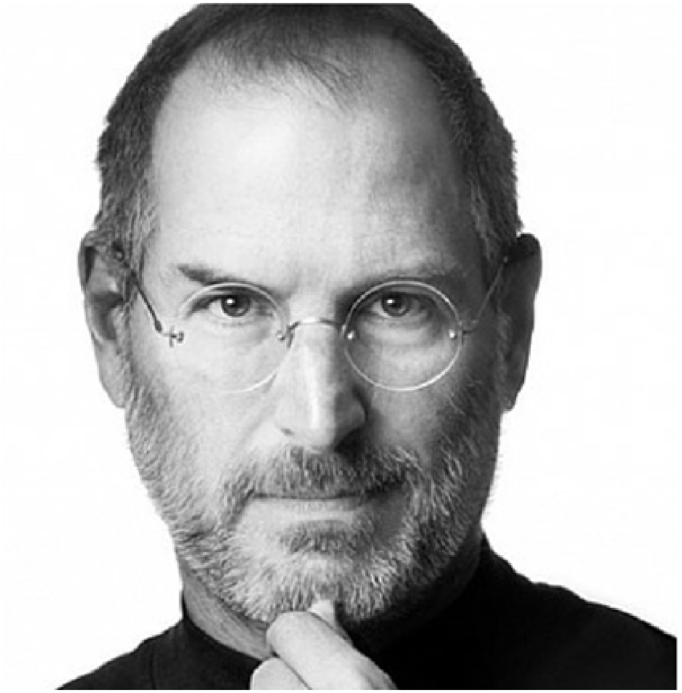
1장. 튜링머신과 지능형기계의 탄생

세상에서 가장 가치 있는 브랜드는 ?

The World's Most Valuable Brands 2023

Brand Values in Billions $

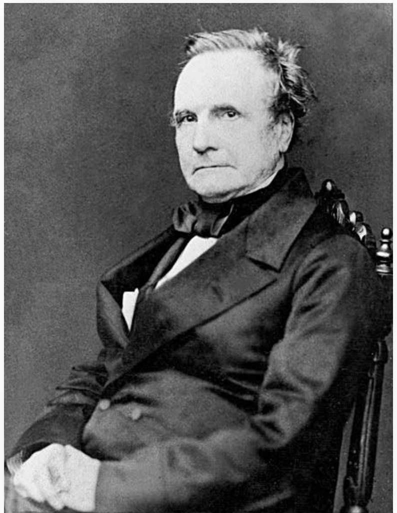
source: © Brand Finance Plc 2023



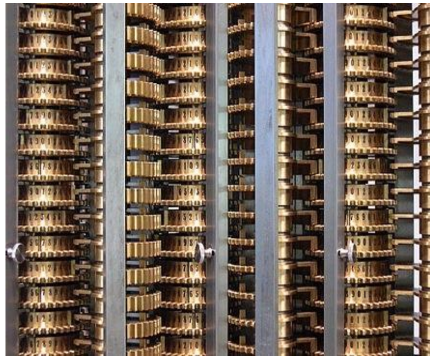
Everybody in this country should learn to program a computer, because it teaches you how to think

