Lecture 6.
The Birth of the Computer Industry

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How many computers are needed: four, five, six?

The work on world's first computers in the late 1940s created the first generation of computer experts: hardware designers, programmers, analysts. They continued to work on computers and to disseminate computer knowledge that they acquired opening up computing to new organizations and new applications. Some decided to try their luck with their own computer companies that were to build not a single computer for some dedicated scientific or military purpose but a series of hardware for general commercial use.

- In 1949, Konrad Zuse (the creator of the Z1, Z3, and Z4) founded Zuse KG (quite successful);
- in 1946, J. Presper Eckert and John Mauchly (the designers of ENIAC) founded Eckert-Mauchly Computer Corporation (later acquired by Remington Rand) and designed the UNIVAC I (UNIVersal Automatic Computer I) – the first American volume-manufactured computer;
- Howard Aiken (the creator of the Mark 1 programmable calculator) continued his designs of programmable calculators and computers coming up with: Mark 2, 3, and 4;
- the work initiated by Williams and Kilburn at the University of Manchester (The Baby) attracted Ferranti (UK) to computer making and that would be one of the main business lines of the company until its closure in 1993;
- the work on von Neumman's IAS computer attracted the attention of many institutions around the world to computing and seeded their computer industries.

The success of the early computers also attracted the attention of large corporations which began to contemplate manufacturing of their own electronic computers (e.g. IBM (USA), Ferranti (UK), Fuji (Japan), Remington Rand (USA)).

"Contemplate" is a good word to describe a rather cautious approach taken by the calculator and data processing industry as in the late 1940s it was not clear how many of the computers a modern society would require, whether there would be any commercial market for computers.

Various studies on the future use of computers commissioned by governmental agencies such as U.S. Census Bureau or National Research Council produced very negative results. Some quoted computer experts, like Howard Aiken who, apparently, expressed an opinion that

> a commercial market would never develop; in the United States there was a need for perhaps for five or six such machines, but no more. (see [4], page 13).

In spite of the large degree of uncertainty, some companies started manufacturing multiple version of computers for the commercial market as early as 1951/52 when Ferranti started the production of its Mark 1, Remington Rand its UNIVAC, and IBM its 701 Defence Calculator (although IBM was referring to its hardware as calculators or electronic data processing and accounting machines).

On the following pages we shall take a look at two companies, Remington Rand and IBM, that started the commercial manufacturing of computers in America.

