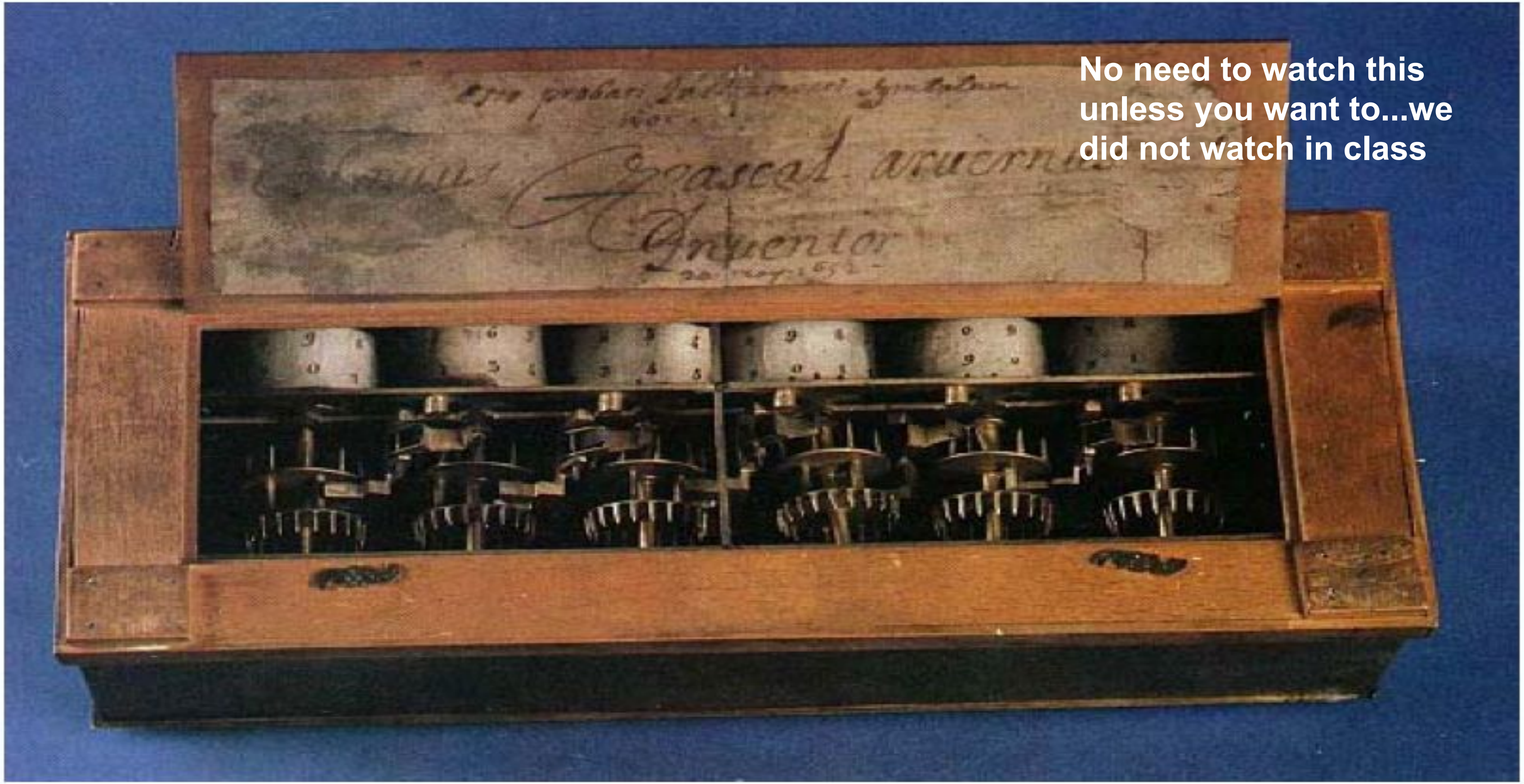
Pascal built 50 of this gear-driven one-function calculator (it could only add) but couldn't sell many because of their exorbitant cost and because they really weren't that accurate (at that time it was not possible to fabricate gears with the required precision).



A 6 digit model for those who couldn't afford the 8 digit model

Up until the present age when car dashboards went digital, the odometer portion of a car's speedometer used the very same mechanism as the Pascaline to increment the next wheel after each full revolution of the prior wheel.

Pascal was a child prodigy. At the age of 12, he was discovered doing his version of Euclid's thirty-second proposition on the kitchen floor. Pascal went on to invent probability theory, the hydraulic press, and the syringe.

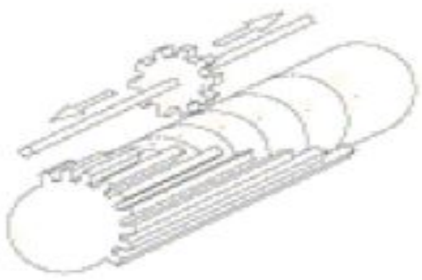


A Pascaline opened up so you can observe the gears and cylinders which rotated to display the numerical result

ONLINE DEMO (9 min): http://www.youtube.com/watch?v=3h71HAJWnVU

1672: Leibniz's Stepped Reckoner

ONLINE DEMO (30 sec):
Legos!
http://www.youtube.com/watch?v=CJVvgzTTGQY



Leibniz's Stepped Reckoner (have you ever heard "calculating" referred to as "reckoning"?)

Just a few years after Pascal, the German Gottfried Wilhelm Leibniz (co-inventor with Newton of calculus) managed to build a four-function (addition, subtraction, multiplication, and division) calculator that he called the stepped reckoner because, instead of gears, it employed fluted drums having ten flutes arranged around their circumference in a stair-step fashion.

Although the stepped reckoner employed the decimal number system (each drum had 10 flutes), **Leibniz was the first to advocate use of the binary number system** which is fundamental to the operation of modern computers. Leibniz is considered one of the greatest of the philosophers but he died poor and alone.

The Staffelwalze, or Stepped Reckoner, a digital calculating machine invented by Gottfried Wilhelm Leibniz around 1672 and built around 1700, on display in the Technische Sammlungen museum in Dresden, Germany. It was the first known calculator that could perform all four arithmetic operations; addition, subtraction, multiplication and division. 67 cm (26 inches) long. The cover plate of the rear section is off to show the wheels of the 16 digit accumulator.

Only two machines were made. The single surviving prototype is in the National Library of Lower Saxony (Niedersächsische Landesbibliothek) in Hannover; this is a contemporary replica.

1801: The Jacquard Loom

In 1801 the Frenchman **Joseph Marie Jacquard** invented a power loom that could base its weave (and hence the design on the fabric) upon a pattern automatically read from punched wooden cards, held together in a long row by rope.

Punched cards have been in use ever since (remember the "hanging chad" from the Florida presidential ballots of the year 2000?).

Jacquard's Loom showing the threads and the punched cards

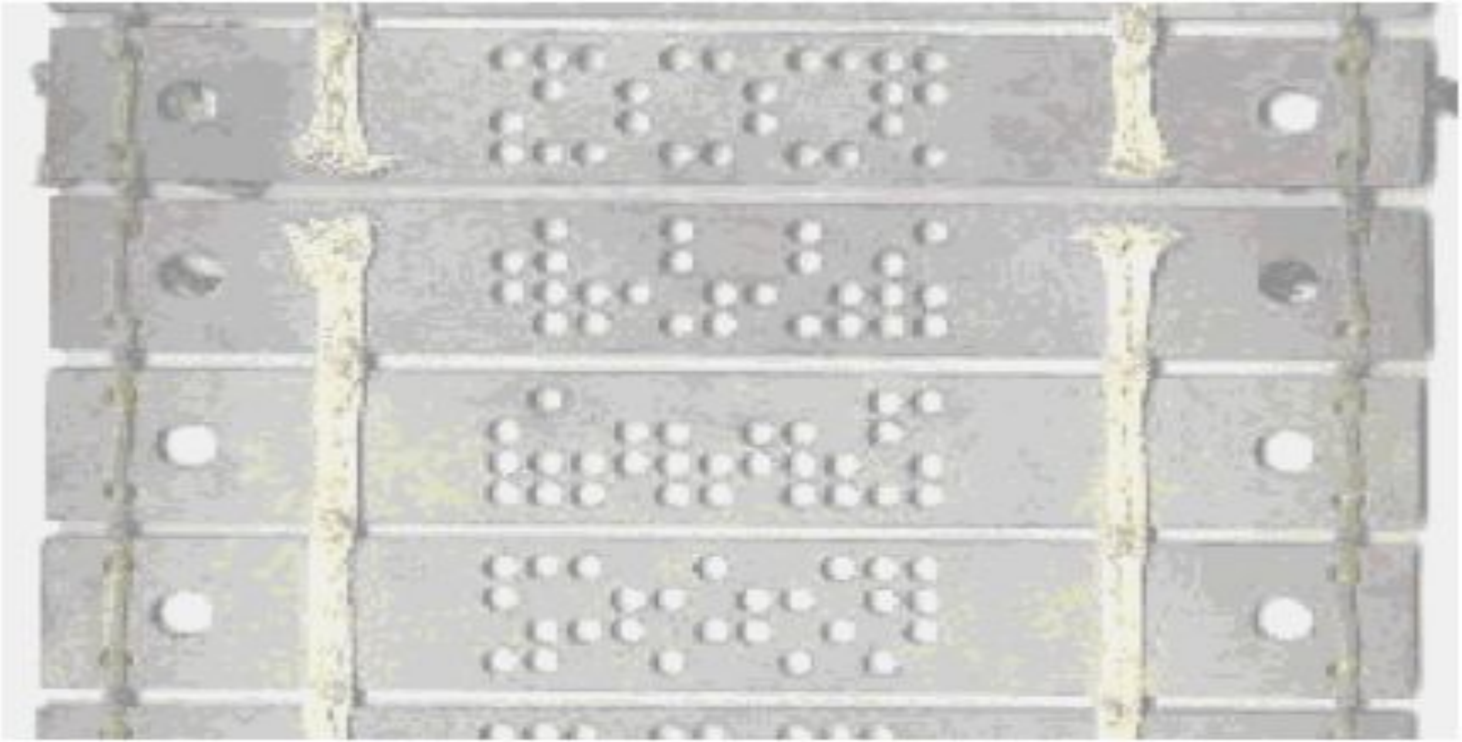
What other kinds of punch cards do we use today?

[Jacquard-card Making.]

Video:

There's great footage of this device during the Charlge Babbage video in a few slides.

By selecting particular cards for Jacquard's loom you defined the woven pattern [photo © 2002 IEEE]



A close-up of a Jacquard card

In a vivid demonstration of the power of his invention, Joseph-Marie Jacquard, using 10,000 punch cards, programmed a loom to weave a portrait of himself in black and white silk (above).

This tapestry was woven by a Jacquard loom

Jacquard's technology was a real boon to mill owners, but put many loom operators out of work. Angry mobs smashed Jacquard looms and once attacked Jacquard himself.

History is full of examples of labor unrest following technological innovation yet most studies show that, overall, technology has actually increased the number of jobs.

1820: The Arithmometer

Since the invention of Schickard's calculator, it took nearly 200 years for calculators to become commercially successful.

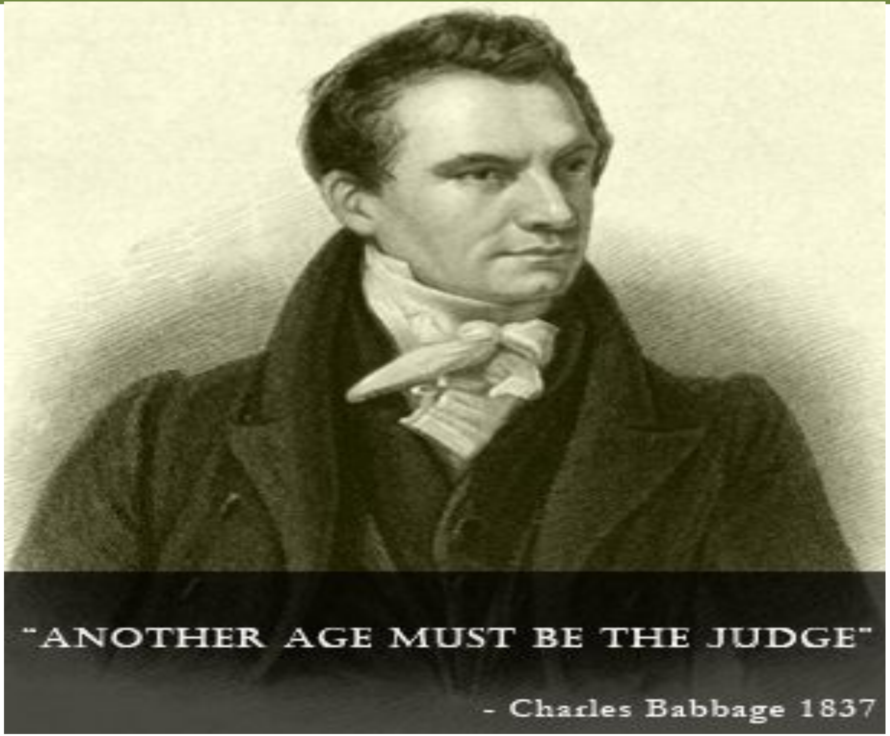
In 1820, **Charles Xavier Thomas de Colmar**, a French mathematician, created the first commercially successful mechanical calculator.

The machine, which used the same stepped cylinder invented by Leibniz, was called the Arithmometer. It could add, subtract, multiply (and with some user intervention, divide) and was the calculator of choice for nearly a hundred years.

1822: Charles Babbage's Engines

Charles Babbage (1791-1871)

Father of Computing
Englishman
Mathematician
Computer Pioneer



Overview Video
Describes both the Difference and the Analytic Engine (7 min 41 sec)

This is a re-creation video with actors, also includes a very good video of a Jacquard Loom, and a discussion of Ada Lovelace

http://www.youtube.com/watch?v=QVxbNZWLP60

Babbage Designed Two Different Kinds of Machines: Difference Engines and Analytical Engines

Difference engines are so called because of the mathematical principle on which they are based, namely, the method of finite differences. The beauty of the method is that it uses only arithmetical addition and removes the need for multiplication and division which are more difficult to implement mechanically.

