15-292 History of Computing

Post War Computing (1945-1959)

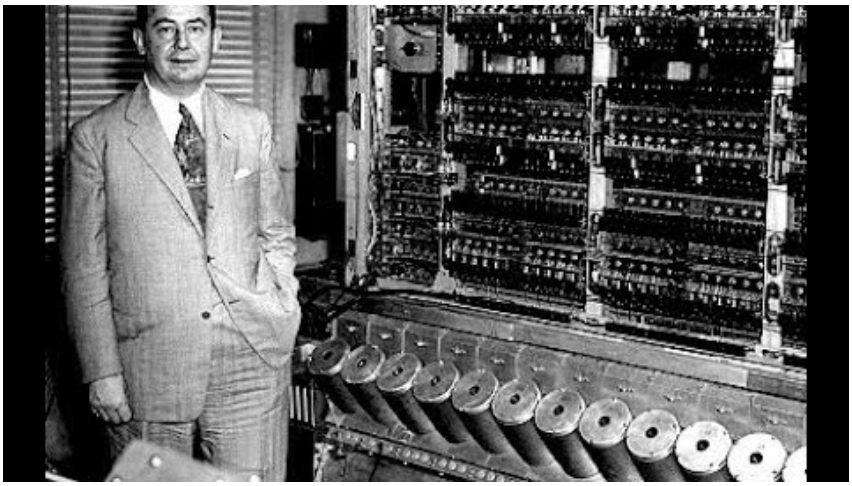
John von Neumann

- 1903-1957
- born in Budapest, Hungary
- a child prodigy
  - at age 6, could divide 8-digit numbers in his head
- fled persecution of Jews in Hungary
- renowned mathematician at Princeton

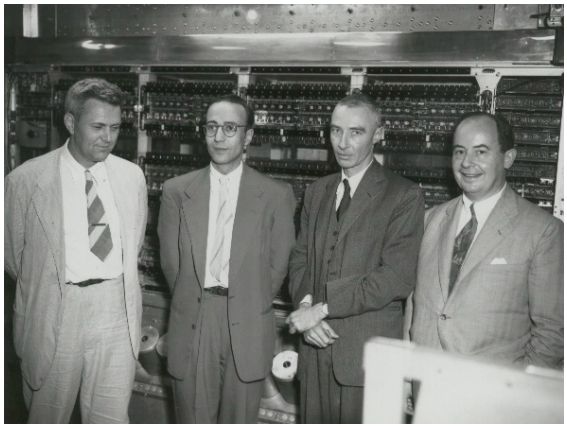
John von Neumann

- During WWII, he served as a consultant to the armed forces.
- Contributions:
  - proposal of the implosion method for bringing nuclear fuel to explosion
  - participation in the development of the hydrogen bomb
  - guess what? more calculating necessary
- Member of the Navy Bureau of Ordnance 1941-1955
  - chance meeting with Herman Goldstine, introducing him to the ENIAC project
  - visited ENIAC team and observed its use, including its deficiencies
  - Interested in project, he became an advisor to the group to help develop a new design
    - new design was the “stored-program” computer

John von Neumann



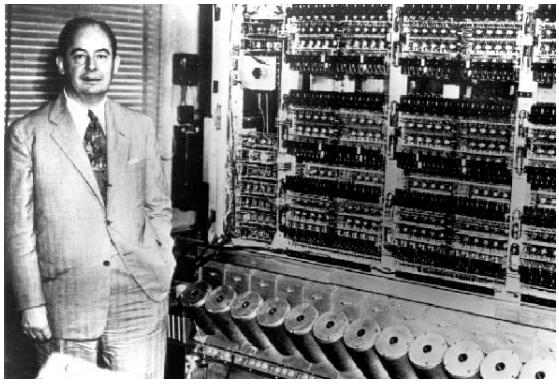
IAS



Left to right: Julian Bigelow, Herman Goldstine, J. Robert Oppenheimer, and John von Neumann at Princeton Institute for Advanced Study. (Wikipedia)

5

John von Neumann



von Neumann with his first IAS computer

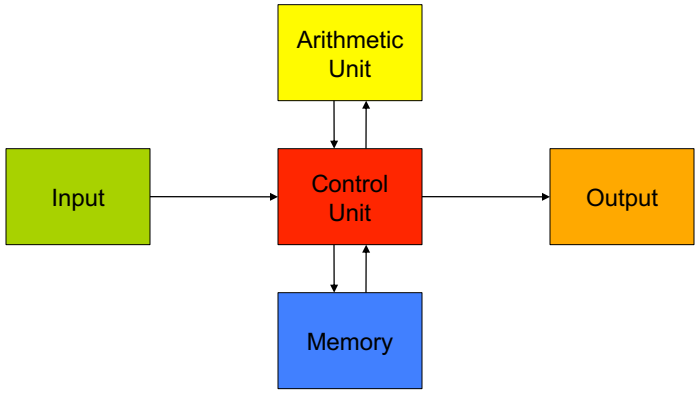
from the Archives of the Institute for Advanced Study