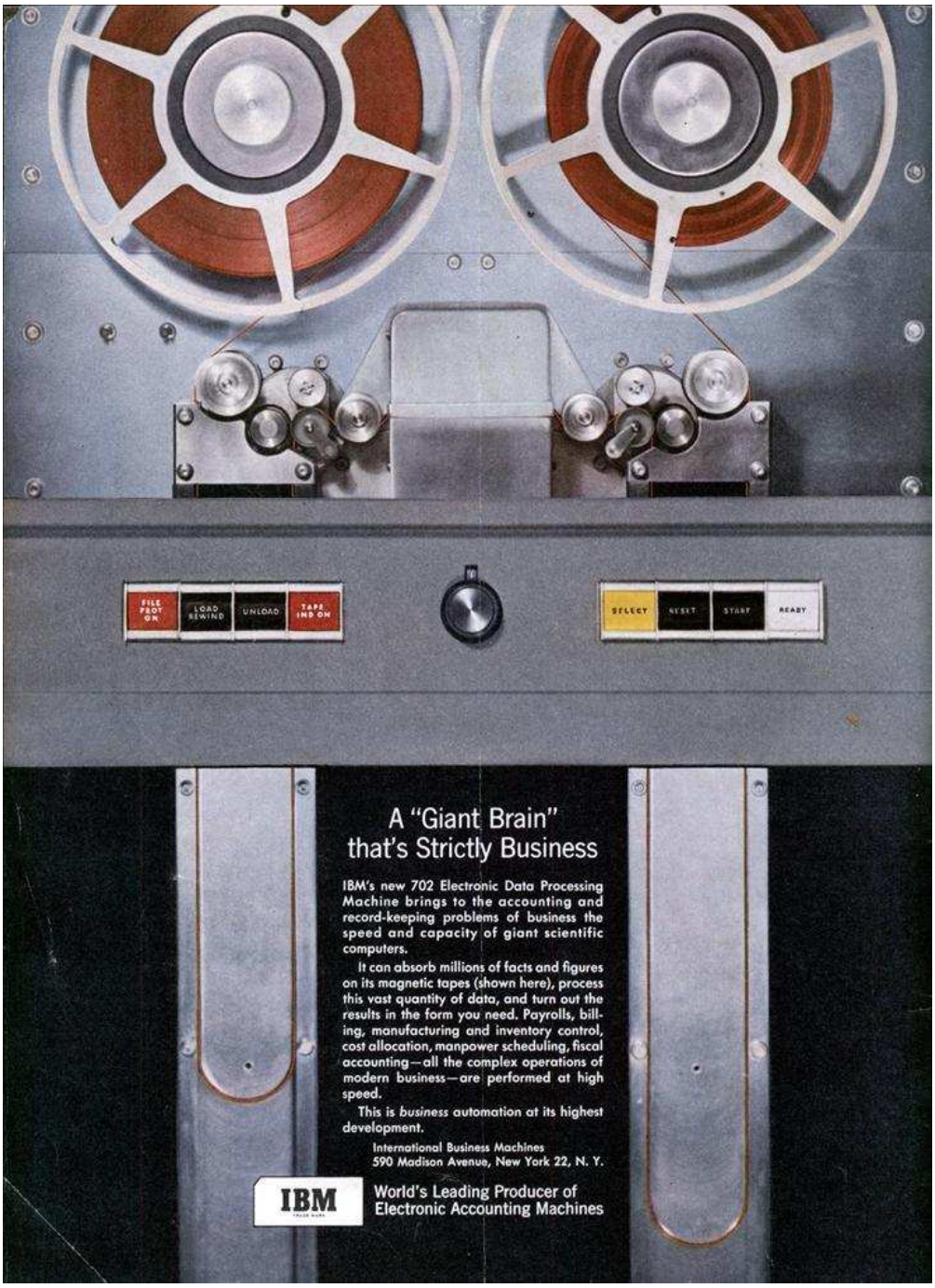


Fig. 1. The IBM 702 "Giant Brain" data processing system (1952). Source: Scientific American, August 1954.

These early commercial computers, manufactured in the 1950s and 1960s, are commonly classified as mainframes. They were large and required specially constructed rooms, even whole floors of buildings to contain and protect them. The mainframes required power substations (large power consumption) and air conditioners to remove excessive heat generated by vacuum tubes and other electronic components.

The mainframes were also very expensive and could be found only on the premises of the largest and richest organizations exclusively, such as banks, insurance companies, government and military departments and labs, large industrial corporations, and selected universities (as they typically contributed to the computers' designs).

The programing and operation of mainframes was done by a selected "priesthood" of computer professionals who alone were granted access to the mysteries that could tame these monsters.

The Tail of the UNIVAC

In 1948, capitalizing on their success with ENIAC and EDVAC and seeing growing interest in such machines from industry, Eckert and Mauchly decided to start their own company–the Eckert-Mauchly Corporation–with the purpose to manufacture computers. They named their next computer the Universal Automatic Computer or UNIVAC.

The company had no problems with design ideas, but raising capital to implement them was something else. In the end the Eckert-Mauchly Corporation was acquired by a manufacturer of business machines–Remington Rand–which provided funds to complete the UNIVAC and to unveil it in 1951.

The first UNIVAC was delivered to the United States Census Bureau on March 31, 1951. Between 1951 and 1954, 19 computers were sold and installed on a customer's premises, each machine bringing about one million dollars to Remington Rand. The customers ranged from private corporations, such as General Electric (GE), to military and defence agencies; they were used mostly for data processing. The UNIVAC proved to be a very successful product for the company and its success contributed significantly to the commercial acceptance of computers.

At GE, the UNIVAC was used to do payroll, material scheduling and inventory control, order service and billing, and general cost accounting.

Remington Rand was acquired by Sperry Corporation in 1955 to form Sperry Rand which continued to manufacture a very successful line of Univac data processing equipment and computers. In 1986 Sperry Rand merged with Burroughs (calculator and computer maker) to form Unisys. The mergers were in response to the domination of IBM in the marketplace.

Significance of UNIVAC: demonstrated that already in the early 1950s there was a substantial commercial demand for electronic computers.

The IBM Way

At the end of the 1940s, IBM was already a half-a-century-old corporation dominating the data processing and tabulating market. The company collaborated on the development of the Harvard Mark 1 programmable calculator but it was probably the UNIVAC's success that made IBM switch its focus on electronic computers. It's first electronic computer–the IBM 701 Defence Calculator–was announced in 1952.

IBM's predecessor–Computing-Tabulating-Recording Company (C-T-R)–was formed in 1911 as a result of amalgamation of a number of firms including Tabulating Machine Company founded by Herman Hollerith, a statistician at the U.S. Census Bureau.

In the late 19th century, the U.S. Census Bureau recognized that its traditional counting methods (involving hundreds of clerks) would be inadequate for measuring and researching rapidly expanding American population (at that time, U.S. was accepting large numbers of new immigrants). To deal with its problem, the Bureau sponsored a contest to find a more efficient means of tabulating census data. The winner was Herman Hollerith whose Punch Card Tabulating Machine used paper punched cards to record data. In 1896, capitalizing on his success, Hollerith formed his company to build and apply his electric tabulating and accounting machines.

Fig. 3. Herman Hollerith's tabulator (1890). Source: *Understanding Computers, Illustrated Chronology and Index*, Time-Life Books, 1989

A short IBM time-line

1896: Herman Hollerith founded Herman Hollerith's Tabulating Machine Company to manufacture and use electric tabulating and accounting machines.

1911: The formation of C-T-R

1914: C-T-R manufactured a range of accounting machines

1920: C-T-R introduced printing tabulator

1924: C-T-R's name was formally changed to International Business Machines Corporation.