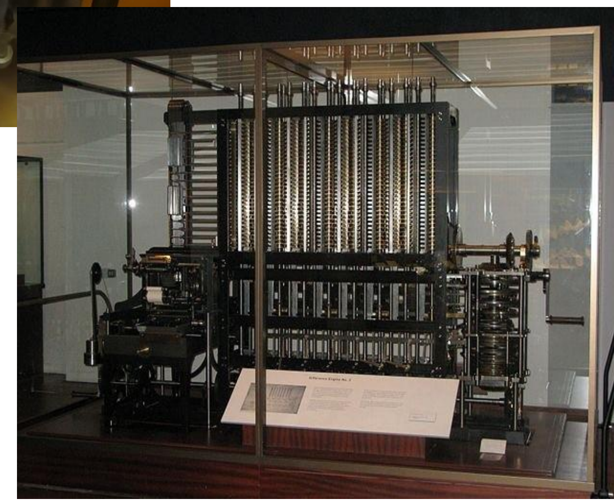
- Steve Jobs -

200년의 축적

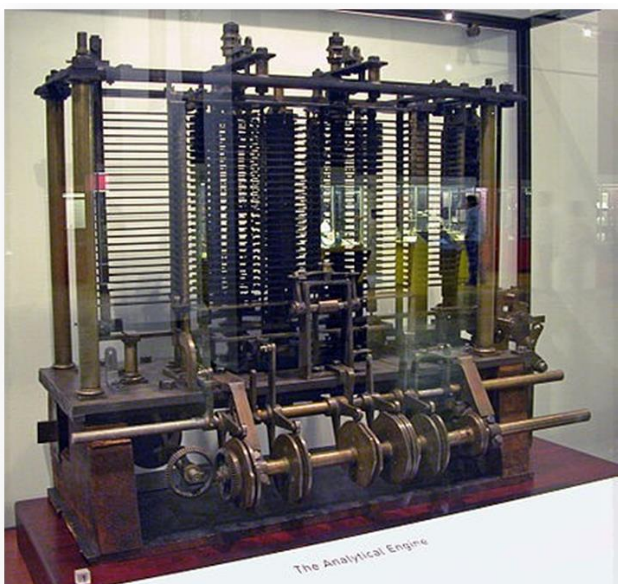


찰스 바베지
1791-1871





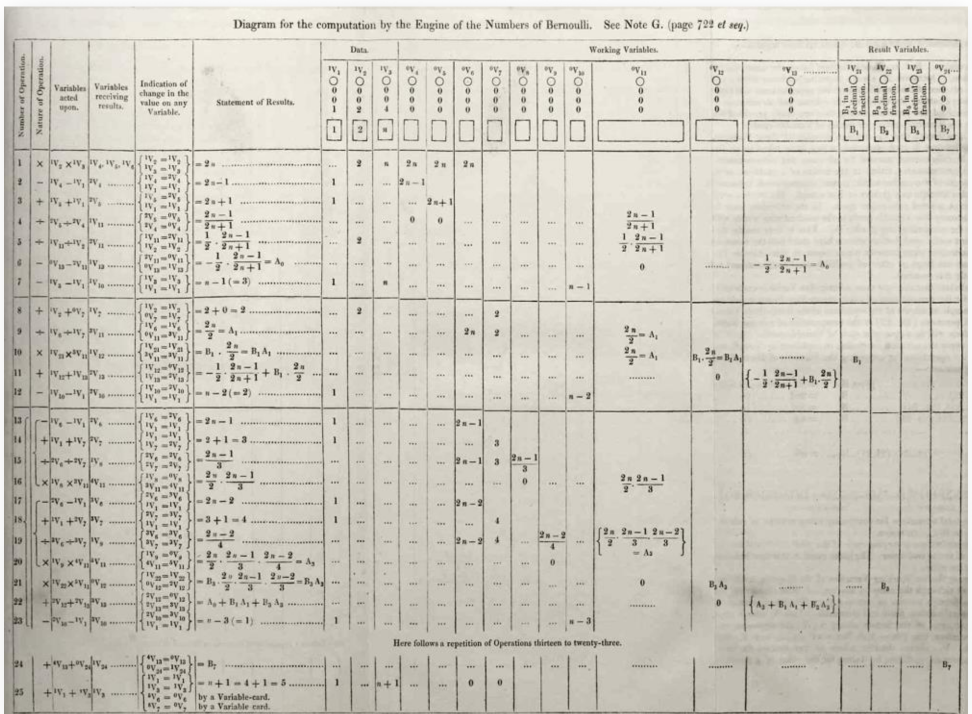
Difference Engine
(차분엔진)
1822



Analytical Engine
(해석엔진)
1837

최초의 컴퓨터 알고리즘

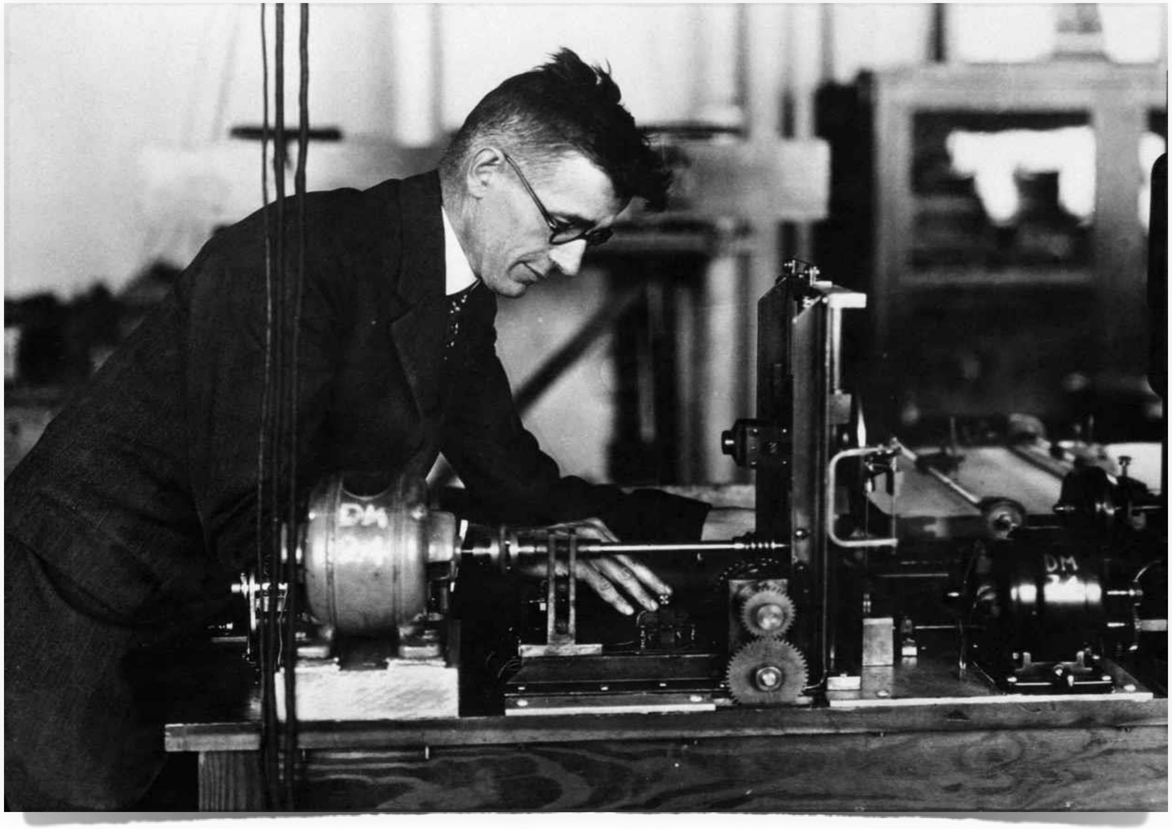
- 에이다 러브레이스(Ada Lovelace)
  - 1843년 베르누이 수를 계산하기 위해 제작



에이다 러브레이스
1815-1852

100년 후

- 최초의 기계식 아날로그 컴퓨터



미분해석기
(Differential Analyzer)
Vannevar Bush
1931

Hilbert's Program

- 1928년 David Hilbert의 결정문제
  1. Was the set of mathematical rules complete?
  2. Was it consistent?
  3. Was it decidable? (Decision Problem)

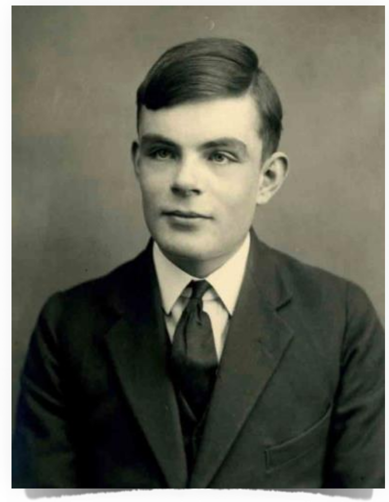
David Hilbert
1862-1943

Hilbert's Program에 대한 반박

Gödel's Incompleteness Theorem (1931)

1. No (Liar's Paradox)
2. No

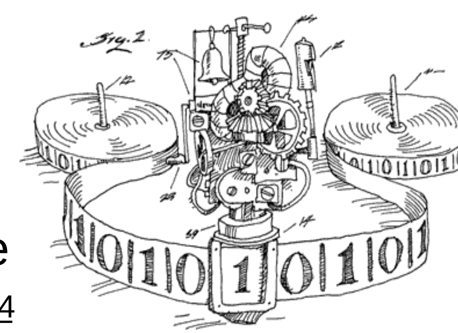
Kurt Gödel
1906-1978



The Halting Problem is not solvable (1936)

3. No

Alan Turing
1912-1954



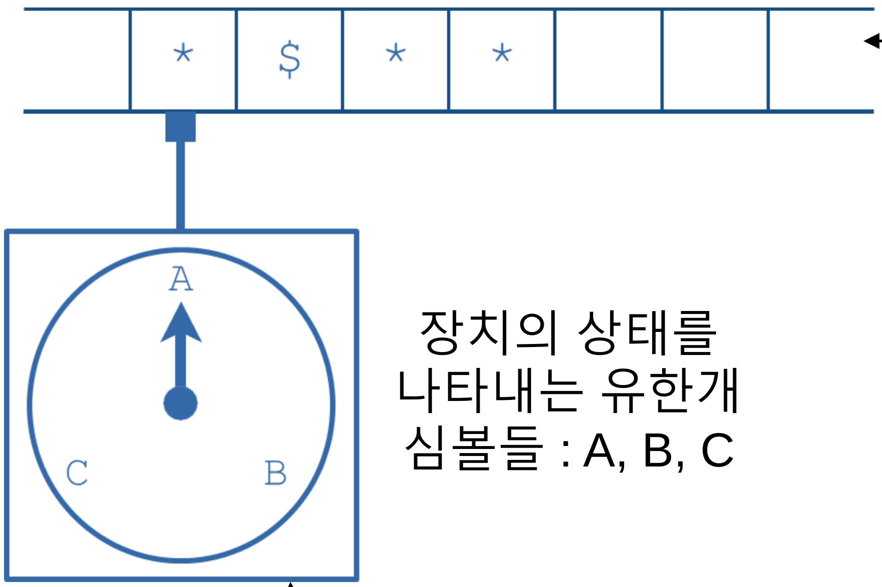
Universal Turing Machine

출처 : http://www.felienne.com/archives/2974

Turing Machine (1/10)