Hungarian stamp in his honor

The stored-program concept

- Instructions and data were to be stored together in the same memory unit
- Instructions were executed sequentially except where a conditional instruction would cause a jump to an instruction someplace
- Binary switching circuits for computation and control
- This is how all modern-day computers work
  - Called the von-Neumann machine
  - Eckert & Mauchly were furious it was not named after them
    - They claimed it was their idea first, but could not implement it during the war due to time constraints

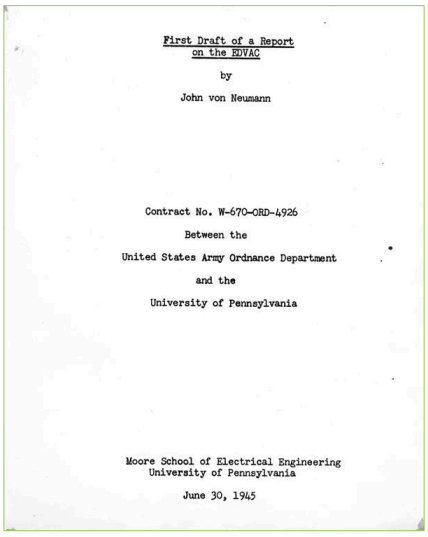
The stored-program concept



The EDVAC Report

- Stored-program concept is the fundamental principle of the EDVAC (Electronic Discrete Variable Automatic Computer)
- Although Mauchly and Eckert are generally credited with the idea of the stored-program, von Neumann publishes a draft report that describes the concept and earns the recognition as the inventor of the concept
  - "von Neumann architecture"
    - some Germans might say Zuse had this idea first
  - *A First Draft of a Report of the EDVAC* published in 1945