Difference engines are strictly calculators. They crunch numbers the only way they know how - by repeated addition according to the method of finite differences. They cannot be used for general arithmetical calculation.

An Analytical Engine is much more than a calculator and marks the progression from the mechanized arithmetic of calculation to fully-fledged general-purpose computation. There were at least three designs at different stages of the evolution of his ideas.

Good Website for Babbage History

http://www.computerhistory.org/babbage/overview/

The Difference Engine
Design began in 1822
Finally built in 2002

A small section of the type of mechanism employed in Babbage's Difference Engine [photo © 2002 IEEE]

This machine would be able to compute tables of numbers, such as logarithm tables. Babbage obtained government funding for this project due to the importance of numeric tables in ocean navigation. By promoting their commercial and military navies, the British government had managed to become the earth's greatest empire. But in that time frame the British government was publishing **a seven volume set of navigation tables** which came with a **companion volume of corrections which showed that the set had over 1,000 numerical errors**. It was hoped that Babbage's machine could eliminate errors in these types of tables. But construction of Babbage's Difference Engine proved exceedingly difficult and **the project soon became the most expensive government funded project up to that point in English history**. Ten years later the device was still nowhere near complete, acrimony abounded between all involved, and funding dried up. The device was never finished.

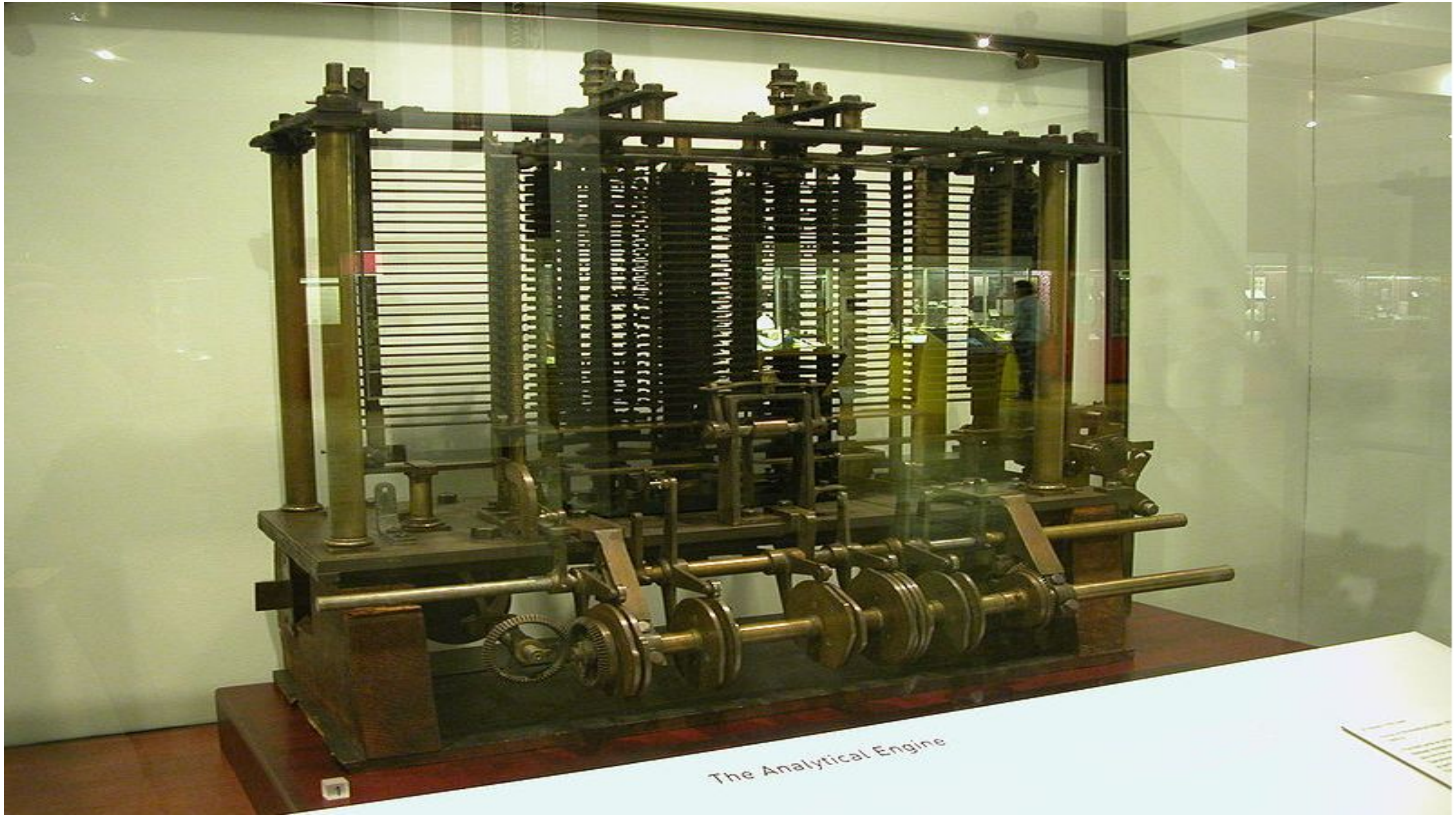
ONLINE DEMO (24 min) go to near the end:
http://www.youtube.com/watch?v=BlbQsKpq3Ak

The Analytical Engine: Design began in 1834. It has never been built. Only a small “demo” section exists

Babbage conceived, in 1834, a more ambitious machine, later called Analytical Engine, a general-purpose programmable computing engine.

The Analytical Engine has many essential features found in the modern digital computer. It was **programmable** using punched cards, an idea borrowed from the Jacquard loom used for weaving complex patterns in textiles. The Engine had a 'Store' where numbers and intermediate results could be held, and a separate 'Mill' where the arithmetic processing was performed. It had an internal repertoire of the four arithmetical functions and could perform direct multiplication and division. It was also capable of functions for which we have modern names: **conditional branching**, **looping** (iteration), **microprogramming**, **parallel processing**, **iteration**, latching, polling, and pulse-shaping, amongst others, though Babbage nowhere used these terms. It had a variety of **outputs** including hardcopy printout, punched cards, graph plotting and the automatic production of stereotypes - trays of soft material into which results were impressed that could be used as molds for making printing plates.

The logical structure of the Analytical Engine was essentially the same as that which has dominated computer design in the electronic era - the separation of the memory (the 'Store') from the central processor (the 'Mill'), serial operation using a 'fetch-execute cycle', and facilities for inputting and outputting data and instructions. Calling Babbage 'the first computer pioneer' is not a casual tribute.



The Analytic Engine: this is the “demo section” of the much larger machine. If fully built, the Analytic Engine would have been the size of a locomotive and run by steam power.

Charles Babbage: Analytic Engine (2 min 30 seconds)

BBC's short video on Charles Babbage's Analytic Engine

http://www.youtube.com/watch?v=GJiyGvoYd5E

The online campaign to finally build Charles Babbage's Analytical Engine - over a century and a half after the 'first computer' was designed

- **Plan to finally build Charles Babbage's Analytical Engine**
- **The design predated the birth of computers by 100 years**

By DAMIEN GAYLE

PUBLISHED: 11:49 EST, 25 October 2012 | **UPDATED:** 12:54 EST, 25 October 2012

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A campaign has been launched to finally build what could be the first computer ever envisaged - which was designed over a century and a half ago.

Charles Babbage's 'Analytical Engine', conceived of in 1837 - 100 years before Alan Turing's work launched the computer age - would have been the size of a small locomotive, built from brass and iron, and powered by steam.

It would have included a central processing unit, which he called 'the mill', expandable memory, known as 'the store', and would have been programmable by punched cards.

http://plan28.org/

http://www.dailymail.co.uk/sciencetech/article-2223149/Online-campaign-launched-finally-build-Charles-Babbages-Analytical-Engine.html

Perhaps someday the Analytical Engine will be built?

Conditional Statements

The **Analytic Engine** had a key function that distinguishes computers from calculators: the conditional statement. A conditional statement allows a program to achieve different results each time it is run. Based on the conditional statement, the path of the program (that is, what statements are executed next) can be determined based upon a condition or situation that is detected at the very moment the program is running.

As the name implies, conditional statements specify whether another statement or block of statements should be executed or not. These are often called "selection constructs". The two general types are "if...then" and the "switch...case" construct.

The Conditional

Consider the following statement: "If you earn an A in logic, then I'll buy you a Yellow Mustang." It seems to be made up out of two simpler statements:

p: "You earn an A in logic," and

q: "I will buy you a Yellow Mustang."

What the original statement is then saying is this: *if p is true, then q is true*, or, more simply, if p, then q. We can also phrase this as p implies q, and we write $p \rightarrow q$.

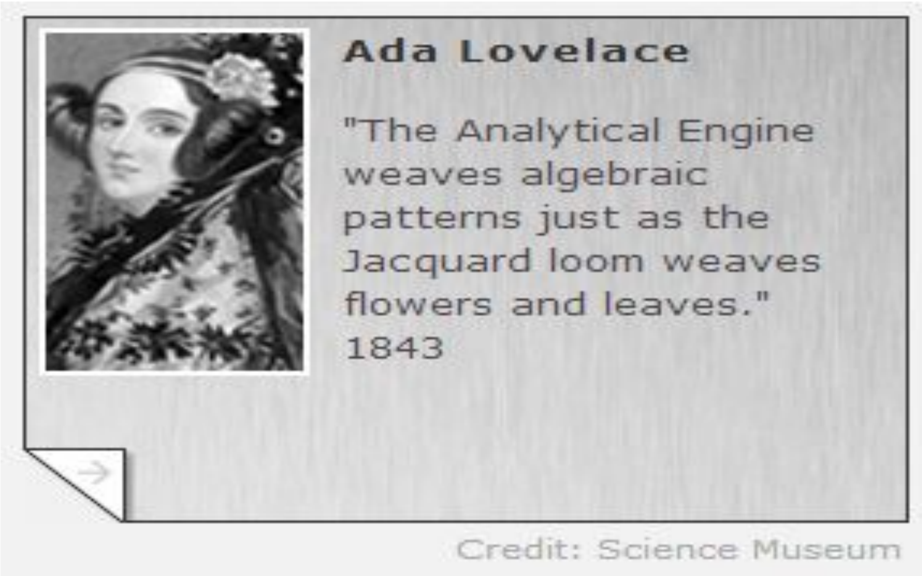
1843: Ada Byron Lovelace

Ada Byron Lovelace

The First Computer Programmer

Ada Lovelace met and corresponded with Charles Babbage on many occasions, including socially and in relation to Babbage's Difference Engine and Analytical Engine. Babbage was impressed by Lovelace's intellect and writing skills. He called her "The Enchantress of Numbers". In 1843 he wrote of her:

Forget this world and all its troubles and if possible its multitudinous Charlatans — every thing in short but the Enchantress of Numbers.



Byron designed the "punch-card" program which was a program that gave instructions to a computer.

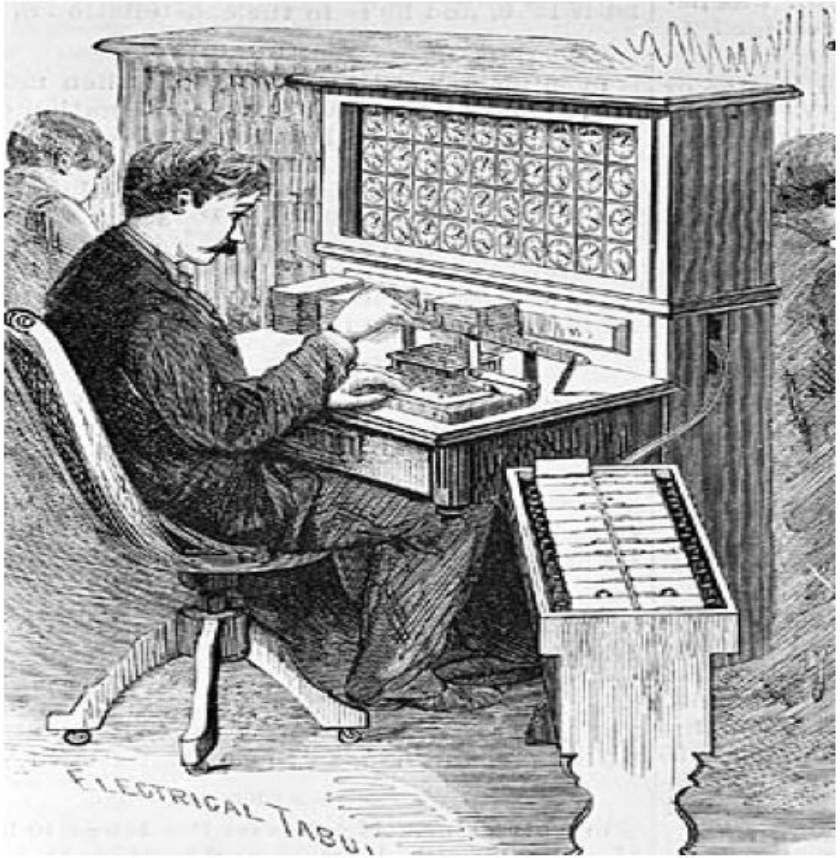
She also created the computer law known as **GIGO** (Garbage In, Garbage Out). This law basically states that a computer can use only what is put into it. In other words, a computer cannot have a mind of its own.

Because of Byron's pioneering efforts in the computer era, the U.S. Department of Defense named a computer programming language (ADA) after her in 1977.

```
if condition then
    -- statements;
elsif condition then
    -- more statements;
elsif condition then
    -- more statements;
...
else
    -- other statements;
end if;
```

Conditional Statement written in ADA programming language

1890: Hollerith Desk



An operator working at a Hollerith Desk like the one below

The next breakthrough occurred in America. The U.S. Constitution states that a census should be taken of all U.S. citizens every 10 years in order to determine the representation of the states in Congress. While the very first census of 1790 had only required 9 months, by 1880 the U.S. population had grown so much that the count for the 1880 census took 7.5 years. Automation was clearly needed for the next census. The census bureau offered a prize for an inventor to help with the 1890 census and this prize was won by Herman Hollerith, who proposed and then successfully adopted Jacquard's punched cards for the purpose of computation.