테이프에 기록되는 유한개의 심볼들 : $, *

테이프



장치의 상태를 나타내는 유한개 심볼들 : A, B, C

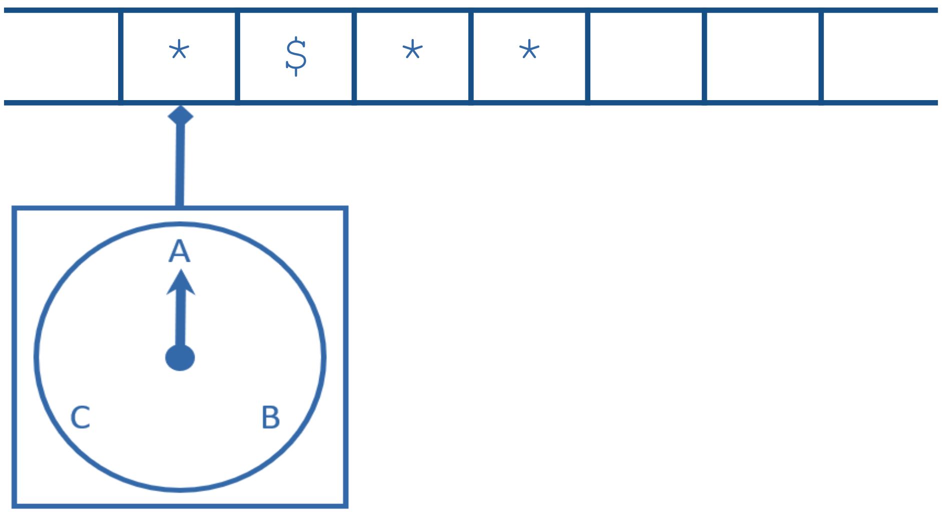
테이프에 기록된 심볼들을 읽거나 쓰는 장치

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B

기계의 작동 규칙표

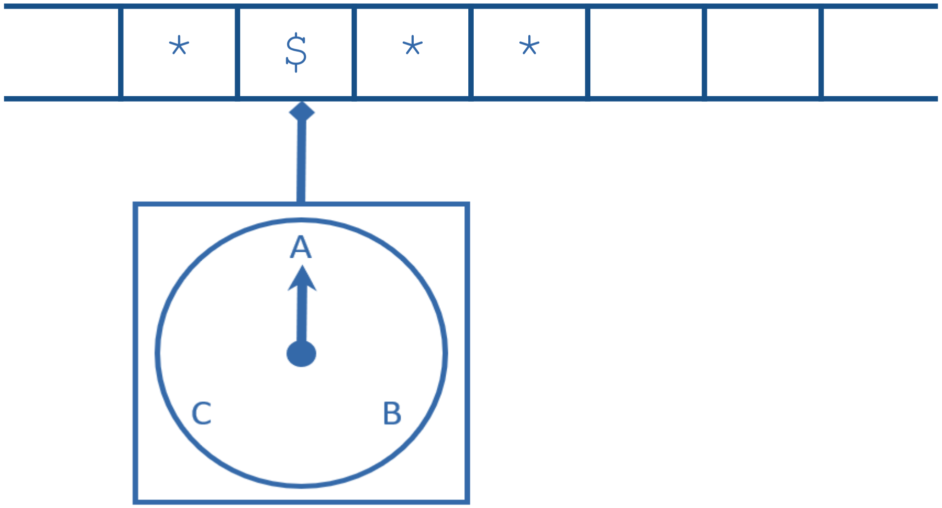
Turing Machine (2/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



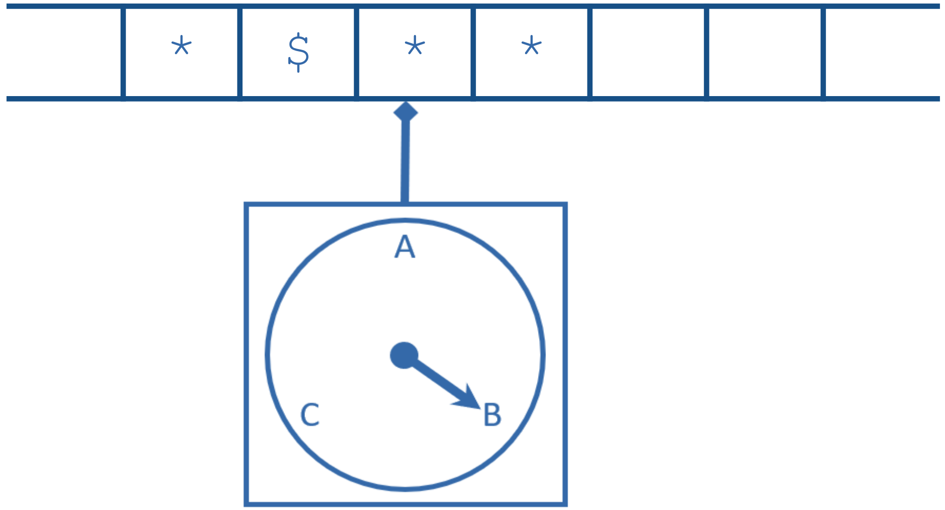
Turing Machine (3/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



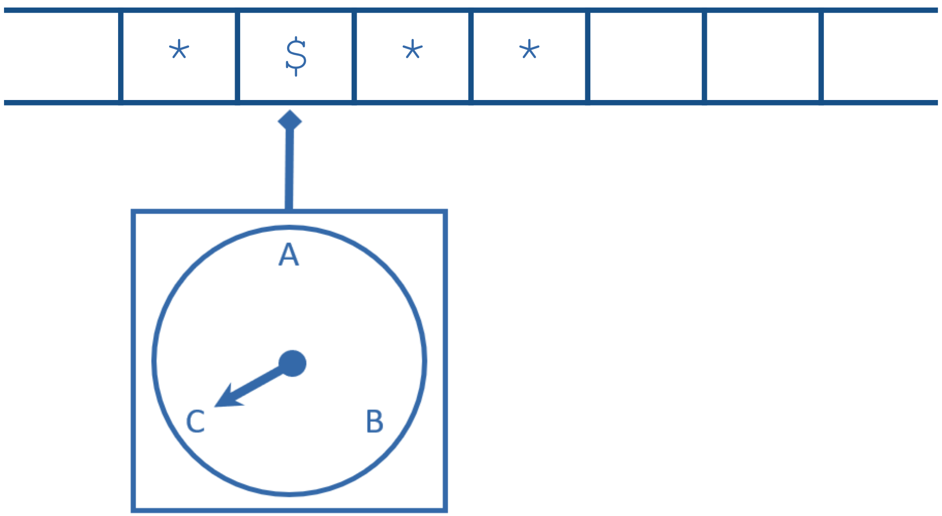
Turing Machine (4/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