EDVAC Report



First Draft of a Report
on the EDVAC

by

John von Neumann

Contract No. W-670-ORD-4926

Between the

United States Army Ordnance Department

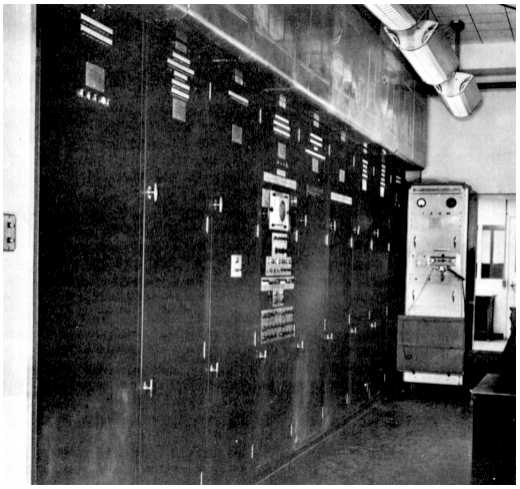
and the

University of Pennsylvania

Moore School of Electrical Engineering
University of Pennsylvania

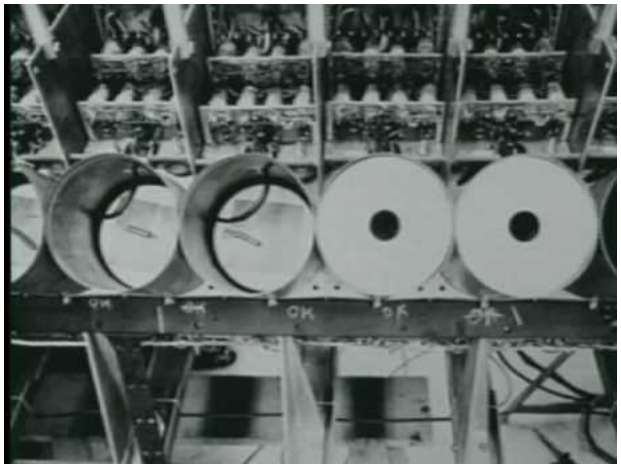
June 30, 1945

EDVAC



from U.S. Army
Research Laboratory
ftp.arl.army.mil

EDVAC



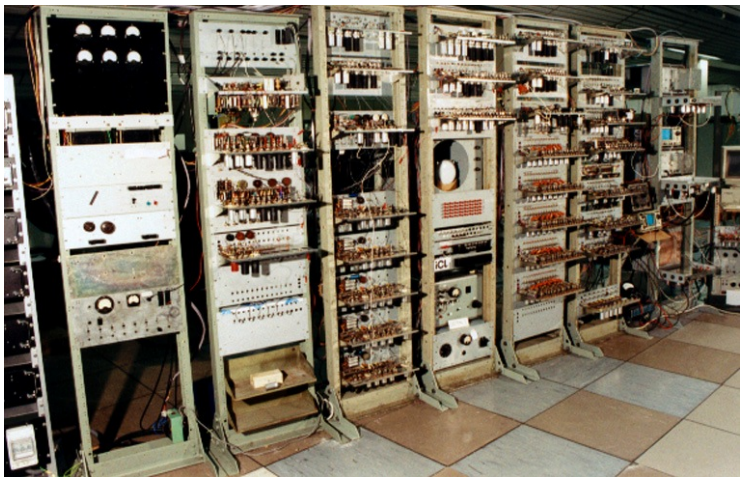
Who created the first electronic computer?

- Eckert and Mauchly refuse to sign over patent rights to the University of Pennsylvania in 1946 and leave to form their own company, EMCC (Eckert Mauchly Computing Company).
- Remington Rand buys them out in 1950 when EMCC was financially in trouble. Remington tries to force other companies to pay royalties due to Eckert and Mauchly's patent filed for the ENIAC.
- On October 19, 1973, US Federal Judge Earl R. Larson signed his decision following a lengthy court trial which declared the ENIAC patent of Mauchly and Eckert linvalid.

Meanwhile, back in England…

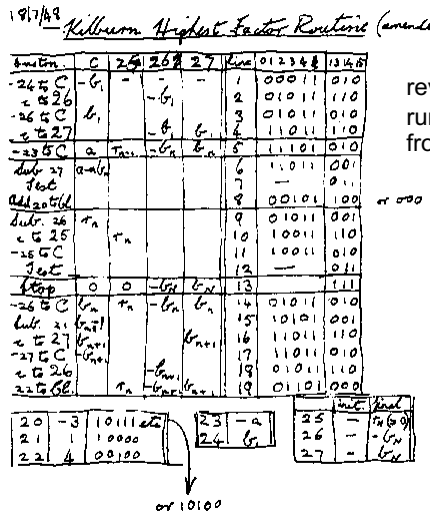
- Max Newman and F.C. Williams build the Manchester Baby Computer in 1948 and demonstrate the feasibility of the stored-program concept.
  - first von Neumann computer to become operational
- Maurice Wilkes attends the Moore School Lectures in 1946 and builds EDSAC at Cambridge University
  - first practical stored-program computer
  - 32 memory delay lines
  - 3000 vacuum tubes (1/6 of ENIAC)
  - 30 kW of electric power

Manchester Baby Computer

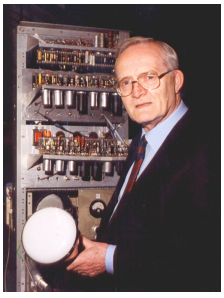


Replica of “Baby” from 1998, from University of Manchester

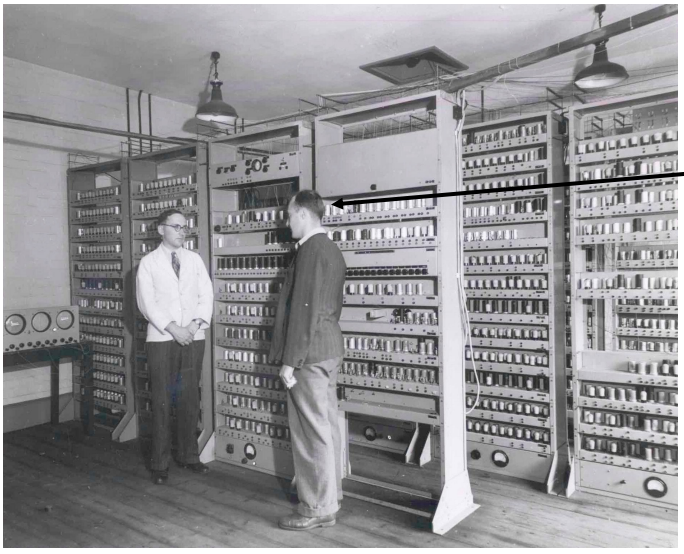
Manchester Baby Computer



revised version of the first program run on the Baby, written by Tom Kilburn, from University of Manchester