1928: IBM adopted the 8-column punch card–the IBM format–setting a de facto industry standard for decades to come

1931: IBM introduced the 601 Multiplier calculator

1933: the introduction of the IBM Type 285 Numeric Printing Tabulator

1944: in collaboration with H. Aiken, IBM build the Automatic Sequence Controlled Calculator (ASCC or Harvard Mark 1),

1946: IBM introduced the 603 Electronic Multiplier – the first commercially manufacture electronic calculator

1948: IBM introduced SSEC: the Selective Sequence Electronic Calculator (hybrid design with vacuum tubes and electromagnetic relays, input on paper tape.

In 1952 IBM announced the IBM 701 Defence Calculator, the company's first large electronic computer (vacuum tubes). The 701 was designed primarily for scientific calculation, some were rented for about $16,000 per month.

Although IBM continued the manufacturing and sale of new computer equipment throughout the 1950s the company's (and the computer industry's) next milestone came in April 7, 1964, when IBM introduced the System 360, the first large "family" of computers whose software and hardware configuration could be tailored to customers' needs.

The IBM System 360 represented a radical departure from the industry standard of offering all clients the same computer with the same peripheral configuration. A customer could purchase or rent a System 360 of configuration that fit the customer's needs and budget the best. The main architect of the 360 family of mainframes was a brilliant engineer Gene Amdahl who,late, will start his own Amdahl Corporation.

Unfortunately for other computer companies, the tremendous success of the System 360 placed IBM in a dominant position for a number of decades. By 1965, IBM had over 65.3% of the mainframe market to itself, the seven dwarfs: Burroughs, Sperry Rand, Control Data, Honeywell, General Electric, RCA and NCR, shared the rest ("IBM and the seven dwarfs" was how the mainframe business was described in the 1960s).

The IBM's supremacy in the mainframe market extended to Europe and other regions of the world. Unfortunately, the popularity of IBM computers caused the rapid decline of national computer industries in Europe.

IBM 360s at York University

In the 1960s and early 1970s, the computational needs of academic institutions in Canada were served mostly by IBM computers (University of Toronto, Waterloo, Alberta, Queen's, and York can serve as examples).

York University's first mainframe computer was the smallest in the IBM 360 family–the model 30–installed in October 1966 (it had just 22K of memory!).

Fig. 4. The IBM System 370 model 155 at York University in 1972. Source: York University Computer Museum, photographer unknown.

Fig. 5. Students' computer room at York University, 1972. Source: York University Computer Museum, photographer unknown.

In May 1968, York made the decision to replace its small IBM 360 computer and rented a slightly larger IBM 360 model 40 (with 128K of memory) from IBM. The rental cost was high: $247,300 a year (in 1968/69; equivalent of 88 new Ford Mustang I-6 Convertible cars).

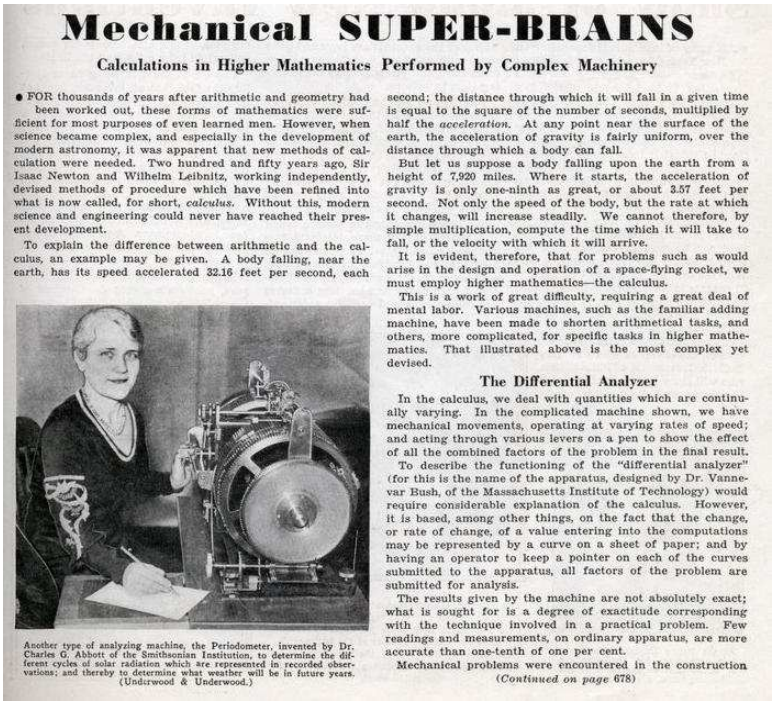
A year later, York's IBM 360 model 40 was replaced by another IBM machine – 360 model 50 (with 256K of memory). That machine was previously used by the University of Toronto. In 1970, York acquired another IBM 360 model 50 and in 1972, replaced both machines with the state-of-the-art in hardware – the IBM 370 model 155.

Giant Brains, computer priesthood and the mortals

Comparing the formation of the calculator industry in the 19th century to that of the computer industry a century later, one can observe the difference in presenting both types of calculating technologies to the society. While calculators were widely advertised as helpful tools for everyone, and a large variety of such machines were offered to fit every body's pocket, the first industrial computers were sold to a very selective group of customers.