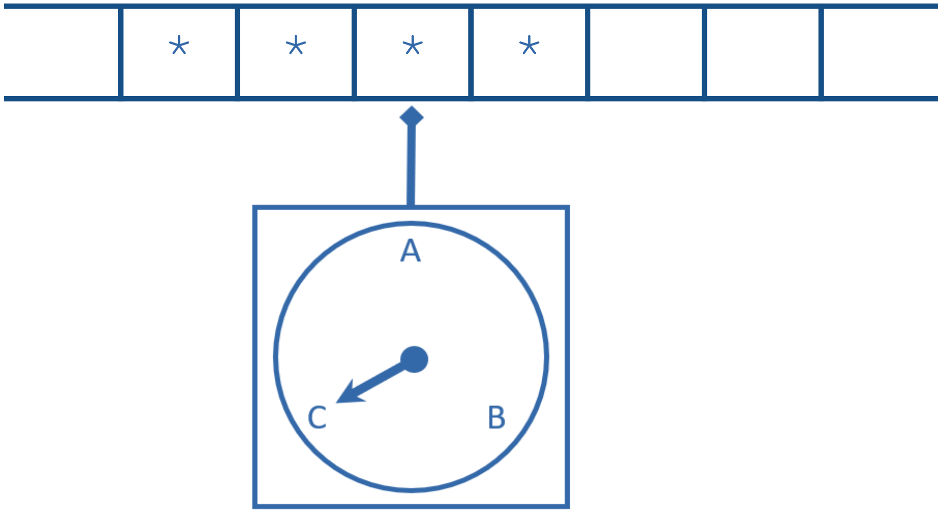
Turing Machine (5/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



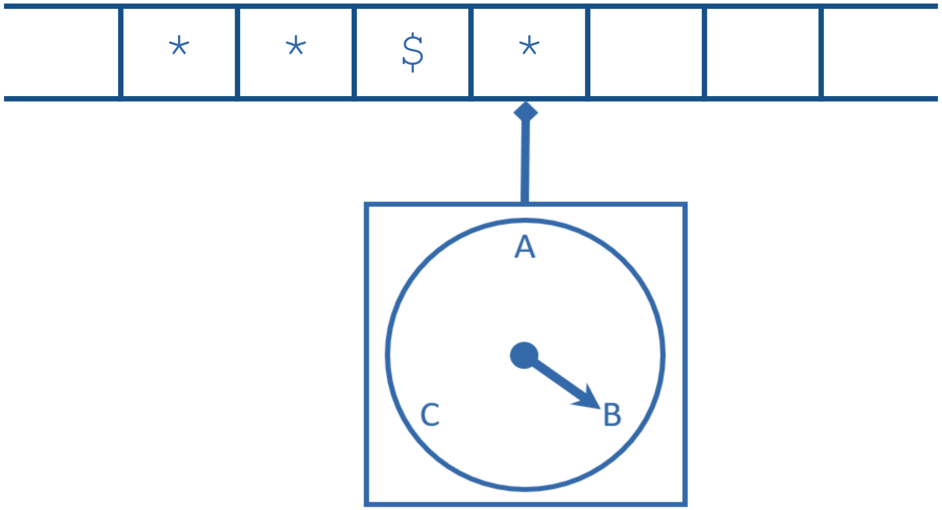
Turing Machine (6/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



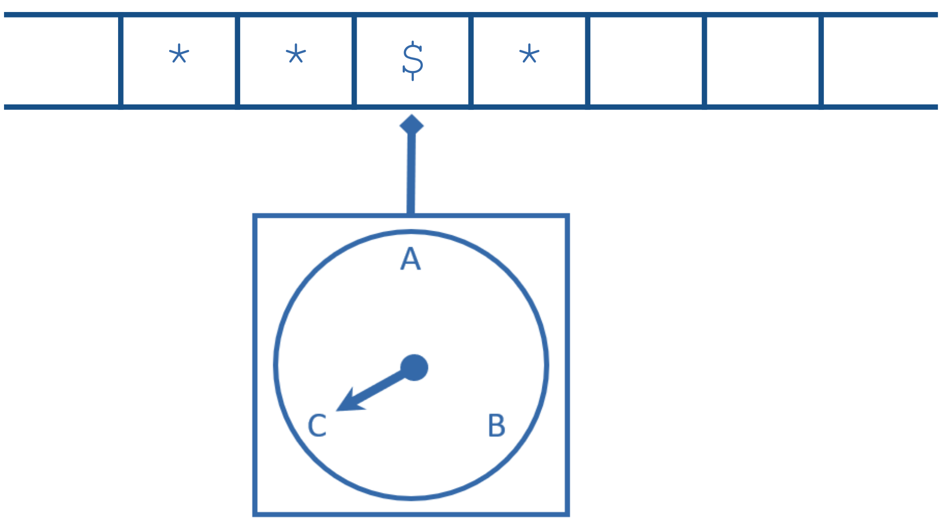
Turing Machine (7/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



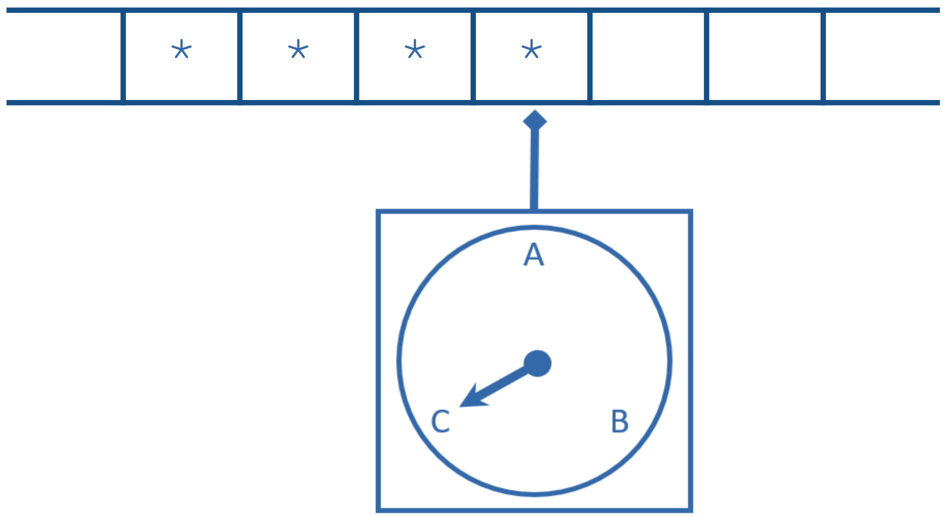
Turing Machine (8/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