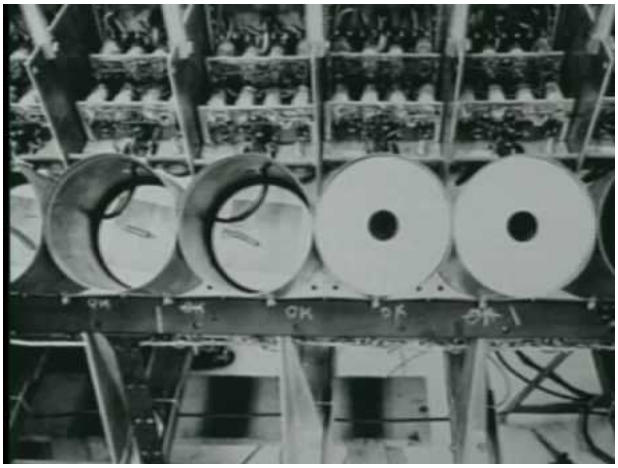


Tom Kilburn



EDSAC I, from University of Cambridge

Programming EDSAC



Turing's Work Continues

- Joins the National Physical Laboratory in 1946 and works on ACE (Automatic Computing Engine)
- Works on MADAM (Manchester Automatic Digital Machine) project in 1948 at Manchester University

ACE

1950s

- Computer makes a transition
  - from a mathematical instrument
  - to an electronic data-processing machine
  - transition led mainly by computer manufacturers and business leaders
- During the 1950s:
  - 30 American computer companies
  - 10 British computer companies

The Commercial Computer

- Who was properly positioned to take foster and benefit most from this transition?
  - IBM of course
    - in 1950, they had a 0% share in computer market
    - by 1960, they would have a 70% share in computer market
- For US Government, competition of WW II is replaced by another war:
  - the Cold War
    - made US Government, military, & military contractors perennial cutting edge computer customers
    - continually fed competition & progress in private sector

UNIVAC

- Eckert and Mauchly left the Moore School in 1946 to start their own company
- Company becomes EMCC in 1948
  - Eckert & Mauchly Computer Company
    - first completed BINAC (a stored-program computer) in 1949
- First customer: Bureau of the Census
  - Paid $300K up front
  - Actual cost to build the first UNIVAC was estimated to be up to $1M

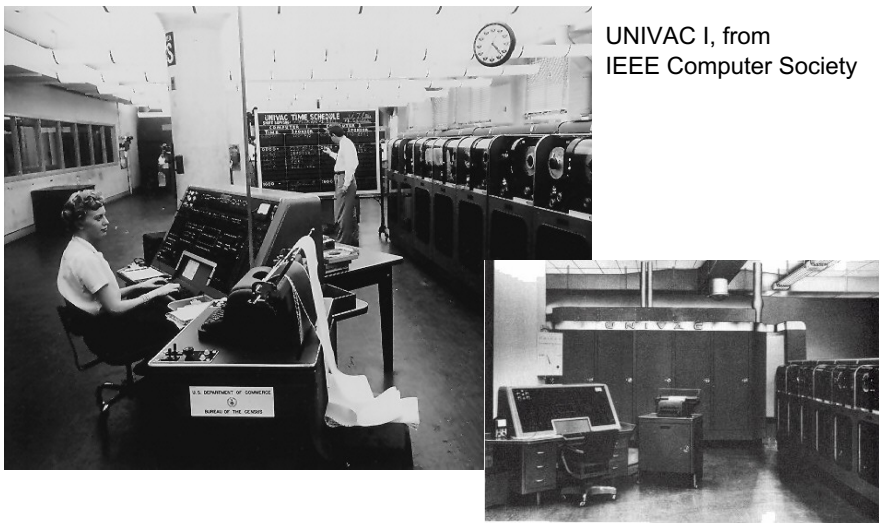
UNIVAC

- Remington Rand buys EMCC in 1950
- Eckert & Mauchly envisioned a general purpose computer (UNIVAC)
- Government receives delivery of first UNIVAC in 1951 after U.S. Census processing started
- By 1954, 20 had been built and delivered for $1 million each