Hollerith's invention, known as the Hollerith desk, consisted of a card reader which sensed the holes in the cards, a gear driven mechanism which could count (using Pascal's mechanism which we still see in car odometers), and a large wall of dial indicators (a car speedometer is a dial indicator) to display the results of the count.

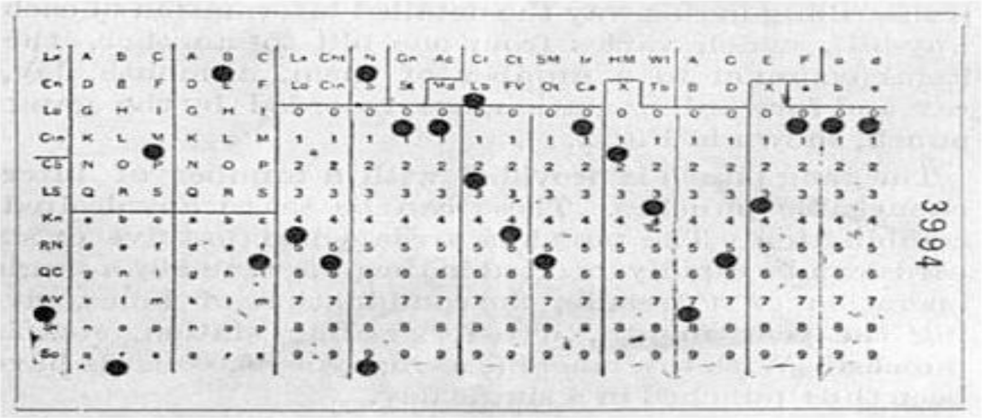
James Burke: Connections Episode 4 "Faith In Numbers"
This is from the 1970's but it's still relevant.

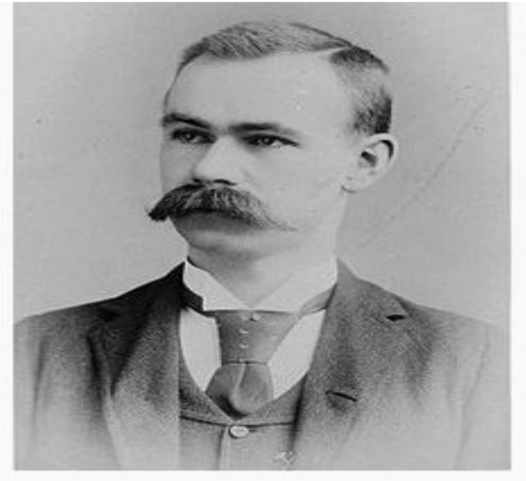
Wonderful Video!! (8 min 57 seconds)

NOTE: 2016 class, we did not watch this so you don't need to worry about watching it

Yay! On 12/23/2016 I finally found a recording of this video at archive.org and downloaded it. Now I have it forever!!

Herman Hollerith





The patterns on Jacquard's cards were determined when a tapestry was designed and then were not changed. Today, we would call this a read-only form of information storage. Hollerith had the insight to convert punched cards to what is today called a read/write technology. While riding a train, he observed that the conductor didn't merely punch each ticket, but rather punched a particular pattern of holes whose positions indicated the approximate height, weight, eye color, etc. of the ticket owner. This was done to keep anyone else from picking up a discarded ticket and claiming it was his own (a train ticket did not lose all value when it was punched because the same ticket was used for each leg of a trip). Hollerith realized how useful it would be to punch (write) new cards based upon an analysis (reading) of some other set of cards. Complicated analyses, too involved to be accomplished during a single pass thru the cards, could be accomplished via multiple passes thru the cards using newly printed cards to remember the intermediate results. Unknown to Hollerith, Babbage had proposed this long before.

The Hollerith system really proved itself in the real census of 1890. Complete results were available two years sooner than the previous census. The data was more thoroughly analyzed, too, and at less cost—an estimated $5 million less than manual tabulation, nearly ten times greater than the predicted savings.

Indeed, where would Hollerith have been. He built on this initial success and later supplied equipment for the Russian census of 1897, several European censuses and the 1900 census in the United States. Gradually, business applications of his machines were developed, too.

But Hollerith always thought of his machines as statistical machines and himself as a statistical engineer.

When asked in the middle 1890's why he did not apply his machines to railroad accounting, he responded: "One good reason and that was that I did not know the first damned thing about railroad accounts." His first business application was on the New York Central Railroad. He went on to install systems in utilities, a department store, and other railroads; and these led to development of more business applications.

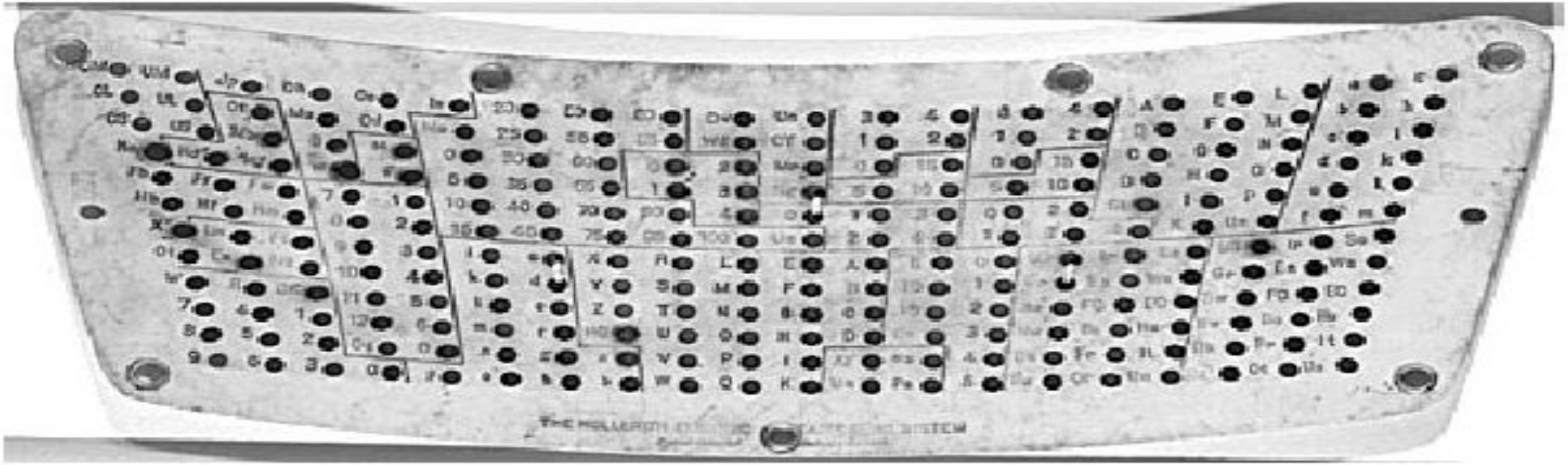
http://www-03.ibm.com/ibm/history/exhibits/builders/builders_hollerith.html

Photo: [103]; CLICK to enlarge.

This apparatus works unerringly as the mills of the gods, but beats them hollow as to speed.
–The Electrical Engineer, 11 Nov 1891.

The 1890 tabulator was capable only of counting. Subsequent models, developed by Hollerith himself, were also able to add, thus broadening their scope to accounting, warehousing, and shipping applications. Between 1902 and 1905, Hollerith also developed an automatic card feed and a method for reading cards in motion and settled on a standard card format. In 1928, IBM produced its first tabulator (the Type IV) with both addition and subtraction capability.

http://www.columbia.edu/acis/history/census-tabulator.html



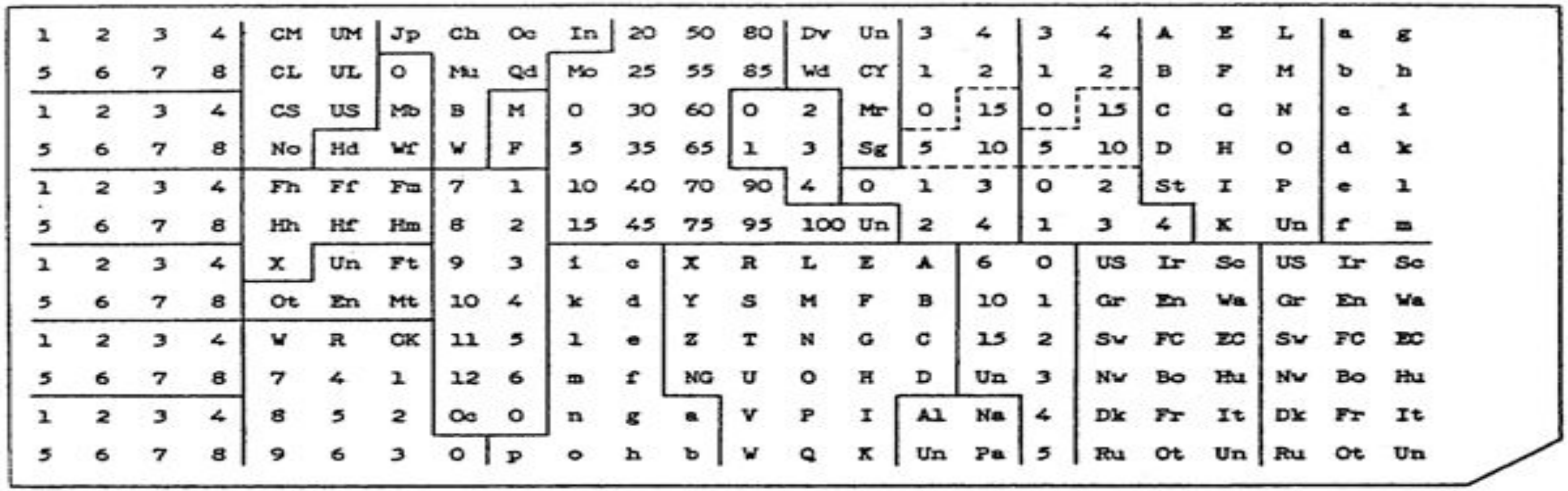
Above: A punch-card template from a Pantographic punch used the 1890 US census (image: US Library of Congress). Notice there are 12 rows (as in modern punch cards), of which only the bottom 10 were used, and only 20 columns; the curved shape is due to the Pantographic mechanism, an early ergonomic device allowing operators to punch 500 cards per day with good accuracy and minimal physical strain (compared to the handheld "train conductor" punches used in previous trials, which could cause near paralysis with prolonged use -- carpal tunnel syndrome did not start with PCs! -- and with which correct placement of holes was problematic). The Pantographic punch operator positioned a stylus over the desired hole in the template and pressed it to punch a hole in the corresponding position of the rectangular card. The template has areas marked off for various demographic categories.

http://www.columbia.edu/acis/history/census-tabulator.html

Above: The Pantographic card punch in operation. The operator holds the stylus over the template. The card is in the punch station above the template. Photo (from the 1920 census): [44].

http://www.columbia.edu/acis/history/census-tabulator.html

Preparation of punched cards for the U.S. census



Above: The "reading board" for a punched card from the 1890 census (the cards themselves were blank; this is like the "decoder ring" for the holes, which itself needs a second "decoder ring" to decipher the alphanumeric codes). Cards had one one corner cut diagonally to protect against upside down and/or backwards cards that might not otherwise be detected and the reading board had the same cut for obvious reasons (image from [69]). The card measures 3.25 by 7.375 inches, the same size as the 1887 US paper currency because Hollerith used Treasury Department containers as card boxes (pictures not actual size, but all to the same scale):

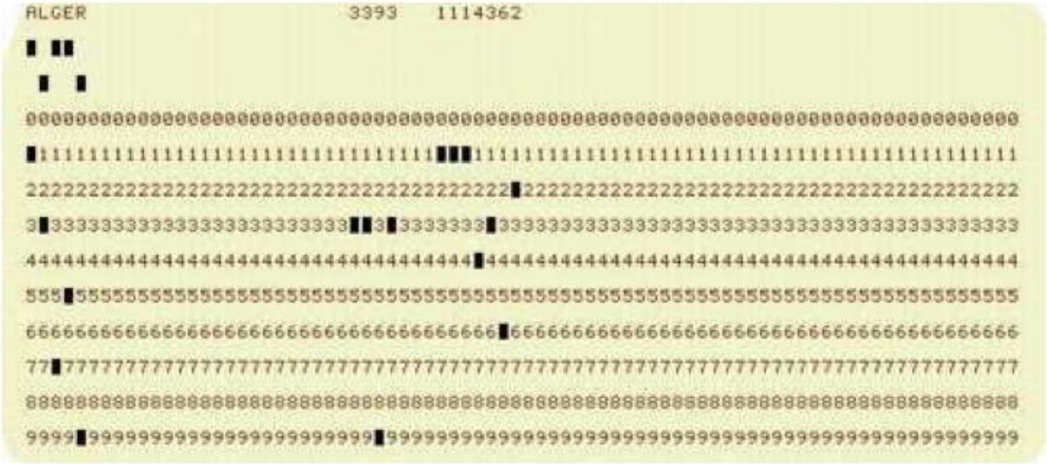
http://www.columbia.edu/acis/history/census-tabulator.html

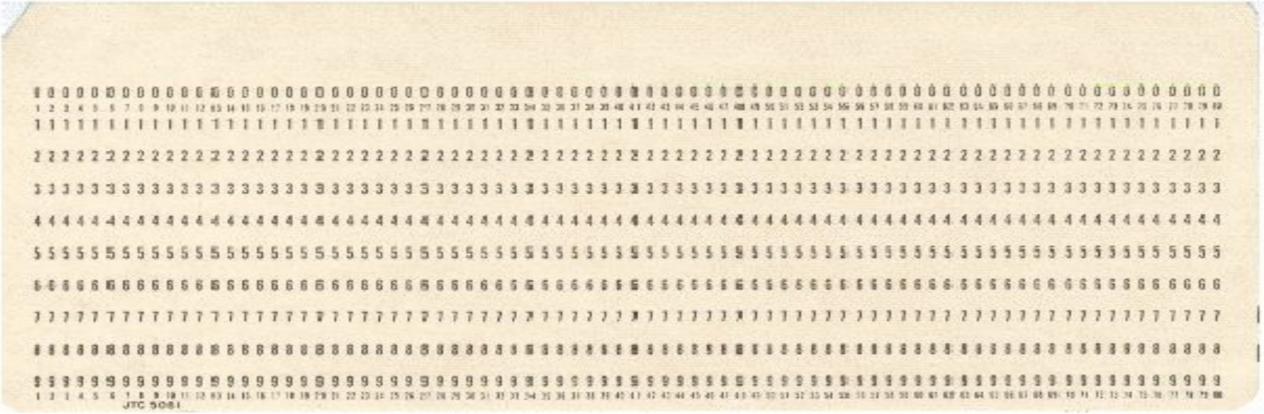
US banknotes were reduced in size by 20% to their present dimensions in 1929:

Above: 1887 currency

http://www.columbia.edu/acis/history/census-tabulator.html

Two types of computer punch cards





The modern, standard, corner-cut, 80-column general-purpose IBM punch card, introduced in 1928, and popularly known as the "IBM card". Holes in the 80-column card are rectangular, rather than round as in earlier models. The bottom ten rows are labeled with digits; the top two rows are unlabeled and are used in an alphanumeric character code first standardized (by IBM) in 1931 as BCDIC, a 40-character set that included digits, uppercase A-Z, space, minus sign, asterisk, and ampersand [52], eventually expanded to a large family of 256-character Extended BCDIC (EBCDIC) codes, IBM's Country Extended Code Pages.