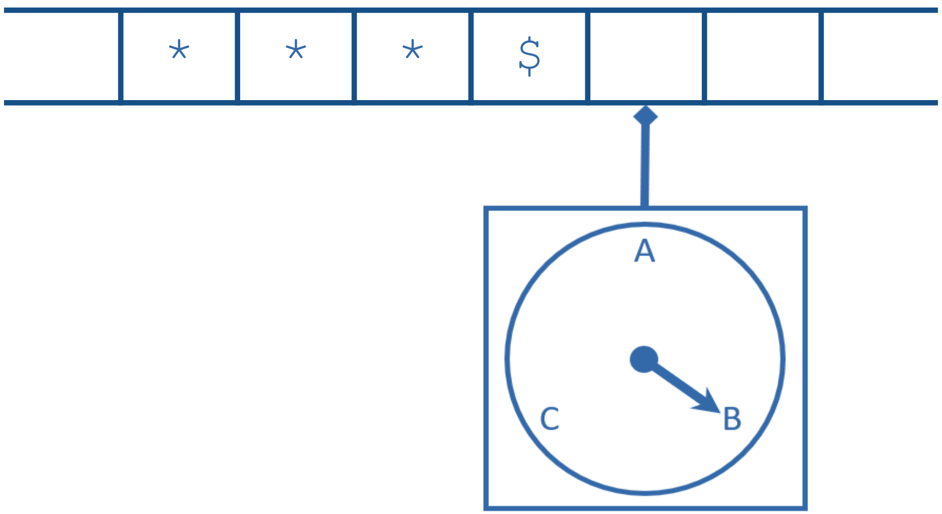
Turing Machine (9/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



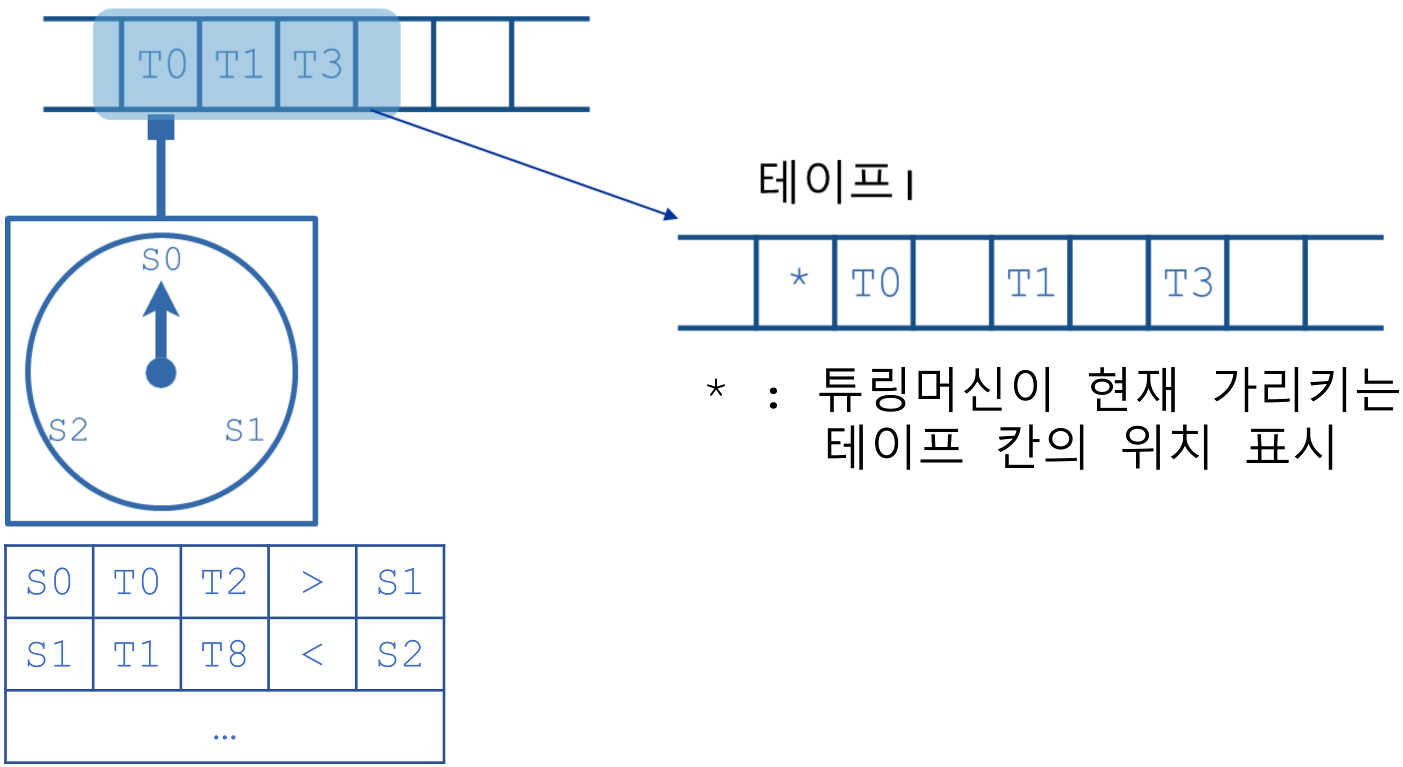
Turing Machine (10/10)

Current State	Symbol to Read	Symbol to Write	Shift	Next State
A	*	*	>	A
A	$	$	>	B
B	*	*	<	C
C	$	*	>	C
C	*	$	>	B



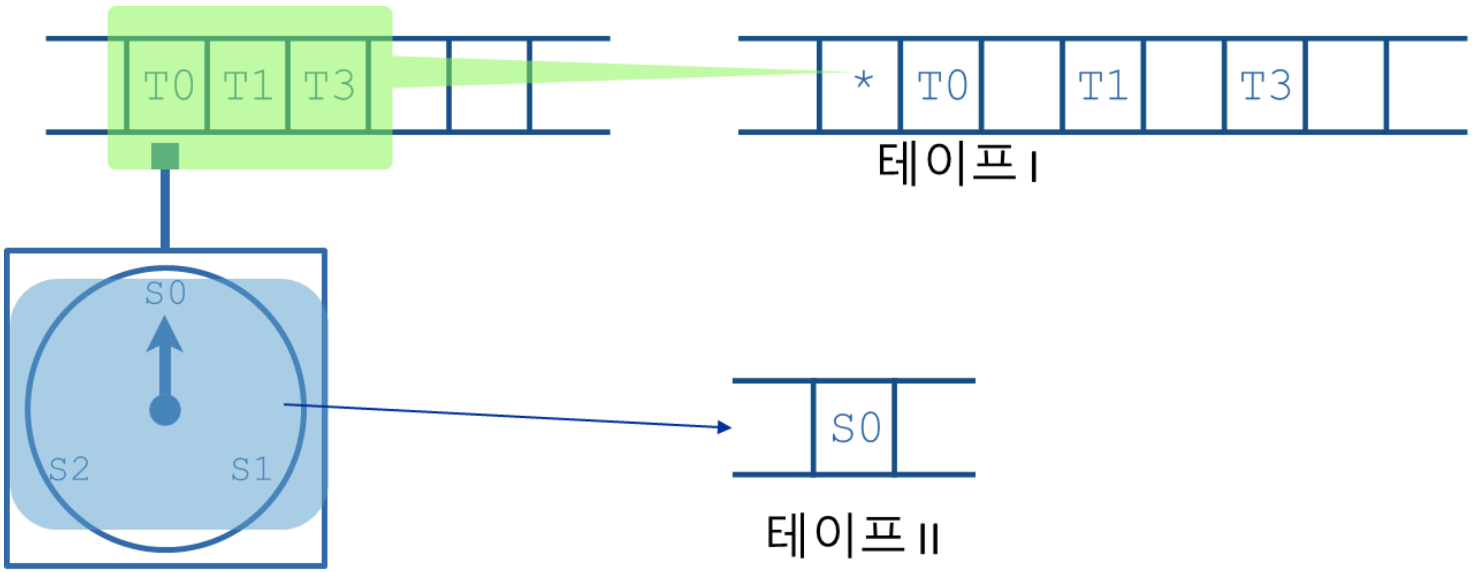
Universal Turing Machine (1/4)