Some UNIVAC Features

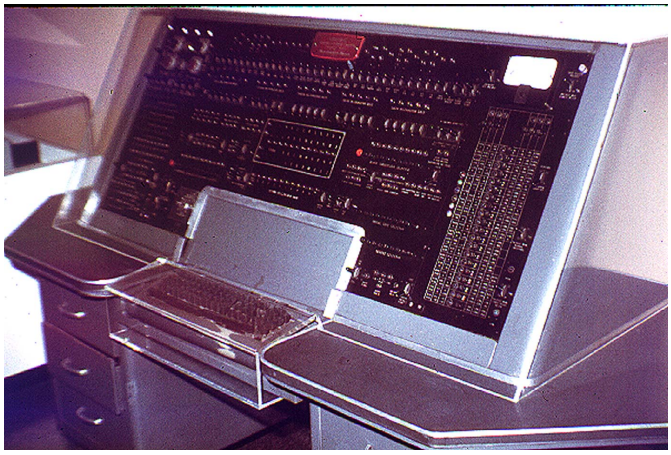
- Used magnetic tape to store data rather than punched cards
  - Transfer rate 12800 characters/second
  - Read in speed 100 inch/second
  - Card-to-tape 240 cards/minute
- Processing times:
  - Addition 120 microseconds
  - Multiplication 1800 microseconds
  - Division 3600 microseconds
- Output
  - High speed printer 600 lines/minute

UNIVAC



UNIVAC I, from
IEEE Computer Society

UNIVAC

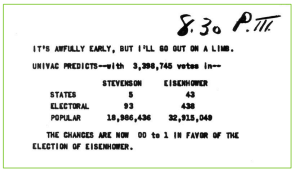


The UNIVAC I console, from Virginia Tech

The UNIVAC Stunt

J. Presper Eckert and Walter Cronkite next to the UNIVAC (Center for the Study of Technology and Society)

- Used to predict the winner of the 1952 U.S. Presidential Election based on ~3.4M votes
  - The first run of the numbers had predicted an electoral vote of 438 for Eisenhower and 93 for Stevenson.
  - The official count was 442 for Eisenhower and 89 for Stevenson – an error of less than 1%.
  - On the popular vote, the Univac projected a total of 32,915,000 nods for Eisenhower, which was only about 3% off the official total of 33,936,252.
  - UNIVAC became synonymous with computer



8:30 P.M.

IT'S AWFULLY EARLY, BUT I'LL GO OUT ON A LIMB.

UNIVAC PREDICTS--with 3,398,745 votes in--

	STEVENSON	EISENHOWER
STATES	5	43
ELECTORAL	93	438
POPULAR	18,986,436	32,915,049

THE CHANCES ARE NOW 00 to 1 IN FAVOR OF THE ELECTION OF EISENHOWER.

UNIVAC Advertisement

IBM & Columbia's Selective Sequence Electronic Calculator

- Following ENIAC, IBM looked to incorporate electronics into their existing machines
- Led by Columbia's Wallace Eckert
- Watson's objective:
  - thumb his nose at Aiken
  - ensure IBM had a test bed for new ideas & devices
- Completed in 1948
  - the most powerful & advance machine available when it was completed
  - not a stored program computer
  - not commercially viable, it went on display
  - its real importance was that its production trained IBM engineers
- After Northrop ordered a UNIVAC from EMCC, defense companies asked IBM for similar machines
  - IBM would be a little slow to build stored-program computers

IBM 701
(Defense Calculator)

"Clink, clank, think"

- Designed as a response to get government contracts during the Korean War in 1950
- Advocated by Thomas J. Watson Jr.
- Stored program computer
  - optimized for scientific calculations.
- First machine installed in IBM World Hdqtrs. in NYC in 1952

IBM 701
(Defense Calculator)

- Design used parallel architecture influenced by IAS designs
  - Made performance much faster than UNIVAC
  - Would subsequently be adopted by Remington Rand computers
  - Designed out of modular components for easy transport and configuration
- Other appearances and uses:
  - March 1955 – IBM 701 at IBM World headquarters is featured on NBC-TV's "Today" show with Dave Garroway
  - April 1955 – Machine #19 begins daily weather forecasts for Joint Numerical Weather Prediction Unit at Suitland, Md.

IBM 701 Components

- IBM 701 Electronic analytical control unit
- IBM 706 Electrostatic storage unit
- IBM 711 Punched card reader
- IBM 716 Printer
- IBM 721 Punched card recorder
- IBM 726 Magnetic tape reader/recorder
- IBM 727 Magnetic tape unit
- IBM 731 Magnetic drum reader/recorder
- IBM 736 Power frame #1 (not shown)
- IBM 737 Magnetic core storage unit
- IBM 740 Cathode ray tube output recorder
- IBM 741 Power frame #2
- IBM 746 Power distribution unit
- IBM 753 Magnetic tape control unit