This type of card was a mainstay of data processing and computing from 1928 through the 1980s and was still in use in voting machines through the 2000 USA presidential election, in which they were discredited when the number of swing ballots might have been less than the number questionably-punched cards and therefore contested ballots (we'll never know, since they weren't counted). Although the poorly punched cards were due primarily to unmaintained machines (many of them more than 40 years old), most localities resolved to replace punched-card technology with something more modern, like optical scanners. Whether the new technology is more reliable, accurate, cost effective, durable, and resistent to fraud and tampering remains to be seen. In any case, punched cards are still used in data processing today -- or at least as late as 1999, when THIS ARTICLE was written -- and the last remaining manufacturer of punched-card equipment, Cardamation Company, is still in business.

http://www.columbia.edu/acis/history/census-tabulator.html

Hollerith built a company, the Tabulating Machine Company which, after a few buyouts, eventually became International Business Machines, known today as IBM. IBM grew rapidly and **punched cards became ubiquitous**. Examples:

1) Your gas bill would arrive each month with a punch card you had to return with your payment. This punch card recorded the particulars of your account: your name, address, gas usage, etc. (I imagine there were some "hackers" in these days who would alter the punch cards to change their bill).

2) As another example, when you entered a toll way (a highway that collects a fee from each driver) you were given a punch card that recorded where you started and then when you exited from the toll way your fee was computed based upon the miles you drove.

3) When you voted in an election the ballot you were handed was a punch card. The little pieces of paper that are punched out of the card are called "chad" and were thrown as confetti at weddings.

Incidentally, the Hollerith census machine was the first machine to ever be featured on a magazine cover.

4) Until recently all Social Security and other checks issued by the Federal government were actually punch cards.

5) The check-out slip inside a library book was a punch card.

Written on all these cards was a phrase as common as "close cover before striking": "do not fold, spindle, or mutilate". A spindle was an upright spike on the desk of an accounting clerk. As he completed processing each receipt he would impale it on this spike. When the spindle was full, he'd run a piece of string through the holes, tie up the bundle, and ship it off to the archives. You occasionally still see spindles at restaurant cash registers.

1890 -- WWII
An Overview of the Birth of the Modern Computer

Modern Marvels - The Creation of the Computer part 1

“Babbage” from time 0 to 12:00
“Saving the Census” (Hollerith) from time 12:00 to end 14:02

http://www.youtube.com/watch?v=AVypDyw0Ckc

NOTE: 2018 class We did not watch these videos

Modern Marvels - The Creation of the Computer part 2

“Saving the Census” (Hollerith) from 0 … 1:15
“The Number Business” from time 1:16 to 4:30 (Tabulating Machine Company TMC)
“A Collossus to Solve An Enigma” from 4:31 to

http://www.youtube.com/watch?v=kVTn3tECIOE

1911: History of IBM

The company was founded in 1911 as the [Computing Tabulating Recording Company] (CTR) through a merger of three companies:

1) the Tabulating Machine Company (Hollerith's)
2) the International Time Recording Company, and
3) the Computing Scale Company.

CTR adopted the name International Business Machines (IBM) in 1924.

Securities analysts nicknamed IBM *Big Blue* in recognition of IBM's common use of blue in products, packaging, and logo.

Thomas J. Watson, SR.

100 Years of IBM: Quick Year-by-Year recap of IBM History (13 min 15 seconds)
From 1911 to 2011. This is like an IBM commercial, but it's a good overview
http://www.youtube.com/watch?v=q45B_1SW2so

No need to watch this unless you want to...we did not watch in class

1930's – 1940's: Hollerith Machine and WWII

IBM AND THE HOLOCAUST

THE STRATEGIC ALLIANCE BETWEEN NAZI GERMANY AND AMERICA'S MOST POWERFUL CORPORATION

IBM and the Holocaust is the stunning story of IBM's strategic alliance with Nazi Germany -- beginning in 1933 in the first weeks that Hitler came to power and continuing well into World War II. As the Third Reich embarked upon its plan of conquest and genocide, IBM and its subsidiaries helped create enabling technologies, step-by-step, from the identification and cataloging programs of the 1930s to the selections of the 1940s.

American Society of Journalists and Authors

ASJA

American Society of Journalists and Authors

Winner, Best Non-Fiction Book 2002
Best Investigative Article 2002
in Village Voice

Real History TV Show: IBM and The Holocaust (Interview with Edwin Black)
(7 min 43 sec)

http://www.youtube.com/watch?v=FYFNMmtJt7w

Another Edwin Black interview (3 min 31 sec)
http://www.youtube.com/watch?v=7K70e0Xj-Ak

Hollerith Machine

1930's – 1940's: Bletchley Park, Alan Turing and the Enigma "Codebreakers"

BLETCHLEY PARK
A mansion house in the Buckinghamshire countryside was to set the scene for one of the most remarkable stories of World War Two.

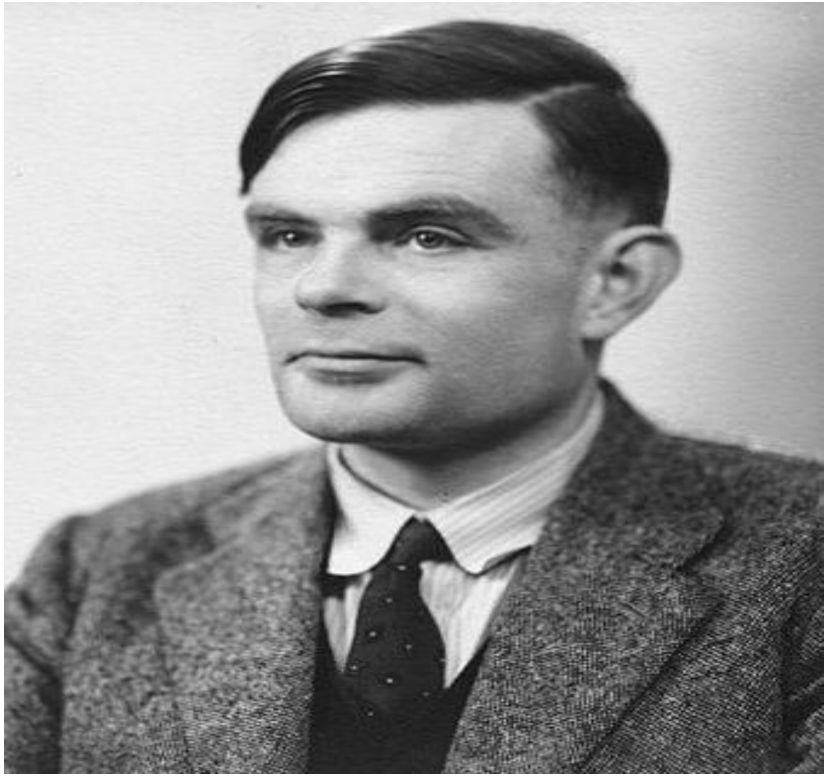
The British **Government Code and Cypher School (GC&CS)**, a secret team of individuals including a number of scholars turned Codebreakers, selected Bletchley Park as their wartime location, well away from London, for intelligence activity.

The GC&CS mission was to crack the Nazi codes and ciphers. The most famous of the cipher systems to be broken at Bletchley Park was the Enigma. There were also a large number of lower-level German systems to break as well as those of Hitler's allies.

Alan Turing -- 1912-1954. British Codebreaker.

Worked on the bombe (code breaking machine). Noted for many brilliant ideas, Turing is perhaps best remembered for the concepts of the Turing Test for Artificial Intelligence and the Turing Machine, an abstract model for modeling computer operations. The Turing Test is the "acid test" of true artificial intelligence, as defined by the English scientist Alan Turing. **In the 1940s, he said "a machine has artificial intelligence when there is no discernible difference between the conversation generated by the machine and that of an intelligent person."** This is the famous “Turing Test”.

Turing was instrumental in breaking the German enigma code during WWII with his Bombe computing machine. The Enigma is a machine used by the Germans to create encrypted messages.



Pictured above: Alan Turing, the great mathematician (Princeton University) and Code Breaker of WWII.

The process of breaking Enigma was aided considerably by a complex electro-mechanical device, designed by Alan Turing and Gordon Welchman. The Bombe, as it was called, ran through all the possible Enigma wheel configurations in order to reduce the possible number of settings in use to a manageable number for further hand testing.

A German Enigma machine.

1940's: British "bombe" used for Code-Breaking during WWII

The working rebuilt bombe at Bletchley Park museum. Each of the rotating drums simulates the action of an Enigma rotor. There are 36 Enigma-equivalents and, on the right-hand end of the middle row, three *indicator* drums.

Who was Alan Turing?

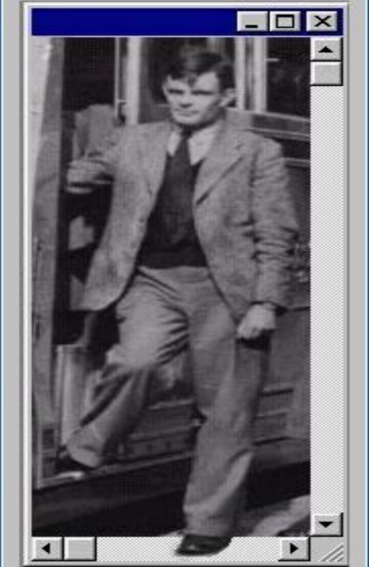
Founder of computer science, mathematician, philosopher, codebreaker, strange visionary and a gay man before his time:

ALAN TURING CENTENARY YEAR 2012

...a quite brilliant mathematician... whose unique contribution helped to turn the tide of war... horrifying that he was treated so inhumanely...

Personal statement of apology by the Prime Minister, Gordon Brown, 10 September 2009.

1912 (23 June): Birth, Paddington, London
1926-31: Sherborne School
1930: Death of friend Christopher Morcom
1931-34: Undergraduate at King's College, Cambridge University
1932-35: Quantum mechanics, probability, logic
1935: Elected fellow of King's College, Cambridge
1936: The Turing machine, computability, universal machine
1936-38: Princeton University. Ph.D. Logic, algebra, number theory
1938-39: Return to Cambridge. Introduced to German Enigma cipher machine
1939-40: The Bombe, machine for Enigma decryption
1939-42: Breaking of U-boat Enigma, saving battle of the Atlantic
1943-45: Chief Anglo-American crypto consultant. Electronic work.
1945: National Physical Laboratory, London
1946: Computer and software design leading the world.
1947-48: Programming, neural nets, and artificial intelligence
1948: Manchester University
1949: First serious mathematical use of a computer
1950: The Turing Test for machine intelligence
1951: Elected FRS. Non-linear theory of biological growth
1952: Arrested as a homosexual, loss of security clearance
1953-54: Unfinished work in biology and physics
1954 (7 June): Death (suicide) by cyanide poisoning, Wilmslow, Cheshire.