- 테이프 I
  - 튜링머신의 테이프와 읽고 쓰는 장치를 표현



Universal Turing Machine (2/4)

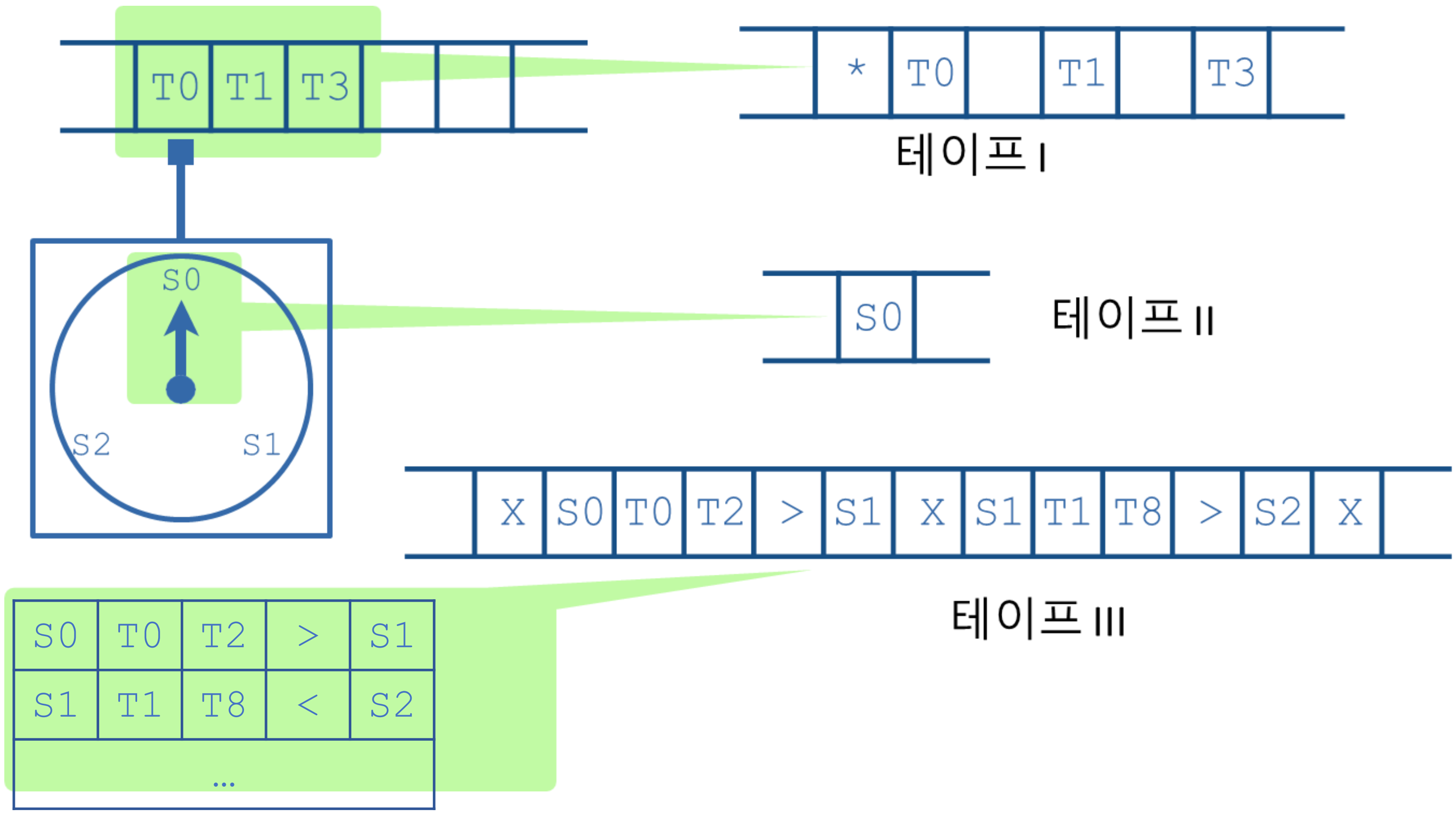
- 테이프 II : 튜링머신의 현재 상태 심볼 표현



S0	T0	T2	>	S1
S1	T1	T8	<	S2
…				

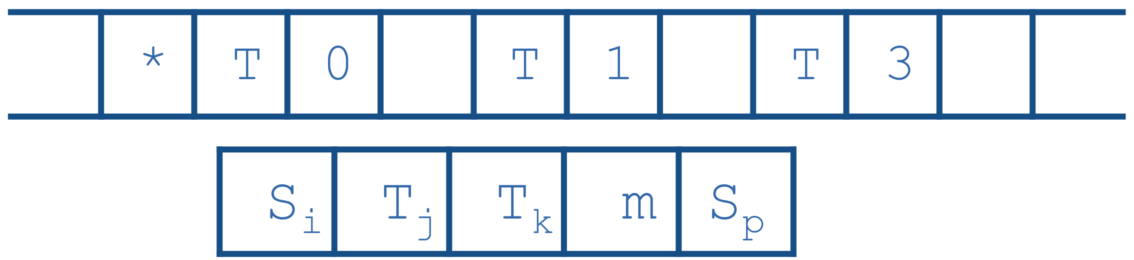
Universal Turing Machine (3/4)

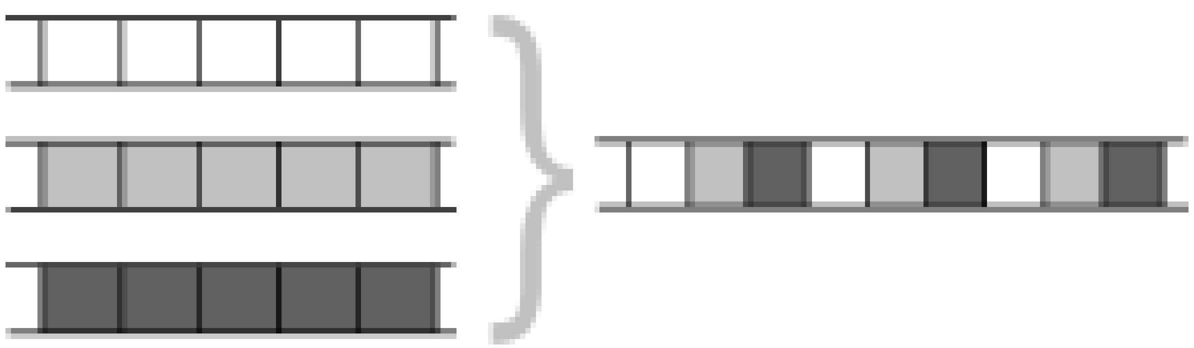
- 테이프 III : 튜링머신의 규칙표 담기



Universal Turing Machine (4/4)