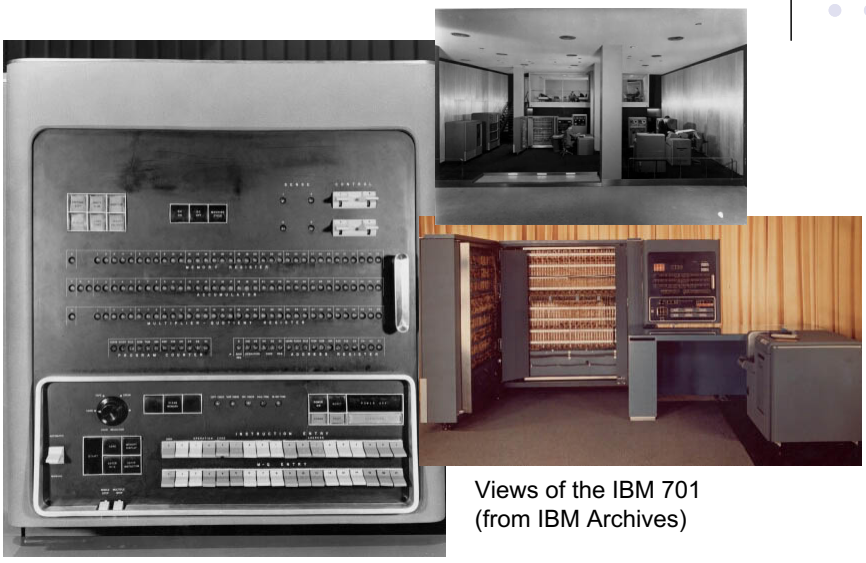
IBM 701 Customers

1 IBM World Headquarters, New York, N.Y. Dec. 20, 1952
2 University of California., Los Alamos, N.M. Mar. 23, 1953 (a)
3 Lockheed Aircraft Company, Glendale, Cal. Apr. 24, 1953 (b)
4 National Security Agency, Washington, D.C. Apr. 28, 1953
5 Douglas Aircraft Company, Santa Monica, Cal. May 20,1953 (c)
6 General Electric Company., Lockland, Ohio May 27, 1953
7 Convair, Fort Worth, Tex. Jul. 22, 1953
8 U.S. Navy, Inyokern, Cal. Aug. 27, 1953 (d)
9 United Aircraft, East Hartford, Conn. Sep. 18, 1953
10 North American Aviation, Santa Monica, Cal. Oct. 9, 1953 (e)
11 Rand Corporation., Santa Monica, Cal. Oct. 30, 1953 (f)
12 Boeing Corporation, Seattle, Wash. Nov. 20, 1953 (g)
13 University of California, Los Alamos, N.M. Dec. 19, 1953
14 Douglas Aircraft Company, El Segundo, Cal. Jan. 8, 1954 (h)
15 Naval Aviation Supply, Philadelphia, Pa. Feb. 19, 1954
16 University of California, Livermore, Cal. Apr. 9, 1954
17 General Motors Corporation, Detroit, Mich. Apr. 23, 1954
18 Lockheed Aircraft Company, Glendale, Cal. Jun. 30, 1954 (b)
19 U.S. Weather Bureau, Washington, D.C. Feb. 28, 1955 (i)

IBM 701

Ronald Reagan and IBM's Herb Grosch in 1956

IBM 701



Views of the IBM 701
(from IBM Archives)

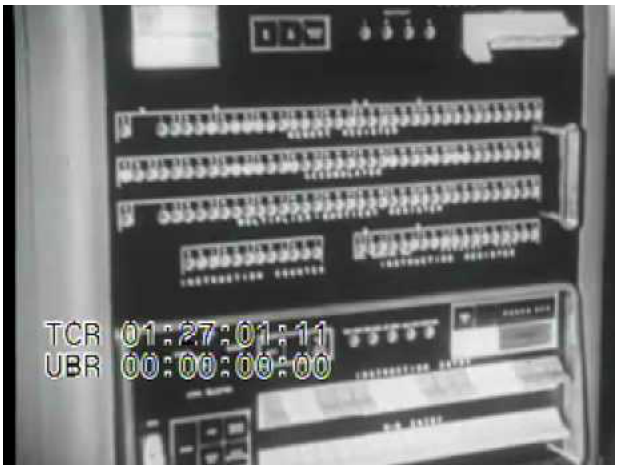
IBM 702
(Tape Processing Machine)

- First shipped in 1955
- The first large IBM computer designed for business data processing
- 15 are eventually installed
- Based on serial, character based processing, with variable length words.
- The machine developed some new standards for subsequent machines.
  - Very high speed magnetic tape machines capable of storing twice as much data as those supplied with the 701, and transferring it at twice the speed.
  - These machines were responsible for the rest of the industry abandoning the metal backed tapes of the UNIVAC, and switching to IBM like tape units.