Alan Turing in 1946.
Full picture

http://www.turing.org.uk/turing/

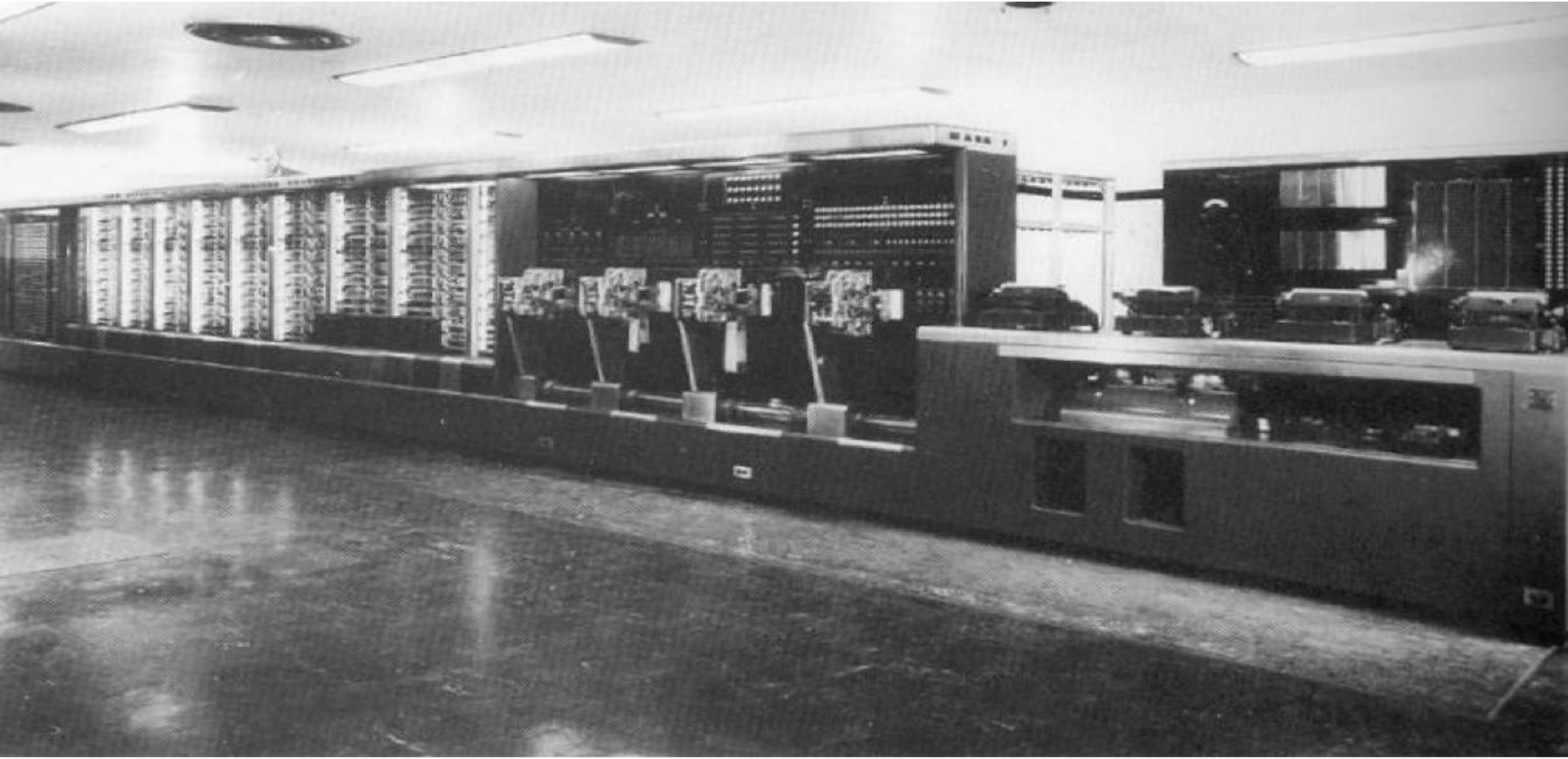
1954: Alan Turing’s Suicide

Alan Turing unfortunately did not live long enough to contribute to computing. In the 1950s his sexual orientation caused problems, leading to botched female hormone treatments (chemical castration causing his breasts to grow), and his ultimate suicide. At the time in England, there was acute public anxiety about spies and homosexual entrapment by Soviet agents, which explains the reduced tolerance by society.

1944: Harvard Mark I

By World War II the U.S. had battleships that could lob shells weighing as much as a small car over distances up to 25 miles. Physicists could write the equations that described how atmospheric drag, wind, gravity, muzzle velocity, etc. would determine the trajectory of the shell. But solving such equations was extremely laborious. This was the work performed by the human computers. Their results would be published in ballistic "firing tables" published in gunnery manuals. During World War II the U.S. military scoured the country looking for (generally female) math majors to hire for the job of computing these tables. But not enough humans could be found to keep up with the need for new tables. Sometimes artillery pieces had to be delivered to the battlefield without the necessary firing tables and this meant they were close to useless because they couldn't be aimed properly. Faced with this situation, the U.S. military was willing to invest in even hair-brained schemes to automate this type of computation.

One early success was the **Harvard Mark I computer** which was built as a partnership between Harvard and IBM in 1944. This was the first programmable digital computer made in the U.S. But it was not a purely electronic computer. Instead the Mark I was constructed out of switches, relays, rotating shafts, and clutches. The machine weighed 5 tons, incorporated 500 miles of wire, was 8 feet tall and 51 feet long, and had a 50 ft rotating shaft running its length, turned by a 5 horsepower electric motor. The Mark I ran non-stop for 15 years, sounding like a roomful of ladies knitting. To appreciate the scale of this machine note the four typewriters in the foreground of the following photo.



The Harvard Mark I: an electro-mechanical computer

MARK I: Developed by Howard H. Aiken (shown to the left), built at IBM and shipped to Harvard in February 1944.

http://plyojump.com/classes/pre_1945.php

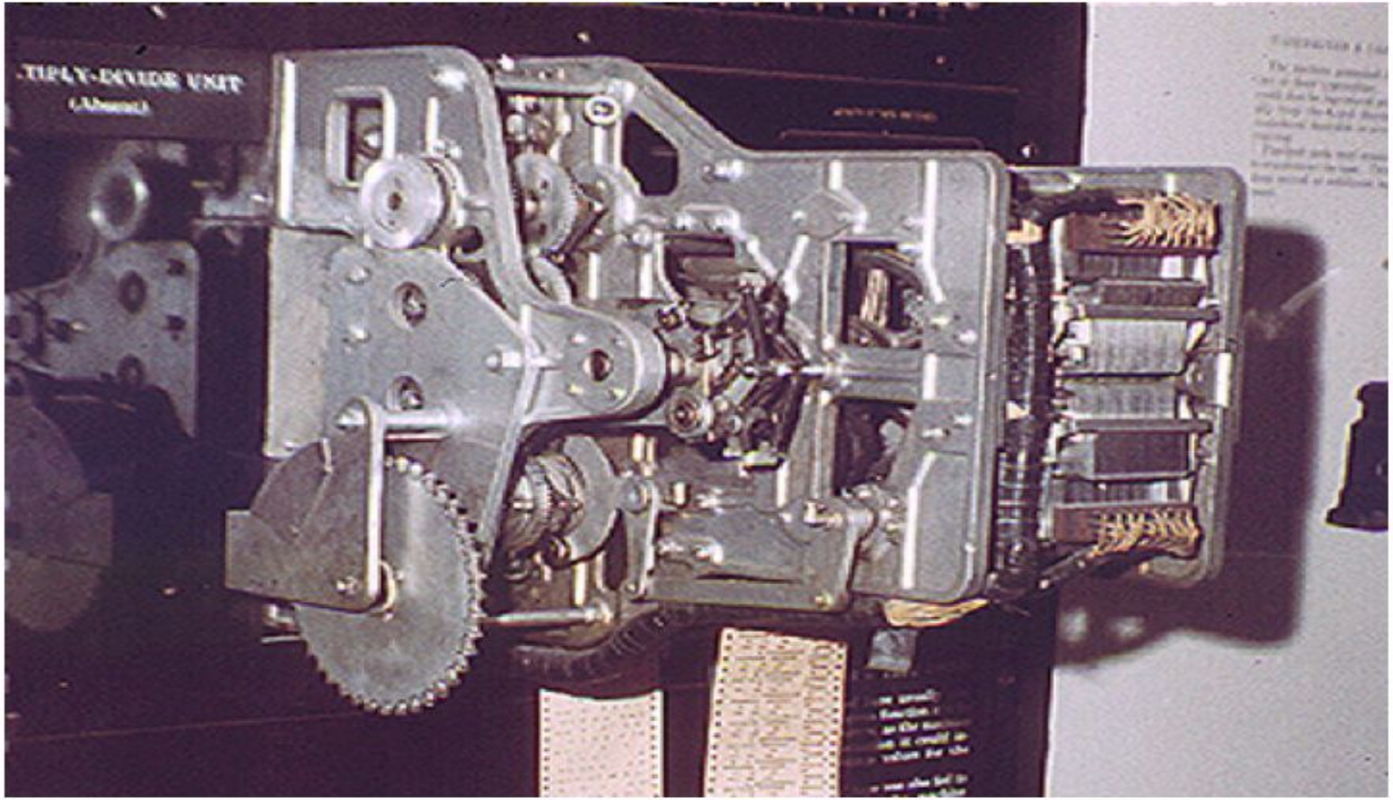
The Mark I operated on numbers that were 23 digits wide. It could add or subtract two of these numbers in three-tenths of a second, multiply them in four seconds, and divide them in ten seconds. Forty-five years later computers could perform an addition in a billionth of a second! Even though the Mark I had three quarters of a million components, it could only store 72 numbers! Today, home computers can store 30 million numbers in RAM and another 10 billion numbers on their hard disk. Today, a number can be pulled from RAM after a delay of only a few billionths of a second, and from a hard disk after a delay of only a few thousandths of a second. This kind of speed is obviously impossible for a machine which must move a rotating shaft and that is why electronic computers killed off their mechanical predecessors.

The Mark I was also unique in not being an experimental system - it was immediately put into use by the US Military. Part of the complex computations needed to produce the first atomic bomb were performed on the Mark I. One of its remarkable features was its reliability - unlike the early electronic computers, it could compute 20 hours a day without breaking down.

The first programmers of the Mark I were computing pioneers Richard Milton Block, Robert Campbell and Grace Hopper.

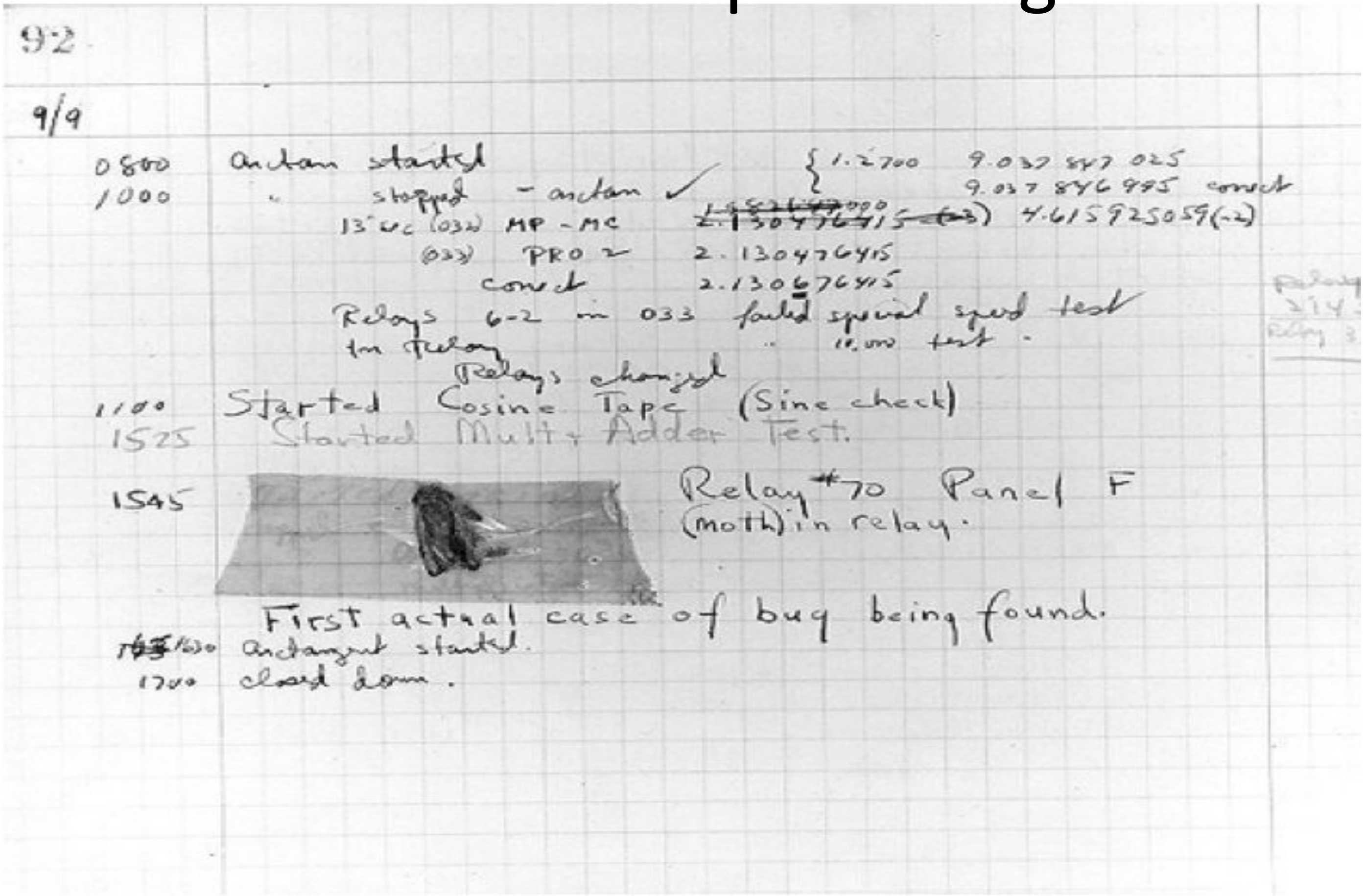
http://plyojump.com/classes/pre_1945.php

Here's a close-up of one of the Mark I's four paper tape readers. A paper tape was an improvement over a box of punched cards as anyone who has ever dropped -- and thus shuffled -- his "stack" knows.



One of the four paper tape readers on the Harvard Mark I (you can observe the punched paper roll emerging from the bottom)

The First Computer Bug!



The first computer bug [photo © 2002 IEEE]

One of the primary programmers for the Mark I was a woman, Grace Hopper. Hopper found the first computer "bug": a dead moth that had gotten into the Mark I and whose wings were blocking the reading of the holes in the paper tape. The word "bug" had been used to describe a defect since at least 1889 but Hopper is credited with coining the word "debugging" to describe the work to eliminate program faults.

Photo # NH 96919-KN Commodore Grace M. Hopper, 1984

Rear Admiral Grace Murray Hopper, USNR, (1906-1992)

USS *Hopper* (DDG-70) is named in honor of Rear Admiral Grace Murray Hopper.

Of the Mark I programmers - probably the first people to create and run useful computing in a data center - Grace Hopper stood out. With a doctorate in mathematics, Hopper joined the Navy in WWII and later joined Aiken's group. Grace Hopper worked closely with Aiken, and in some ways the old Babbage/Byron hardware/software duo had reappeared.