In the 1950s and 1960s, an average individual in North America was aware of computers but had, at best, a vague knowledge about the purpose and use of such machines. The mainframes were mostly hidden from the rest of the society in governmental and corporate buildings, doing something of great importance but what exactly they were used for – was a mystery.

Both the industry and popular culture spoke of the mainframes as "Giant Brains" or "Super Brains" – the terms coined in the 1930s and 1940s.)



Mechanical SUPER-BRAINS

Calculations in Higher Mathematics Performed by Complex Machinery

● FOR thousands of years after arithmetic and geometry had been worked out, these forms of mathematics were sufficient for most purposes of even learned men. However, when science became complex, and especially in the development of modern astronomy, it was apparent that new methods of calculation were needed. Two hundred and fifty years ago, Sir Isaac Newton and Wilhelm Leibnitz, working independently, devised methods of procedure which have been refined into what is now called, for short, *calculus*. Without this, modern science and engineering could never have reached their present development.

To explain the difference between arithmetic and the calculus, an example may be given. A body falling, near the earth, has its speed accelerated 32.16 feet per second, each second; the distance through which it will fall in a given time is equal to the square of the number of seconds, multiplied by half the *acceleration*. At any point near the surface of the earth, the acceleration of gravity is fairly uniform, over the distance through which a body can fall.

But let us suppose a body falling upon the earth from a height of 7,920 miles. Where it starts, the acceleration of gravity is only one-ninth as great, or about 3.57 feet per second. Not only the speed of the body, but the rate at which it changes, will increase steadily. We cannot therefore, by simple multiplication, compute the time which it will take to fall, or the velocity with which it will arrive.

It is evident, therefore, that for problems such as would arise in the design and operation of a space-flying rocket, we must employ higher mathematics—the calculus.

This is a work of great difficulty, requiring a great deal of mental labor. Various machines, such as the familiar adding machine, have been made to shorten arithmetical tasks, and others, more complicated, for specific tasks in higher mathematics. That illustrated above is the most complex yet devised.

The Differential Analyzer

In the calculus, we deal with quantities which are continually varying. In the complicated machine shown, we have mechanical movements, operating at varying rates of speed; and acting through various levers on a pen to show the effect of all the combined factors of the problem in the final result.

To describe the functioning of the "differential analyzer" (for this is the name of the apparatus, designed by Dr. Vannevar Bush, of the Massachusetts Institute of Technology) would require considerable explanation of the calculus. However, it is based, among other things, on the fact that the change, or rate of change, of a value entering into the computations may be represented by a curve on a sheet of paper; and by having an operator to keep a pointer on each of the curves submitted to the apparatus, all factors of the problem are submitted for analysis.

The results given by the machine are not absolutely exact; what is sought for is a degree of exactitude corresponding with the technique involved in a practical problem. Few readings and measurements, on ordinary apparatus, are more accurate than one-tenth of one per cent.

Mechanical problems were encountered in the construction

(*Continued on page* 678)

Another type of analyzing machine, the Periodometer, invented by Dr. Charles G. Abbott of the Smithsonian Institution, to determine the different cycles of solar radiation which are represented in recorded observations; and thereby to determine what weather will be in future years. (Underwood & Underwood.)

Fig. 6. This ad for "Giant Brain" appeared in *Everyday Science and Mechanics*, June 1932, p. 625.

The "Giant Brains" were served by a sophisticated group of "computer priesthood" who were programming and operating them. And we, the "mortals", could only see them in operation in science fiction movies such as the popular The Star Trek series, first aired in 1966, or Kubrick's 1968 masterpiece 2001 Space Odyssey.