IBM 702
(Tape Processing Machine)

The IBM 702 is seen in 1952 at IBM's new Data Processing Center in its headquarters at 590 Madison Avenue in New York City. (IBM Archives)

IBM Promotional Film



IBM 650
(Magnetic Drum Computer)

- First IBM 650 delivered in 1954
- Inexpensive, punch-card oriented computer
  - "Model-T of computing“
- 2,000 are eventually produced
- Applications:
  - Calculation of insurance sales personnel commissions, market research analysis, payroll processing, missile design, customer billing for a utility, oil refinery design and engineering calculations, analyses of flight tests made by supersonic aircraft, actuarial computations, centralized branch store accounting.
- Discounts of 60% provided to universities in exchange for courses in data processing

IBM 650 Customers

ACF Industries Inc.•·ALCO Products, Jamestown•·Allied Chemical, Richmond•·Allis Chalmers, Milwaukee, Wisconsin•·Atlantic Refining, Philadelphia, Pennsylvania.•·Avco Manufacturing, Cincinnati, Ohio•·Avco Manufacturing Corp., Cambridge, Massachusetts·Belknap Hardware & Manufacturing Company, December 13, 1955·Bell Aircraft Corporation, Buffalo, New York•·Bell Telephone, Elizabeth (3)•·Bell Telephone, Philadelphia, Pennsylvania•·Bethlehem Steel, Baltimore, Maryland•·Boeing Airplane Company, August 11, 1955•·Bonneville Power Administration, April 24, 1956·Budd Company, Philadelphia, Pennsylvania•·Business Men's Assurance Company·Carnegie Institute of Technology, August 28, 1956•·Carrier Corp., Syracuse, New York•·Carter Oil, Tulsa, Oklahoma•·Case Institute, Cleveland, Ohio•·Chance Vought Aircraft, Dallas, Texas (2)•·Chrysler, Detroit, Michigan, May 1955•·Clarke Brothers, Jamestown•·Colorado River Association, February 17, 1958·Combustion Engineering Inc., New York, New York•·Cornell University, Elmira, New York, February 3, 1957•·Datamatic Corp., Cambridge, Massachusetts•·Detroit Edison Company, May 10, 1955·Doane Agricultural Service, Inc.·Drexel Institute of Technology, November 20, 1958·E. I. duPont de Nemours & Company, February 15, 1955·Francis I. duPont & Company, November 22, 1955·El Paso National•·Equitable Life, New York, New York, April 1955·Esso Research, Elizabeth•·Esso Standard Oil Co., Baton Rouge Refinery, February 14, 1955·Fairchild Engineering, Garden City, New York•·Fairchild Engineering, Hagerstown, Maryland·General Dynamics, Tyler•·General Dynamics Corporation, Electric Boat Division, August 11, 1955 (for design of USS *Seawolf* (SSN-575), the U.S. Navy's second nuclear-powered submarine)•·General Electric, Boise•·General Electric Aircraft, Cincinnati, Ohio (2)•·General Electric Analytical, Schenectady, New York (2)•·General Electric Apparatus Sales Division, January 26, 1955·General Electric Engineering Lab, Schenectady, New York•·General Electric Heavy Military Electronic Equipment, Syracuse, New York•·General Electric Knolls Atomic Power Lab., Schenectady, New York•·General Electric Large Motor & Generator, Schenectady, New York•·General Electric Medium Induction Motor, Schenectady, New York•·General Electric Missile & Ordnance Systems Department, June 16, 1957·General Electric Special Products, Philadelphia, Pennsylvania•·General Electric Switchgear, Philadelphia, Pennsylvania•·Georgia Institute of Technology, Atlanta, Georgia.•·Goodyear Atomic, Huntington•·Grumman Aircraft Engineering Corporation, Garden City, New York, May 26, 1955 (2)•·Gulf Life Insurance Co., July 14, 1959·Gulf Oil Corporation, September 10, 1956 and June 10, 1957 (2)·Harrison Radiator, Buffalo, New York•·Hartfield Stores, Inc., July 30, 1957·H.P. Hood & Sons·Hughes Aircraft Company, February 19, 1955 (3)•·Humble Oil, Houston (2)•·IBM de Venezuela, February 19, 1957·Illinois Institute of Technology, Chicago, Illinois•·Indiana University, Indianapolis, Indiana•·Interstate Life & Accident Insurance Company, August 16, 1957·Iowa Mutual Insurance Company·Iowa State College Statistical Laboratory, March 9, 1957·John Hancock Mutual Life Insurance