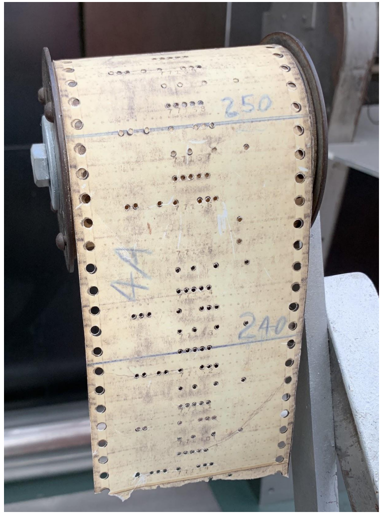
Grace Hopper went on to define many features of modern computing, including "open source" and high-level computing languages. Her creation of software "compilers" was critical in that it brought large numbers of new programmers into the profession in the 1950s.

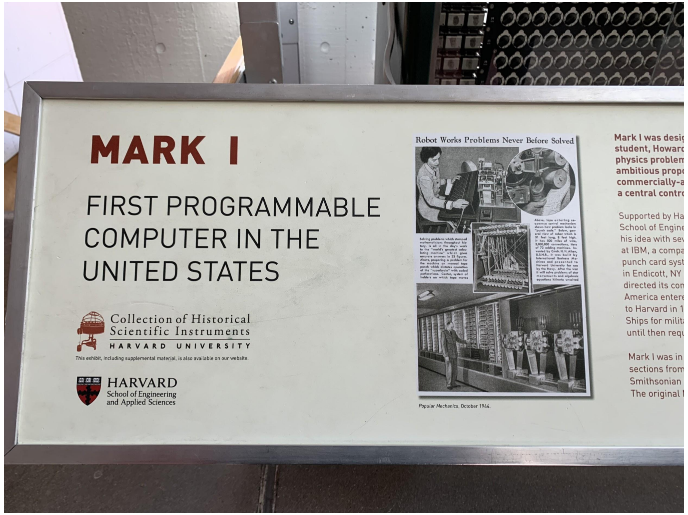
COBOL, the first high-level programming language that she developed circa 1960, is still in use - in fact, 70% of all code running on computers today is still written in COBOL. In part due to Hopper (and Ada Lovelace before her), computing was seen as a profession open to women, and by the 1960s computing was the preferred "high-tech" choice of many women.

In 1953 Grace Hopper invented the first high-level language, "Flow-matic". A high-level language is designed to be more understandable by humans than is the binary language understood by the computing machinery. A high-level language is worthless without a program -- known as a ***compiler*** -- to translate it into the binary language of the computer and hence Grace Hopper also constructed the world's first compiler.

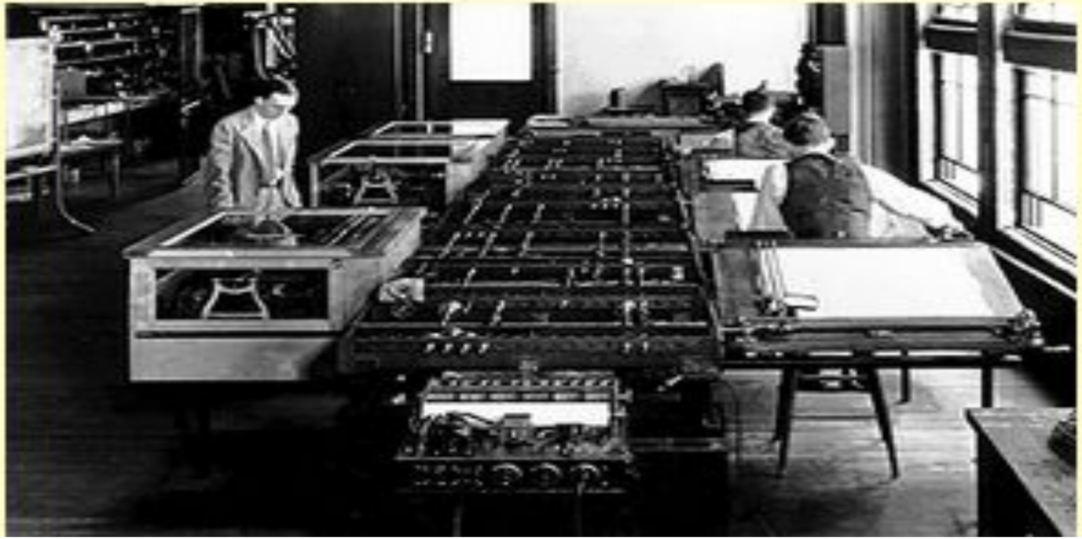
Grace remained active as a Rear Admiral in the Navy Reserves until she was 79 (another record).

I was in Boston in December 2019 and wandered into a science building on the Harvard campus and look what I found in the lobby! I was geeking out so much!!





Vannevar Bush and the Memex (1945)



Bush wrote an astounding article in 1945 which fully envisioned the World Wide Web 50 years before it actually appeared. Like Babbage's Analytical Engine, it was never built. He called his "web browser" a Memex. The design used electrical wires and microfilm files filling a desk to create the equivalent experience of web surfing - in particular, "hyperlinking" one page of data to another. There are two screens, one for visual display of information, and another - a touch-sensitive pad - for writing and drawing. Bush also imagined a user would have a small camera connected to the system, similar to webcams today.
Link to the original Atlantic Monthly article - http://www.theatlantic.com/doc/194507/bush

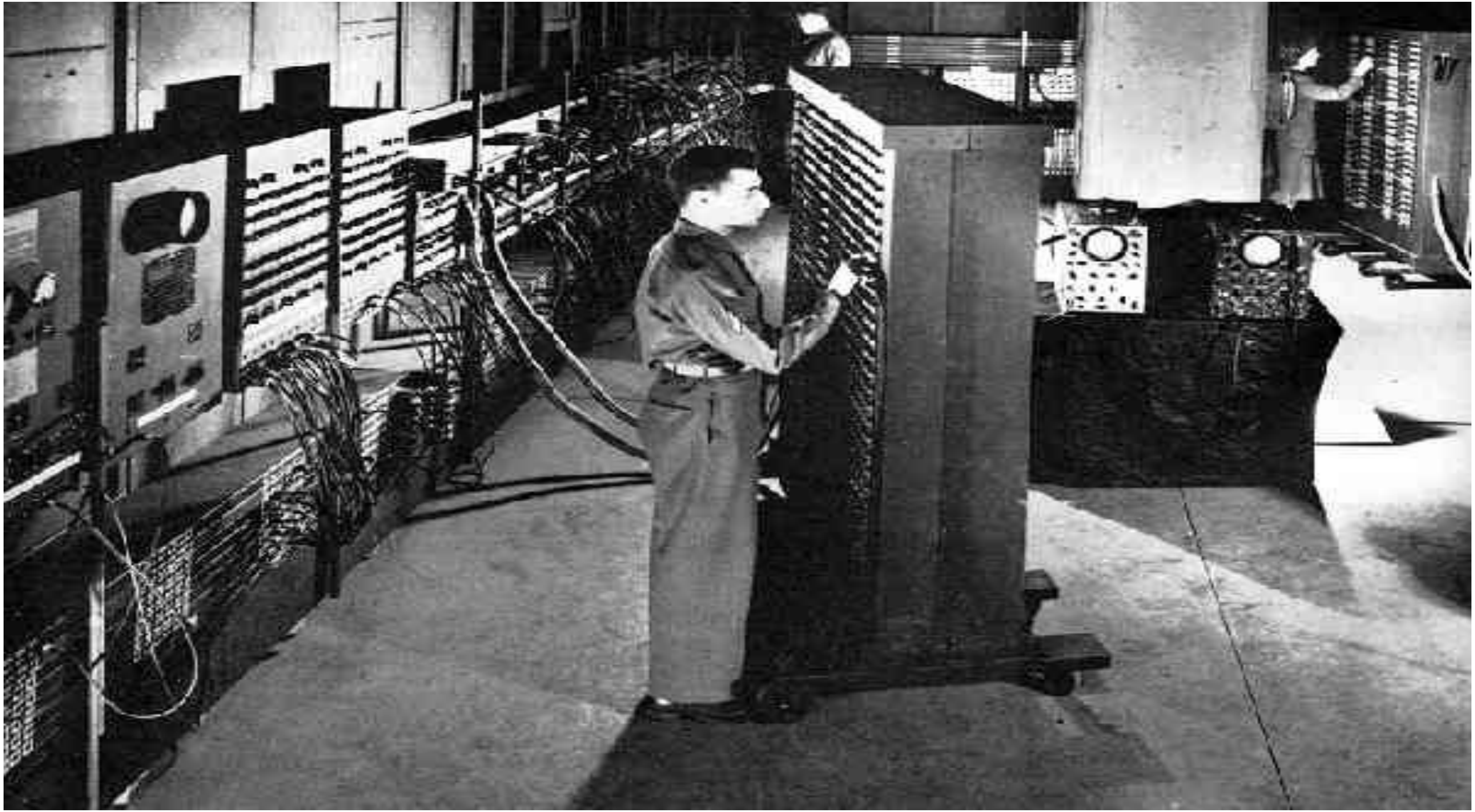
1900s: Vacuum Tubes

In electronics, a **vacuum tube**, **electron tube** (in North America), **thermionic valve**, **tube**, or **valve** is a device controlling electric current through a vacuum in a sealed container. Vacuum tubes were inventing some time in the 1800s

Modern vacuum tubes, mostly miniature style

1946: ENIAC
The "Electric Numerical Integrator and Calculator"

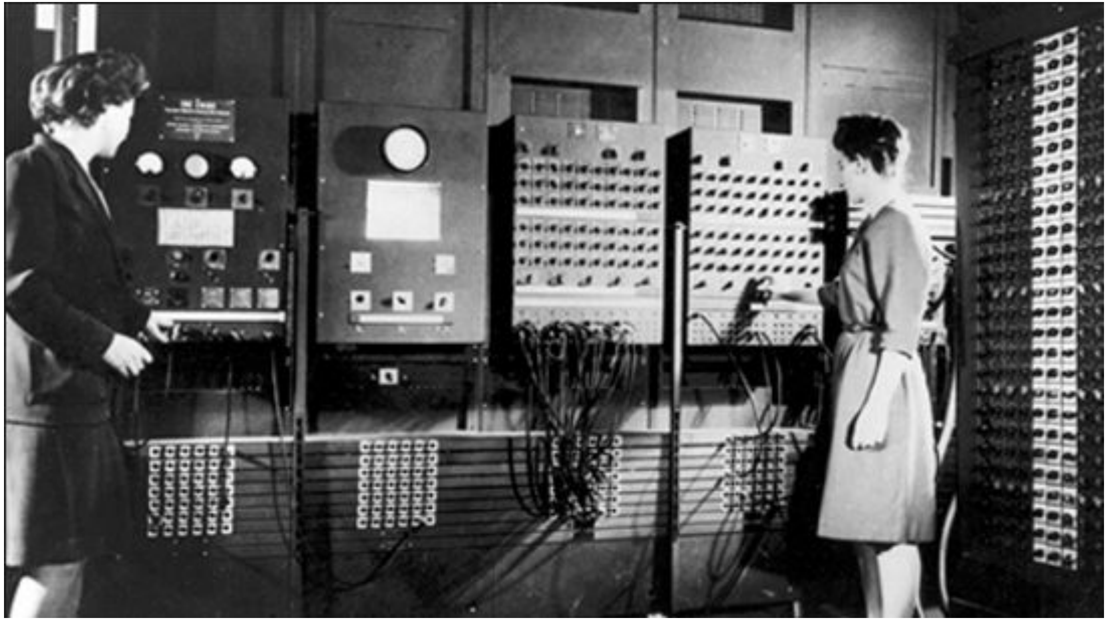
1946 - ENIAC - World's first electronic, large scale, general-purpose computer, built by Mauchly and Eckert, and activated at the University of Pennsylvania in 1946. The ENIAC is a 30 ton machine that measured 50 x 30 feet. It contained 19,000 vacuum tubes, 6000 switches, and could add 5,000 numbers in a second, a remarkable accomplishment at the time.



One view of ENIAC: the "Electronic Numerical Integrator and Calculator" (note that it wasn't even given the name of computer since "computers" were people) [U.S. Army photo]

A reprogrammable machine, the ENIAC performed initial calculations for the H-bomb. It was also used to prepare artillery shell trajectory tables and perform other military and scientific calculations.

Since there was <u>no software</u> to reprogram the computer, people had to <u>rewire it</u> to get it to perform different functions. The human programmers had to read wiring diagrams and know what each switch did.



The title of forefather of today's all-electronic digital computers is usually awarded to ***ENIAC***, which stood for Electronic Numerical Integrator and Calculator. ENIAC was built at the University of Pennsylvania between 1943 and 1945 by two professors, ***John Mauchly*** and the 24 year old ***J. Presper Eckert***, who got funding from the war department after promising they could build a machine that would replace all the "computers", meaning the women who were employed calculating the firing tables for the army's artillery guns.

Like the Mark I, ENIAC employed paper card readers obtained from IBM (these were a regular product for IBM, as they were a long established part of business accounting machines, IBM's forte). When operating, the ENIAC was silent but you knew it was on as the 18,000 vacuum tubes each generated waste heat like a light bulb and all this heat (174,000 watts of heat) meant that the computer could only be operated in a specially designed room with its own heavy duty air conditioning system.

One of the most obvious problems was that the design would require 18,000 vacuum tubes to all work simultaneously. Vacuum tubes were so notoriously unreliable that even twenty years later many neighborhood drug stores provided a "tube tester" that allowed homeowners to bring in the vacuum tubes from their television sets and determine which one of the tubes was causing their TV to fail. And television sets only incorporated about 30 vacuum tubes.