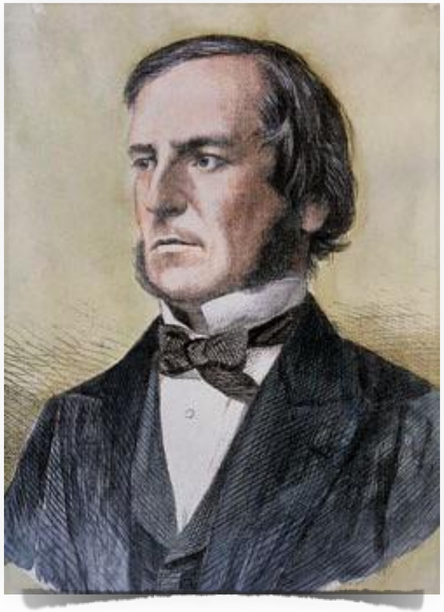
- 3개의 테이프를 하나로 합쳐서 유니버설 튜링머신이 만들어짐





도구의 실현

부울대수 (1/3)



George Boole
1815-1864

An Investigation of the Laws of Thought (1854)

Truth Table

x	y	and	or
T	T	T	T
T	F	F	T
F	T	F	T
F	F	F	F

x	not
T	F
F	T

부울대수 (2/3)

- 부울법칙(Boolean Laws)
  - Commutative law(교환법칙)

    `A or B = B or A    A and B = B and A`
  - Associative law(결합법칙)

    `A or (B or C) = (A or B) or C`

    `A and (B and C) = (A and B) and C`
  - Distributive law(분배법칙)

    `A and (B or C) = A and B or A and C`

    `A or (B and C) = (A or B) and (A or C)`
  - Involution law(이중부정법칙)

    `not(not A) = A`

부울대수 (3/3)

- Identity law(항등법칙)

```
A or 1 = 1        A or 0 = A
A and 1 = A       A and 0 = 0
```

- Absorption law(흡수법칙)

```
A or (A and B) = A
A and (A or B) = A
```

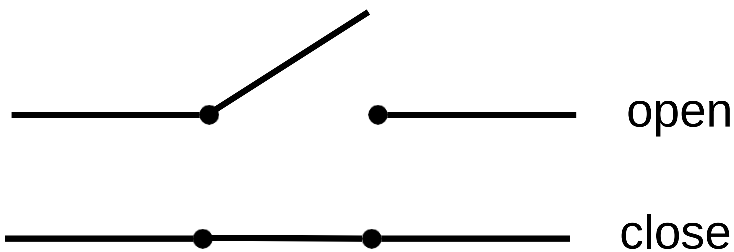
- DeMorgan's law(드모르강의 법칙)

```
not A or not B = not (A and B)
not A and not B = not (A or B)
```

Switching Circuit (1/3)

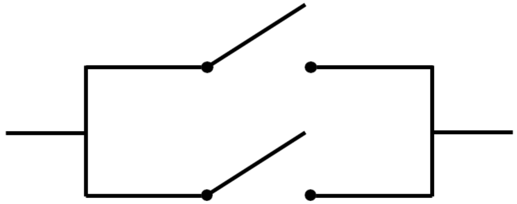
- 1857년 부울대수 ⇒ 1937년 스위칭 서킷
  - 1930년대 스위치

Switch



Serial Circuits

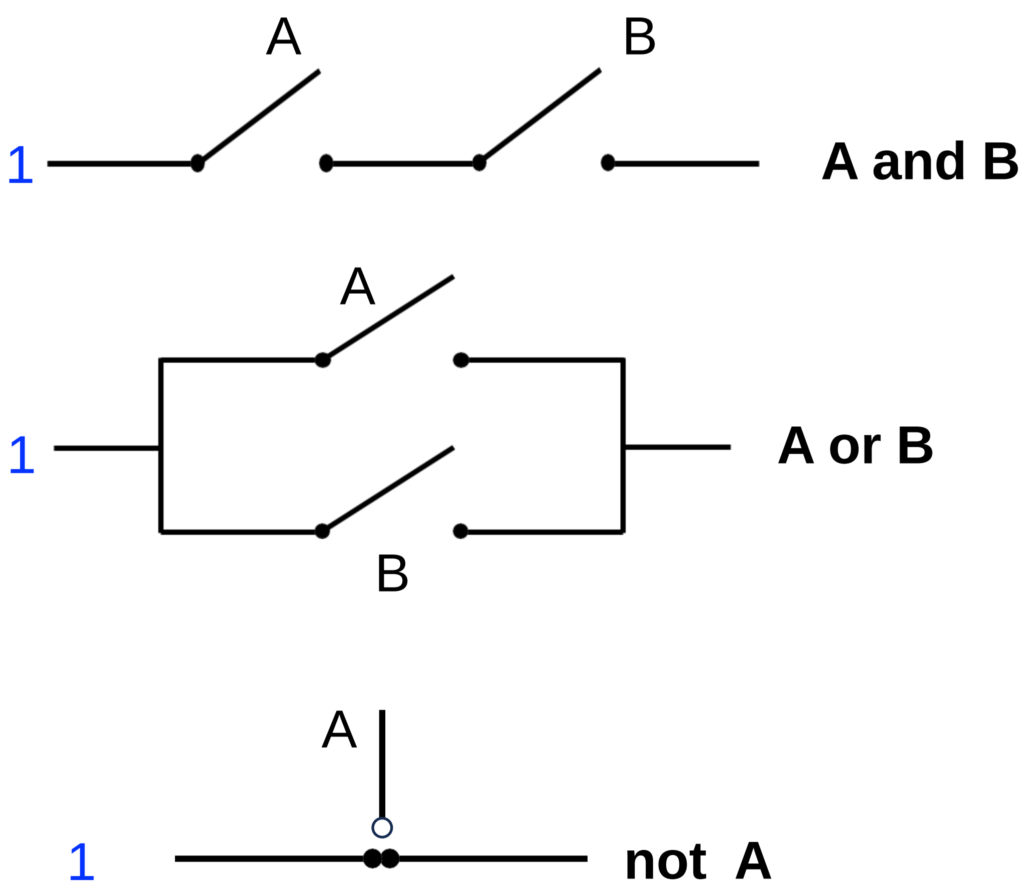
Parallel Circuits

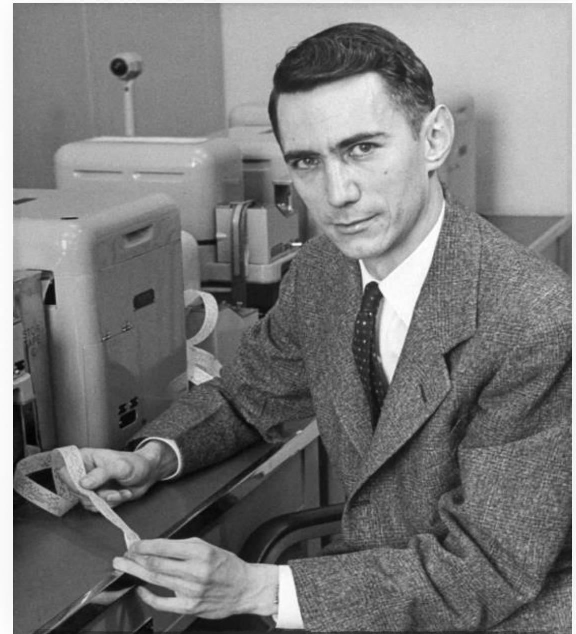


Inverse Circuits

Switching Circuit (2/3)