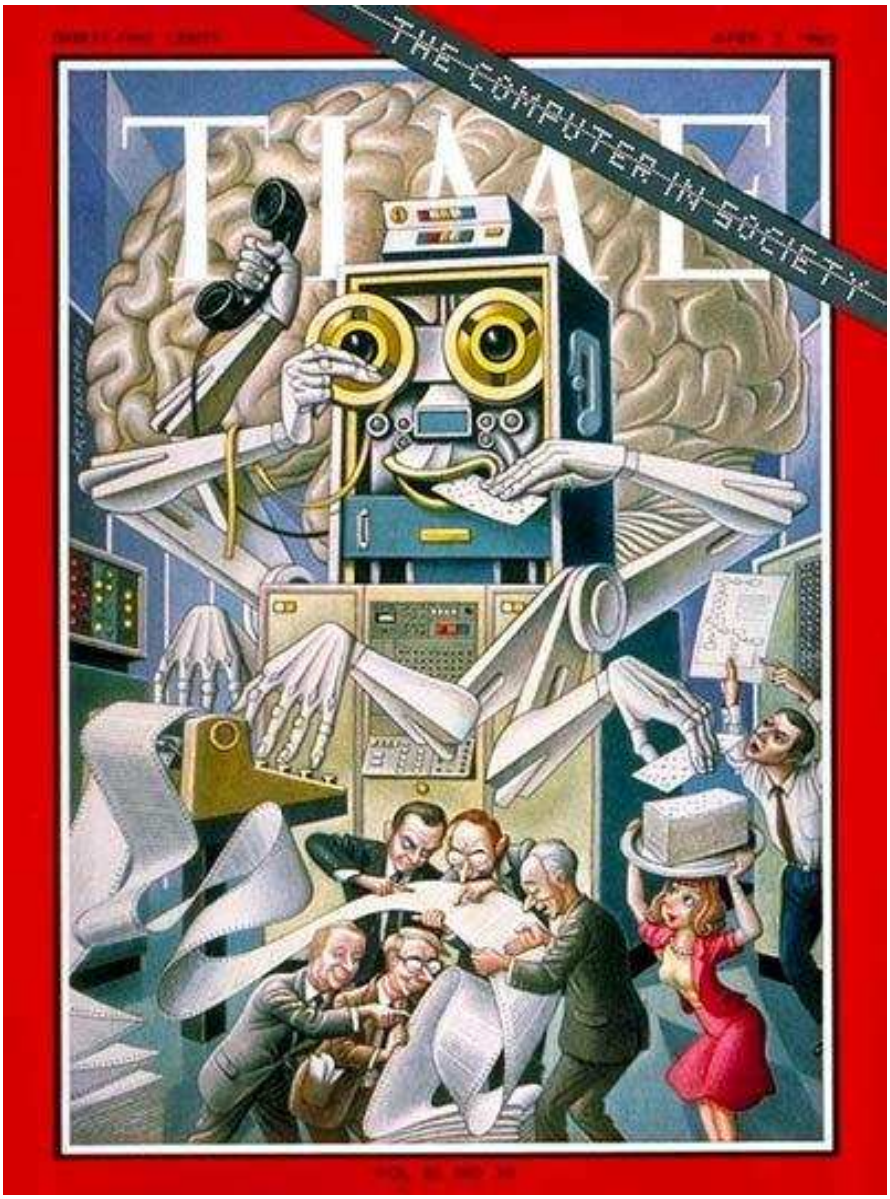


Fig. 7. This cover of *The Time Magazine*, April 2, 1965.

Computers in Films

In a popular early Sci-Fi series Start Trek, first aired in 1966, the computers are mostly evil or misused. But they also obey the rules of logic and blow up when faced with contradiction. Such a depiction of computers reflected a growing mistrust of the use of powerful technologies.

None of the computers depicted in Star Trek had anything to do with modern computer technology (not to mention the technology of the 23rd century!). Computers had to have lights and switches – that was a technological must! In some episodes, Spock removed a module from a computer revealing large electronic components from the 1940s.

Fig. 8. Spock inserting a portable storage card into a "computer" (note lights and switches). Star Trek Episode: unknown.

Interestingly enough, some futuristic technologies depicted in Star Trek have been realized (such as hand-held communication devices). Some of them became our everyday computing reality: small external storage devices (Figure 8), speech and handwriting recognition (Figure 9), touchscreen interfaces (Figure 10) may serve as examples.

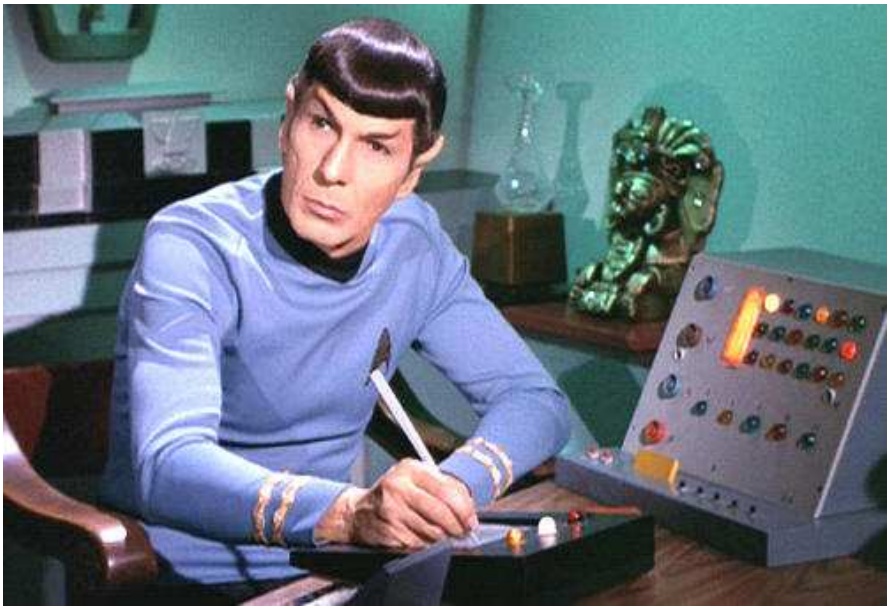


Fig. 9. Spock interacting with his "PC" using a writing pad. Star Trek Episode: TOS, unknown.