The ENIAC had a tube failure (which took 15 minutes to locate) on average every two days.[14]

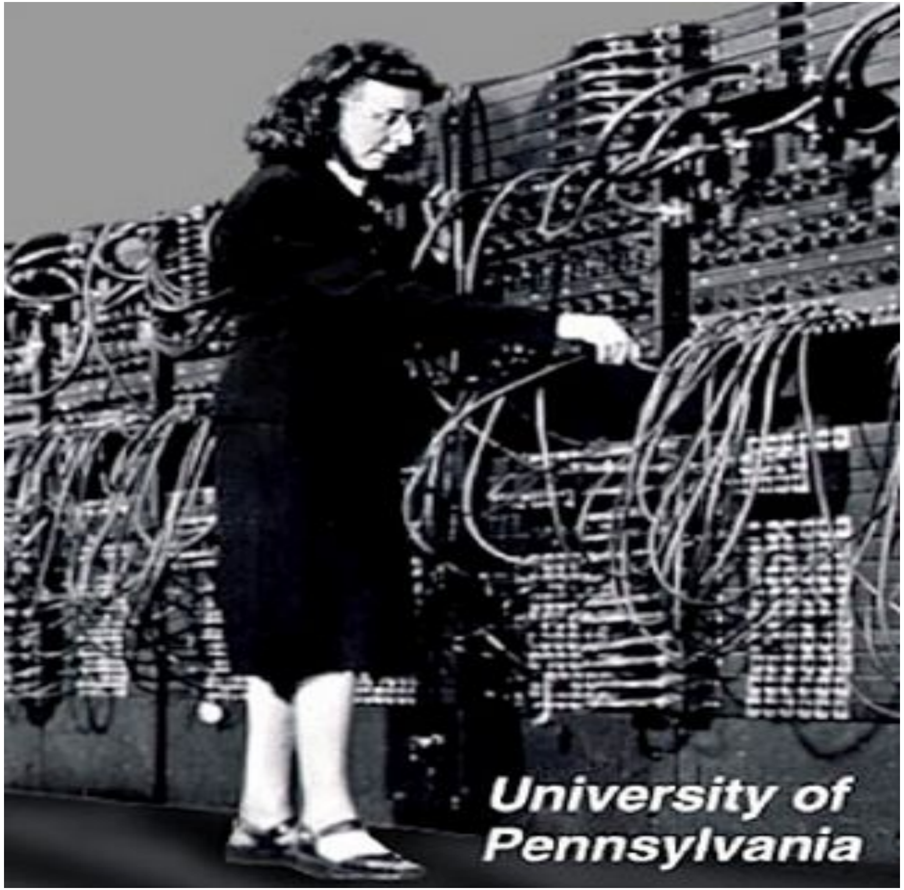
"None of us girls were ever introduced...we were just programmers."

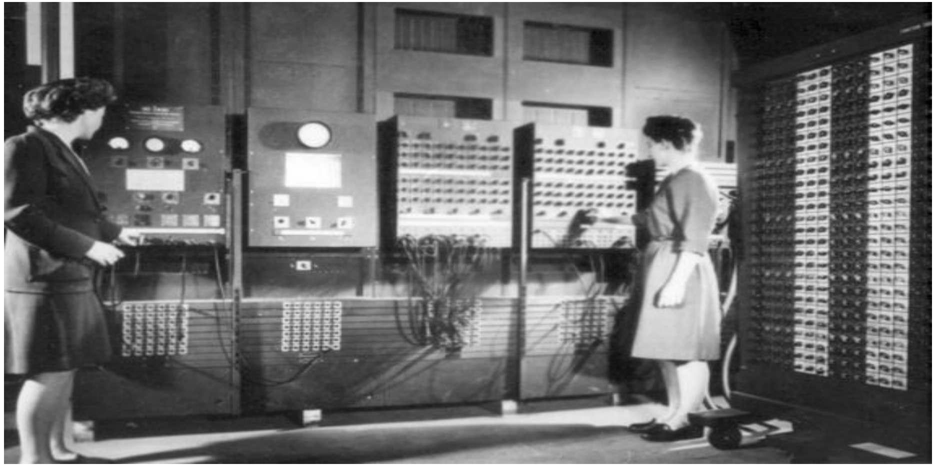
Kay Mauchly Antonelli, ENIAC Programmer, *The Computers: The Untold Story of the Remarkable Women Who Programmed the ENIAC* (Documentary Preview), 2001

Sixty years ago, six young women programmed the world's first all-electronic computer, the ENIAC. Their ballistics program used hundreds of wires and 3000 switches. Never introduced, they never became a part of history. Forty years later, Kathy Kleiman was told that the women in pictures with ENIAC (1946) were "Refrigerator Ladies," models posed in front of the machine.

Nothing could be further from the truth. The ENIAC Programmers worked tirelessly to make programming easier for all. They created the first sort routine, software application and instruction set, and classes in programming. Their work dramatically altered computing in the 1940s and 1950s. They paved the path to the modern software industry.

The ENIAC Programmers Project records the stories, seeks recognition for their accomplishments and seeks to produce the first feature documentary about this dramatic story.





Programmers Betty Jean Jennings (left) and Fran Bilas (right) operate the ENIAC's main control panel at the Moore School of Electrical Engineering.

1950's – 1960's: UNIVAC
The "Universal Automatic computer"

1950s -1960s - UNIVAC - The first commercially successful computer, introduced in 1951 by Remington Rand. Over 40 systems were sold to the US Census Bureau for use in the census. A few other systems were sold for commercial use by companies such as General Electric, who used the UNIVAC computer for payroll.

The word UNIVAC became synonymous with computer (for a while). In a publicity stunt, the UNIVAC computer was used to predict the results of the Eisenhower-Stevenson presidential race. The computer had correctly predicted that Eisenhower would win, but the news media decided to blackout the computer's prediction and declared that the UNIVAC had been stumped.

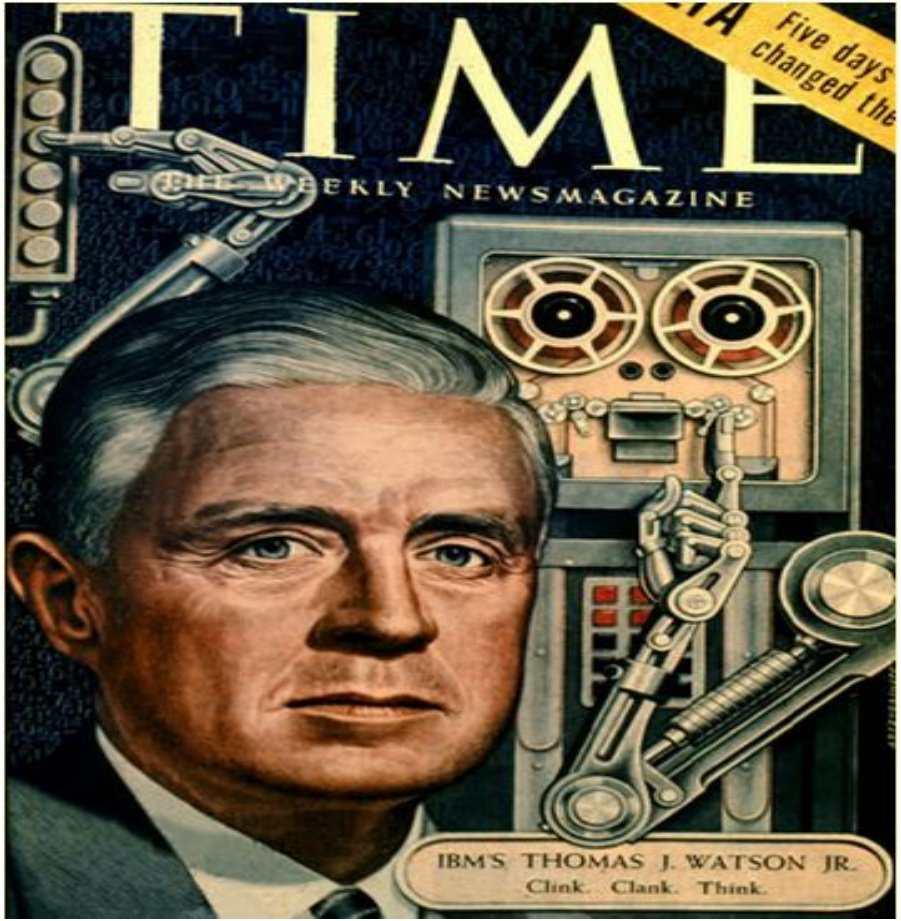
When the truth was revealed, it was considered amazing that a computer could do what political forecasters could not, and the UNIVAC quickly became a household name. The original UNIVAC now sits in the Smithsonian Institution.

http://inventors.about.com/od/uvstartinventions/a/UNIVAC.htm

Univac (1951)

Grace Hopper with fellow programmers, early 1950s

The Artificial Intelligence dream starts early!



The cover of Time magazine showing Tom Watson Jr., head of IBM in the 1950s

1959: IBM Stretch Computer

(that's just the operator's console, here's the rest of its 33 foot length:)

SABRE Reservation system (1960)

An outgrowth of the SAGE military computer system for tracking aircraft, SABRE was the first commercial computer-based airline reservation system when it came online in 1962. A version of this system is still used to handle airline reservations today.

The IBM 360 (1960s)

If you learned computer programming in the 1970's, you dealt with what today are called ***mainframe computers***, such as the IBM 7090 (shown below), IBM 360, or IBM 370.

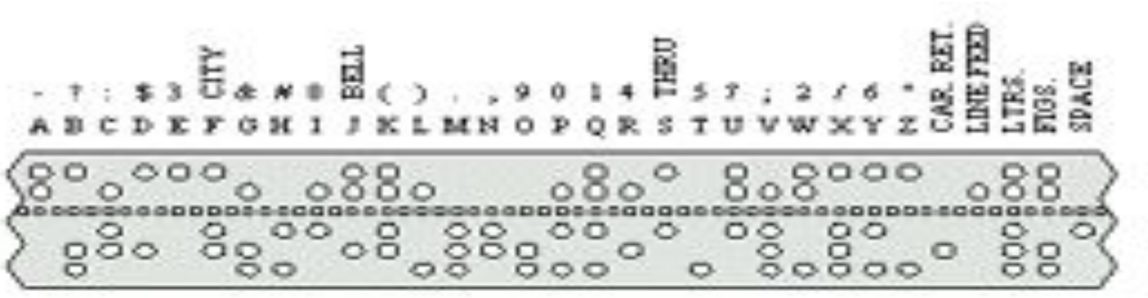
The IBM 7094, a typical mainframe computer [photo courtesy of IBM]

Many mainframe models were developed by IBM in the 1950s and 1960s, but the IBM 360 is particularly important, since it was the first mainframe to enjoy widespread use in business and government. Large numbers of men and women sought careers in computers and data processing during this era.

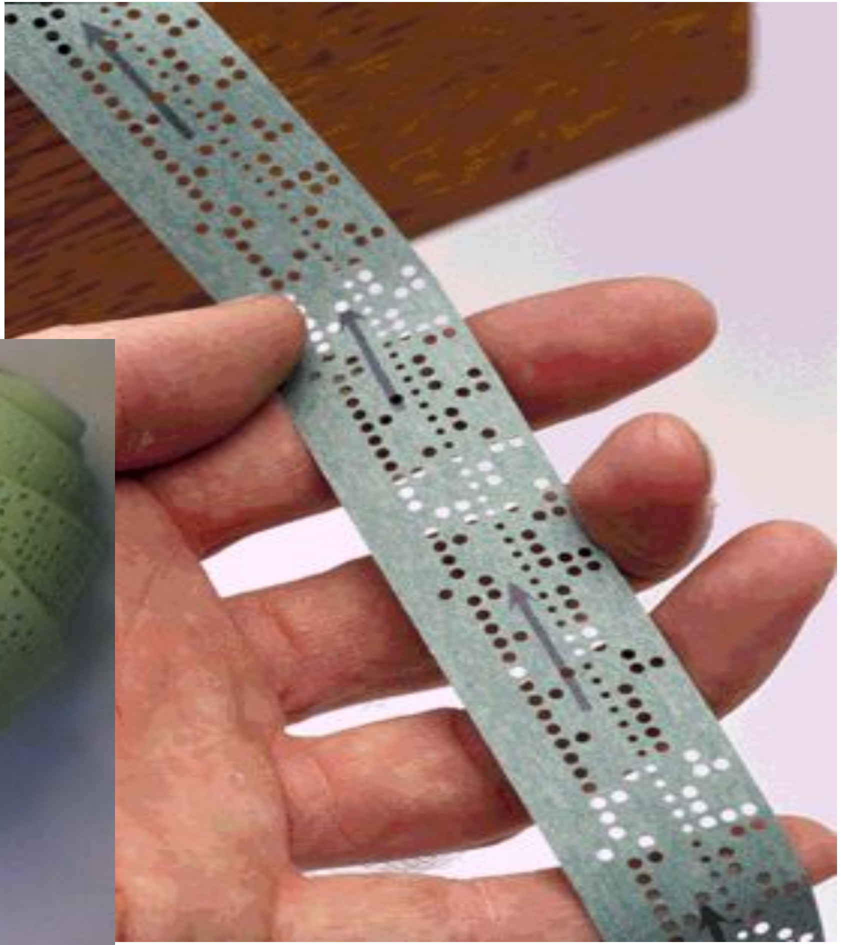
Images from this era show lots of women for two reasons. First, new business environments often don't have gender rules prebuilt, so it wasn't obvious that a woman couldn't work with computers, even program. Second, entering data and managing software was seen as inferior to creating hardware, an exclusively male profession at the time. Today, the relative values of hardware and software are reversed.