Company, December 8, 1954 (2)·Johns Hopkins, Baltimore, Maryland•·Jones & Laughlin Steel Corporation, Aliquippa and Pittsburgh Works Divisions, December 22, 1955·Lockheed Aircraft Corporation, Missile Systems Division, February 11, 1955 (2)•·Los Angeles (city of), June 14, 1956·Massachusetts Institute of Technology, Cambridge, Massachusetts, February 29, 1960•·McDonnell Aircraft Corporation, June 19, 1955•·McLean Trucking Company, April 24, 1959·Mellon National Bank & Trust Company, November 11, 1955·Montgomery Ward & Company, April 2, 1955·National Advisory Committee for Aeronautics [NASA], Ames Aeronautical Laboratory, May 14, 1955•·National Advisory Committee for Aeronautics [NASA], Langley Aeronautical Laboratory, March 16, 1955·National Bureau of Standards, Boulder Laboratories·Nationwide Insurance·New York City Department of Public Works, December 31, 1959·New York University College of Engineering, January 22, 1957·Newport News Shipbuilding, Norfolk, Virginia•·A. C. Nielson, Chicago, Illinois, January 1955·North American Aviation, Columbus•·North Carolina State College, Raleigh•·Northern Pacific Railroad, June 20, 1957·Ohio Oil Company, February 10, 1956·Ohio State University, June 21, 1956•·Oklahoma A & M College, Stillwater•·Olin Mathieson, Buffalo, New York•·Ordnance Aerophysics Laboratory·Charles Pfizer & Company, Inc.·Pennsylvania Railroad, Philadelphia, Pennsylvania•·Phillips Petroleum, Boise•·Pittsburgh Pirates, March 15, 1955·RCA, Trenton•·Republic Aviation, Garden City, New York•·Ryan Aero Co., San Diego•·Shell Oil, Houston (2)•·Society of the Divine Savior·Standard Oil Company (Ohio), April 4, 1955·Stanford University•·State Farm Mutual, December 7, 1956·State Mutual Life Assurance Company·Union Carbon & Carbide, February 3, 1955·Union Carbide, Knoxville (2)•·University of California (3)•·University of Houston, Houston, Texas•·University of Michigan, Ann Arbor, Michigan•·University of Pittsburgh, Pittsburgh, Pennsylvania•·University of Rochester•·University of Wisconsin, Madison•·U.S. Air Force Air Weather, Asheville•·U.S. Air Force Marquardt Jet Laboratory, Van Nuys·U.S. Air Force Proving, Mobile, Alabama•·U.S. Army Guided Missile Division Computational Lab (2)•·U.S. Army Signal Corps, Trenton•·U.S. Navy, July 20, 1955·U.S. Navy Aero Research, February 23, 1955·U.S. Steel, American Bridge Div., Pittsburgh, Pennsylvania, April 1955·Vertol Aircraft Corporation, August 28, 1956•·Washington University, St. Louis, Missouri•·Wayne University, Detroit, Michigan•·Westinghouse Electric, Baltimore. Maryland, May 1955•·Westinghouse Electric Corporation, Analytical Section, E. Pittsburgh Works, March 15, 1955•·Westinghouse Electric Corporation, Steam Turbine Division, December 18, 1956·Wisconsin (state of), Madison•·Yale University, November 17, 1958

IBM 650
(Magnetic Drum Computer)

This "white room" view of a 650 installation shows an IBM 533 Card Read Punch in the foreground at left; the 650 Console Unit at center, with an IBM 655 Power Unit behind it; and an IBM 537 Card Read Punch at right. (IBM Archives)

IBM 650
(Magnetic Drum Computer)

The console of the IBM 650, the 650 with its cover off, and the magnetic drum. (IBM Archives)

IBM advantages over UNIVAC

- IBM's computers soon outdistanced UNIVAC in the marketplace
- 1955 – IBM's 700 series sales first surpassed UNIVAC
- Better technologies?
  - Williams Tube memory rather than mercury delay lines?
    - both had shortcomings speed vs. reliability
  - Superior magnetic tape system
  - Forrester core memory
- Modular designs
  - pluggable components
  - flexibility
- Superior training & service infrastructure
- Rentals vs. Sales

Was it inevitable?

- For IBM:
  - timing is everything
  - being the biggest doesn't hurt either
    - great resources
    - large margin for error
    - large customer base
  - strong leadership with the Watsons
    - they made a commitment to change with the times
  - "losing is not an option" culture at IBM

IBM Recruiting Advertisement