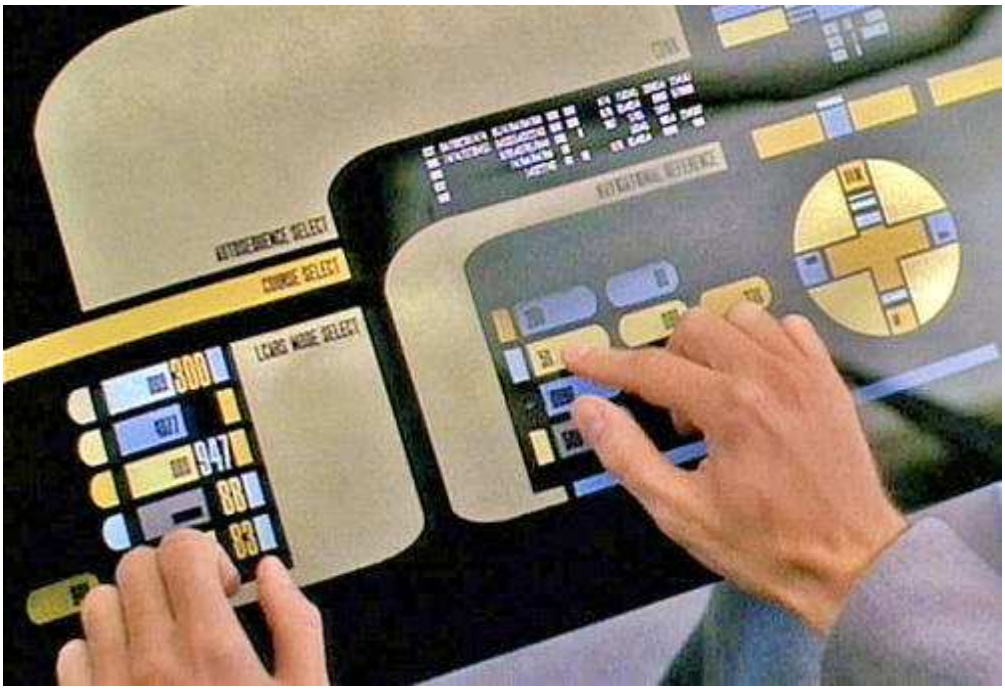


Fig. 10. Touchscreen computer console on the Enterprise. Star Trek Episode: unknown.

Stanley Kubrick's cultural icon and a masterpiece–*2001 Space Odyssey*–portrays another sort of a computer of the future: a self-conscious artificial mind and a potential trouble for us all – the HAL 9000.

Fig. 11. The HAL 9000 operator's console, *2001 Space Odyssey*. Source: unknown.

HAL is ready to do pretty nasty things because – it's afraid. We can read Kubrick's film as the mystery of creation that can turn against the creator:

Dave Bowman: Hello, HAL. Do you read me, HAL?
HAL: Affirmative, Dave. I read you.
Dave Bowman: Open the pod bay doors, HAL.
HAL: I'm sorry, Dave. I'm afraid I can't do that.
Dave Bowman: What's the problem?
HAL: I think you know what the problem is just as well as I do.
Dave Bowman: What are you talking about, HAL?
HAL: This mission is too important for me to allow you to jeopardize it.
Dave Bowman: I don't know what you're talking about, HAL.
HAL: I know that you and Frank were planning to disconnect me, and I'm afraid that's something I cannot allow to happen.
Dave Bowman: Where the hell did you get that idea, HAL?

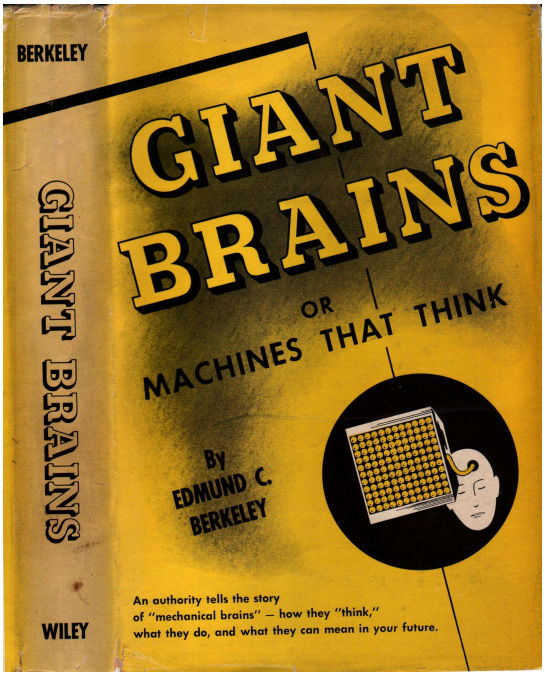
HAL: Dave, although you took very thorough precautions in the pod against my hearing you, I could see your lips move.
Dave Bowman: Alright, HAL. I'll go in through the emergency airlock.
HAL: Without your space helmet, Dave? You're going to find that rather difficult.
Dave Bowman: HAL, I won't argue with you anymore! Open the doors!
HAL: Dave, this conversation can serve no purpose anymore. Goodbye.

Berkeley and his little Idiot

In the 1950s and 1960s, the computer industry was not particularly interested in any form of computer literacy programs aimed at popularizing computer technologies in society. The industry's clients were big corporations and it was up to them–the clients–if at all, to calm the society being distressed by rumors of Giant Brains eroding thousands of jobs and possibly "watching us".