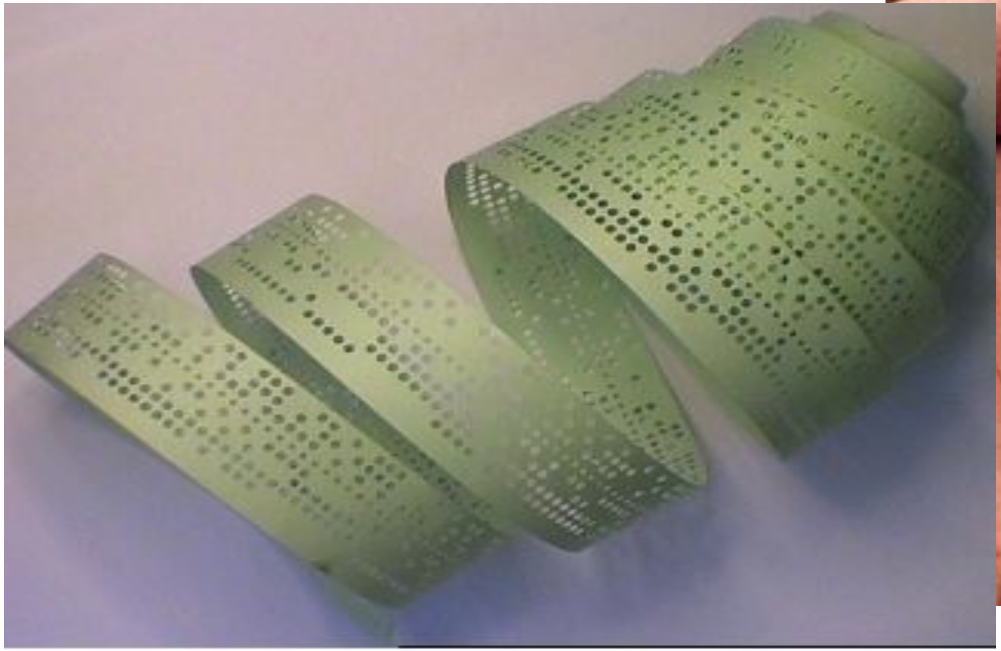
Timesharing

In ***time sharing*** the computer gave each user a tiny sliver of time in a round-robin fashion. Perhaps 100 users would be simultaneously logged on, each typing on a ***teletype*** machine.

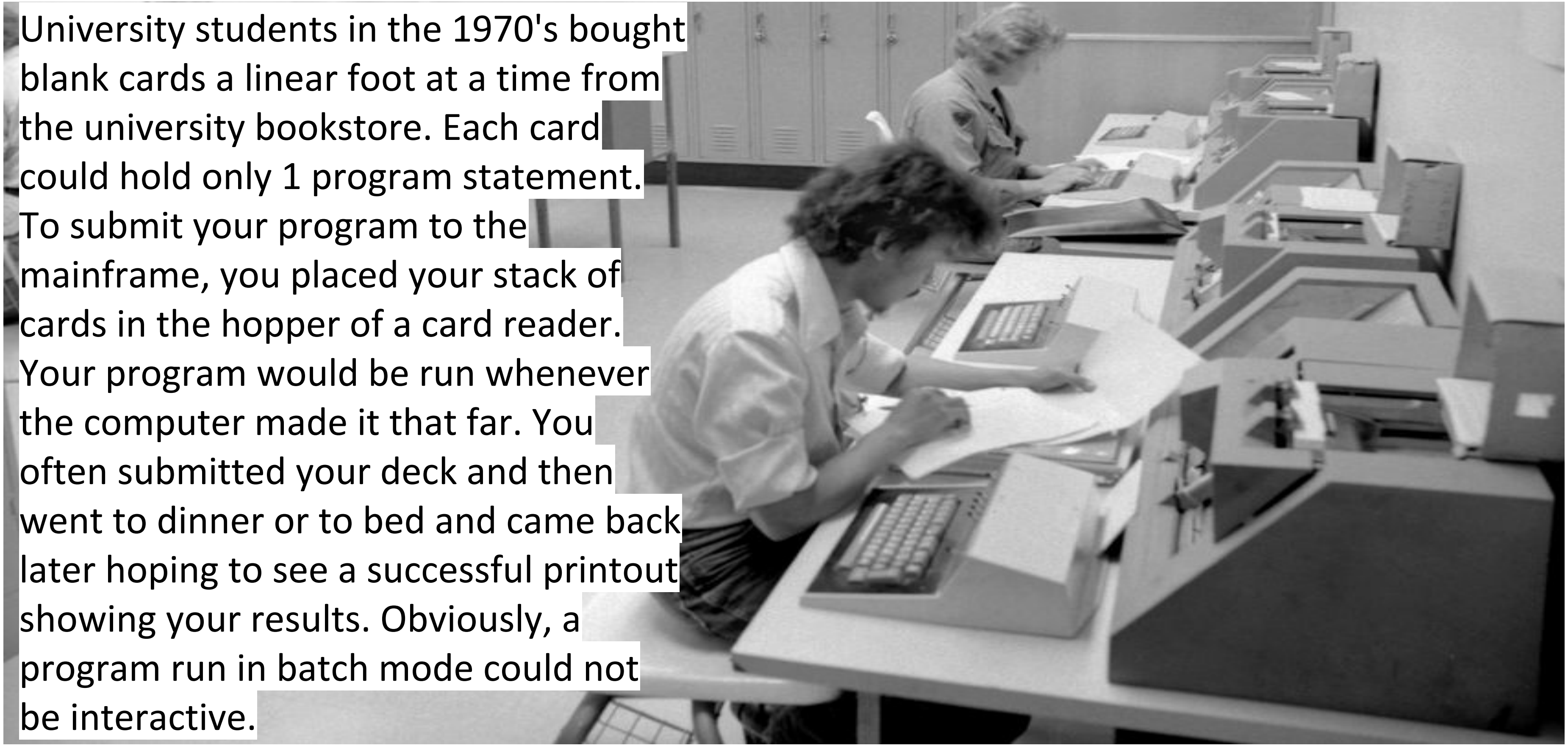


A teletype was a motorized typewriter that could transmit your keystrokes to the mainframe and then print the computer's response on its roll of paper. You typed a single line of text, hit the carriage return button, and waited for the teletype to begin noisily printing the computer's response (at a whopping 10 characters per second). On the left-hand side of the teletype in the prior picture you can observe a paper tape reader and writer (i.e., puncher). Here's a close-up of paper tape:





University students in the 1970's bought blank cards a linear foot at a time from the university bookstore. Each card could hold only 1 program statement. To submit your program to the mainframe, you placed your stack of cards in the hopper of a card reader. Your program would be run whenever the computer made it that far. You often submitted your deck and then went to dinner or to bed and came back later hoping to see a successful printout showing your results. Obviously, a program run in batch mode could not be interactive.



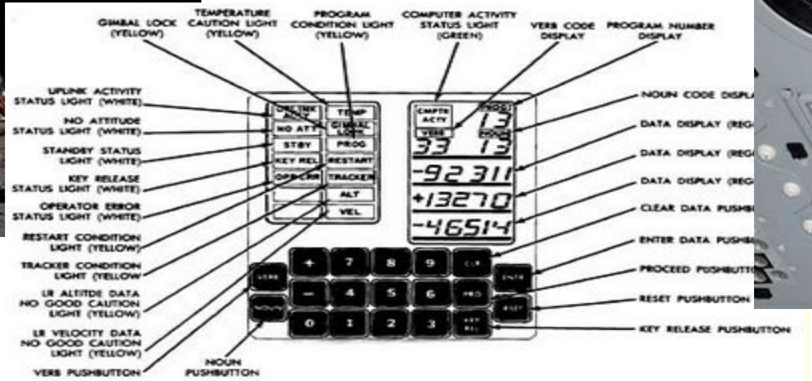
Timeshare computers at a college in the 1960s, with an older punched-card interface.

This image shows IBM computers being used to manage airline reservatons in a timeshare environment.

By the 1960s a model for computing had emerged featuring a central computer with a large set of "dumb" terminals. This allowed many people to use the mainframe at the same time, and caused an enormous expansion of the computing community. The scenes resemble a data center today, but remember that there is only one computer here, connected to a large number of screens. Single-person computers (or "personal" computers) did not become widespread until the 1980s.

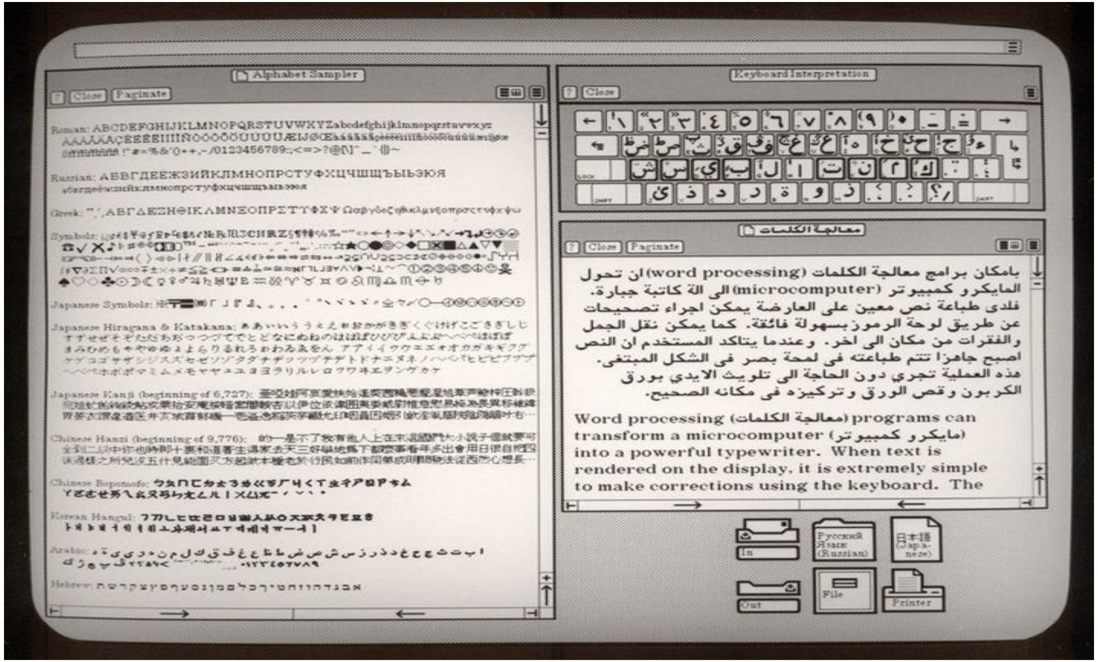
Apollo Guidance Computer (1968)

This computer was used to guide the Apollo lander to the surface of the moon. It was also used in other NASA spacecraft of the 1970s, including Skylab. Moon "hoaxers" sometimes claim that moon landings were impossible due to lack of computers. In reality, powerful computers were available by the mid-1960s - they were just too expensive for ordinary people to own.



Computer History - Workstation Era (1968-1985)

Xerox Star (1981)



This transformation was a result of the invention of the ***microprocessor***. A microprocessor (uP) is a computer that is fabricated on an integrated circuit (IC). Computers had been around for 20 years before the first microprocessor was developed at ***Intel*** in 1971. The micro in the name microprocessor refers to the physical size. Intel didn't invent the electronic computer. But they were the first to succeed in cramming an entire computer on a single ***chip*** (IC). Intel was started in 1968 and initially produced only semiconductor memory (Intel invented both the DRAM and the EPROM, two memory technologies that are still going strong today).

Developed during the late 1970s by Xerox, the Star incorporated features that today define personal computers: a bitmapped display, mouse, windows, local hard disk, network connectivity via Ethernet, and laser printing. The Star also refined the "desktop metaphor" - showing files and folders as icons, dialog boxes, and a "point and click" style of interaction." It was the first commercial object-oriented computer interface. Apple essentially stole key Star concepts to produce the Apple Lisa, and later, the Apple Macintosh. Today, virtually all personal computers have an interface directly descended from the Star.

The Xerox Star was not originally meant to be a stand-alone computer, but to be part of an integrated Xerox "personal office system" that also connected to other workstations and network services via Ethernet. Although a single unit sold for $16,000, a typical office would have to purchase at least 2 or 3 machines along with a file server and a name server/print server. Spending $50,000 to $100,000 for a complete installation was not an easy sell, when a secretary's annual salary was about $12,000 and a Commodore VIC-20 cost around $300.

Later incarnations of the Star would allow users to purchase a single unit with a laser printer, but even so only about 25,000 units were sold, leading many to consider the Xerox Star to be a commercial failure.

Altair 8800 (1976)

This is the computer that Microsoft wrote and sold its first programs for. It had no mouse, keyboard, or printer, or even a monitor. Programs were entered by flipping switches on the front panel, and blinking lights showed the program's execution.

Pirates of Silicon Valley

The early pioneers of personal computing considered themselves rebels in the 1960s counterculture sense. Here we see Bill Gates in jail, and Steve Jobs shortly after he left the hippie commune (where he fathered his daughter).

Apple I (1976)

The Apple I was originally designed by Steve Wozniak, but his friend Steve Jobs had the idea of selling the computer. 50 units of the original Apple I were sold at a price of $666.66 (because Wozniak liked repeating digits and because they originally sold it to a local shop for $500 and added a one-third markup). To make a working computer, users still had to add a case, power supply, keyboard, and display. An optional board providing a cassette interface for data storage was later released for $75.

TRS-80

Sold through Radio Shack, using a cassette player for its memory and a TV for a monitor, the TRS-80 was an early hobby computer.

OSBORNE portable computer (1981)

An early entry into the world of business computing, the Osborne was the first computer that could be carried onboard and used on a plane.

The IBM PC (1982)

The IBM PC helped to convert the microcomputer from a hobbyist geekland to a serious business tool. Microsoft didn't make hardware - but they did make the operating system for the IBM PC. This is a picture of Paul Allen and Bill Gates standing next to one of the computers running their new OS, MS-DOS.

The Apple Macintosh (1984)

Created by Apple computer under Steven Jobs, with brilliant programming by Steve Wozniak, the Macintosh user interface borrowed heavily from the Xerox Star but was affordable (~$2,000 in 1984 dollars) by the masses. The user interface of the Mac is remarkably similar to the design of current Macintosh computers, despite the 500x slower operating speed of its CPU.

www.computerhistory.org

Excellent, year-by-year timelines

starting with 1939 going up to 1994

http://www.computerhistory.org/timeline/?year=1939

Parting Notes

Richard Feynman (Physicist) on Computer Science — Talk at Bell Labs (1985)
"Is Computer Science a Science?" 1 minute video
http://www.youtube.com/watch?v=lL4wg6ZAFIM
Peynman assisted in the development of the atomic bomb during World War II and was a member of the Rogers Commission, the panel that investigated the Space Shuttle Challenger disaster. In addition to his work in theoretical physics, Feynman has been credited with pioneering the field of quantum computing and introducing the concept of nanotechnology.
From: http://en.wikipedia.org/wiki/Richard_Feynman

http://computer.howstuffworks.com/computer-evolution.htm

How will computers evolve over the next 100 years?
by Jonathan Strickland