In that period of time, popular magazines such as *Scientific American* or *Times* were occasionally publishing articles about computers but they generally failed to demystify them. It would take another decade before a forceful wave of computer hobby movement would assume the role of the educator. In the meantime, a few dedicated educators would do their utmost to bring the knowledge about computers to the rest of us.

In 1949, Edmund C. Berkeley, a great enthusiast of computing and an educator, published his book *Giant Brains or Machines That Think*. In the book he described early calculators and computers (such as the Harvard Mark 1 and the ENIAC), how they were designed, built, and operated. He also sketched the design of his own simple computer called Simon.



Berkeley's Simon was completed in 1949 and its design published in a series of articles in *Radio-Electronics* magazine between 1950 and 1951 for the benefit of electronics enthusiasts flocked around the magazine. The magazine called Simon – "World' Smallest Electric Brain", Berkeley himself referred to Simon as "Little Idiot" as the computer could operate only with 4 numbers: 0, 1, 2, and 3. Simon was not a scientific but educational aid "to exhibit in simple understandable form the essential principle of any artificial brain." (See [5].)

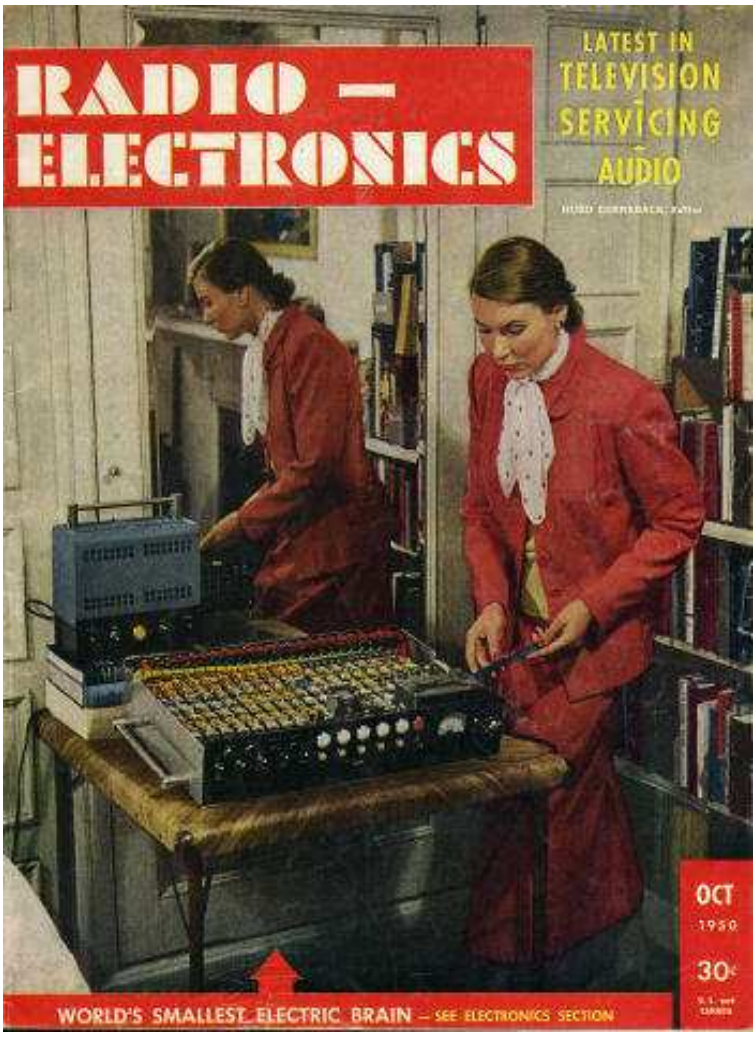
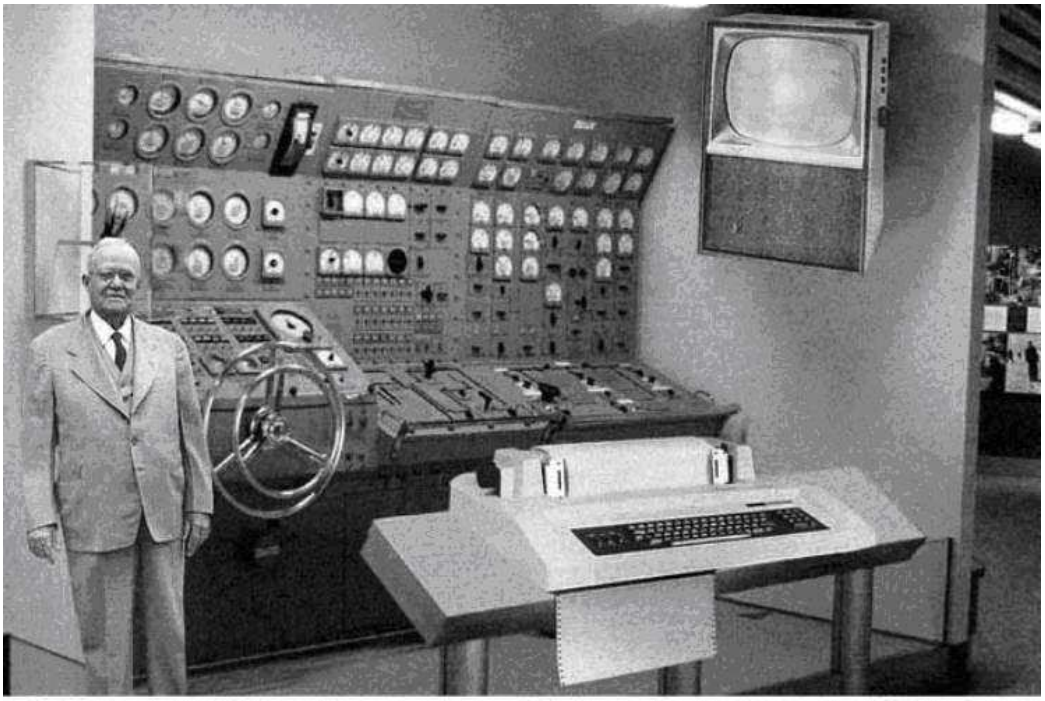


Fig. 12. Berkeley's Simon on the cover of the October 1950 issue of *Radio-Electronics*.

Berkeley's book deserves some attention from another point of view. The book exhibits Berkley's thoughts about the future of computing:

> We can even imagine what new machinery for handling information may some day become: a small pocket instrument that we carry around with us, talking to it whenever we need to, and either storing information in it or receiving information from it." (See [6], page 195.)

Berkeley's vision of personal computing devices was much closer to our present day reality than that of other "visionaries". In 1954, Rand Corporation came up with its vision of a "home computer" that the society were to enjoy in 2004. The computer in Figure 13 shows a total lack of technological vision (the RAND's home computer is based on 1954 technology); it seems also to suggest that by year 2004 American homes would resemble an atomic energy research lab.



Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

Fig. 14. RAND's home computer of the future. Source: *Popular Mechanics*, 1954.

Berkley's *Giant Brains* was the first popular science book aimed at educating electrical engineering enthusiasts (and hobbyists) about computing machines. The book inspired many young people to pursue career in computing.

John Weisbecker, a designer of mainframe computers at RCA was one of them. In the history of computing, Weisbecker is best known as the designer of the first microprocessor to be employed in a spacecraft; his RCA 1802 microprocessor was powering the computer on board of a number of crafts including the Galileo launched in 1982.

But Weisbecker not only built large computers and small microprocessors. He also picked up the educational bug from Berkeley and became the designer and promoter of small microprocessor-based hobby computers. His Elf computer was one of the most popular early computers offered in a kit form to electronics hobbyists.

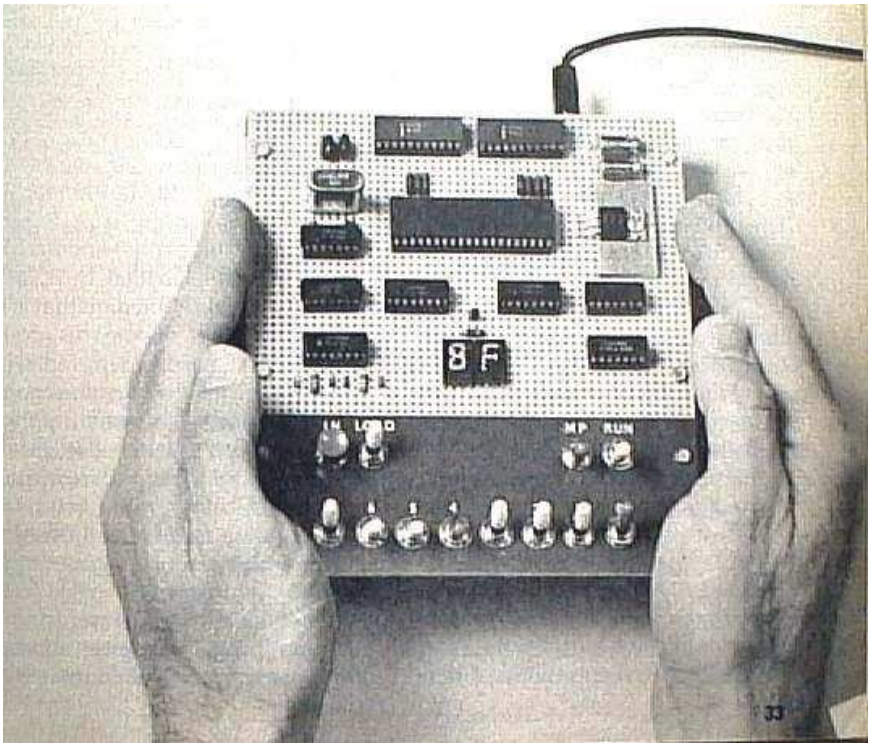


Fig. 15. Weisbecker's hobby computer Elf described in a series of articles in *Popular Electronics*, 1977.

The path of enthusiasm for computers, from Berkeley to Weisbecker, to the computer hobbyists and the first PC manufacturers, and finally to our present day personal computing reality illustrates how unusual and fascinating the process of the transfer of knowledge and technology–from research labs to homes–could be.

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4 P. Ceruzzi, *A History of Modern Computing*, MIT Press (1998).

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