- 스위칭 서킷



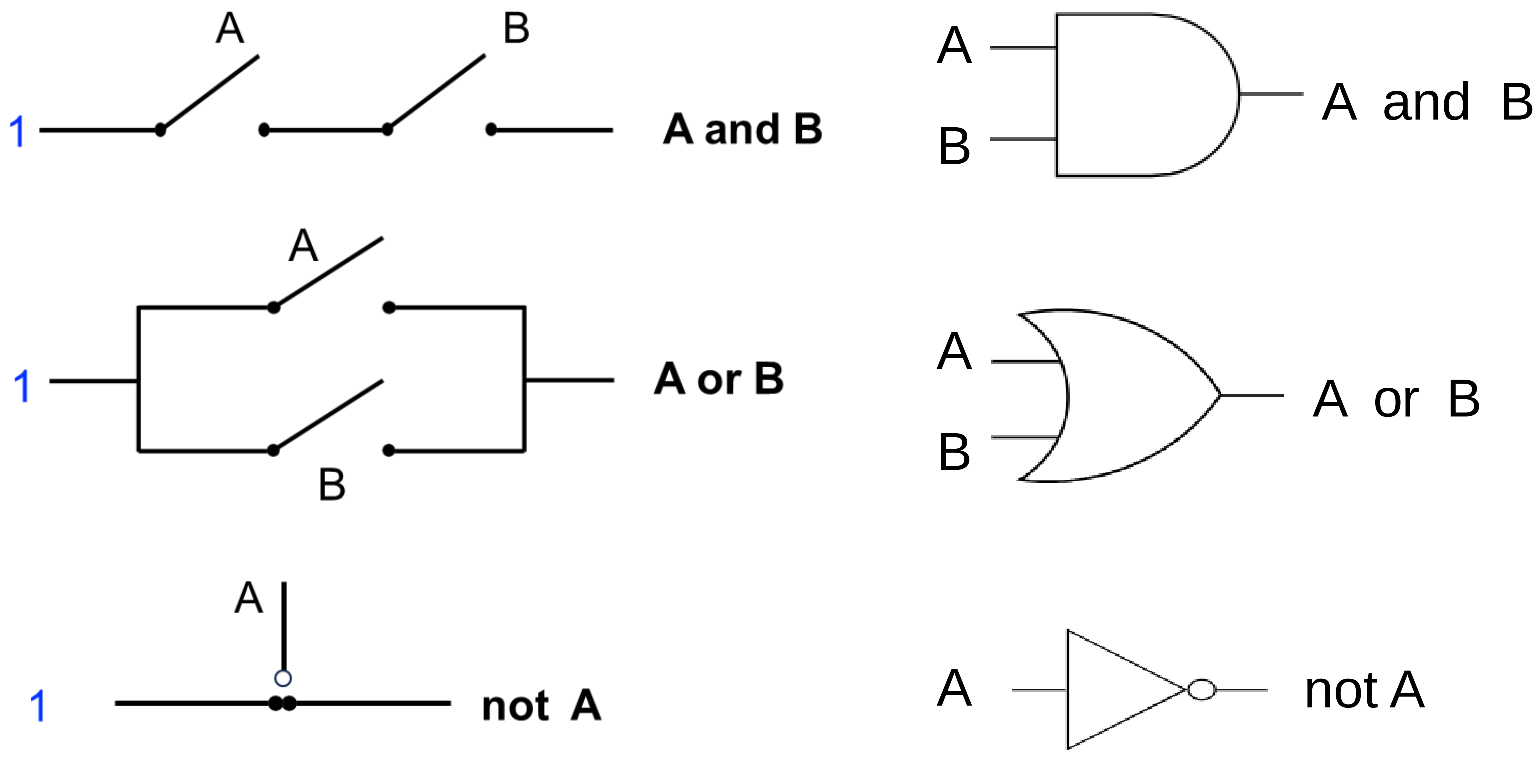


Claude Shannon
1916-2001

A Symbolic Analysis of Relay and Switching Circuits
(Master’s Thesis, MIT, 1937)

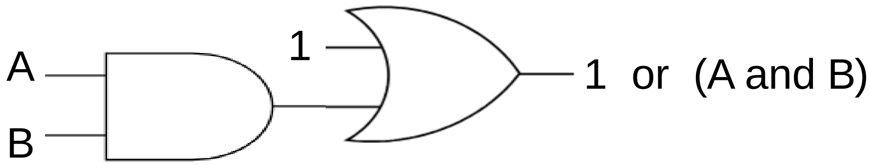
Switching Circuit (3/3)

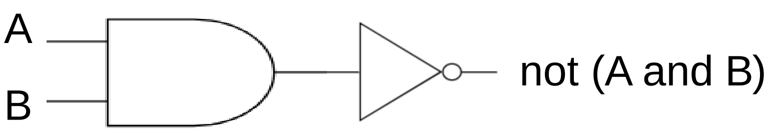
- Digital Logic Circuits
  = Switching circuits + Boolean logic

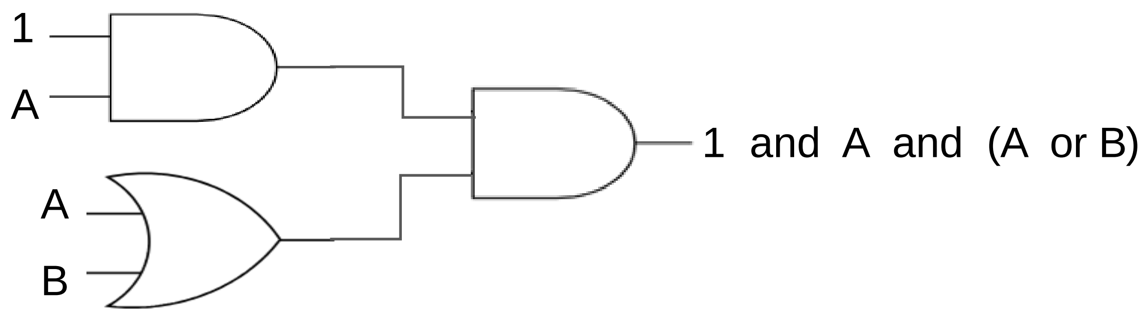


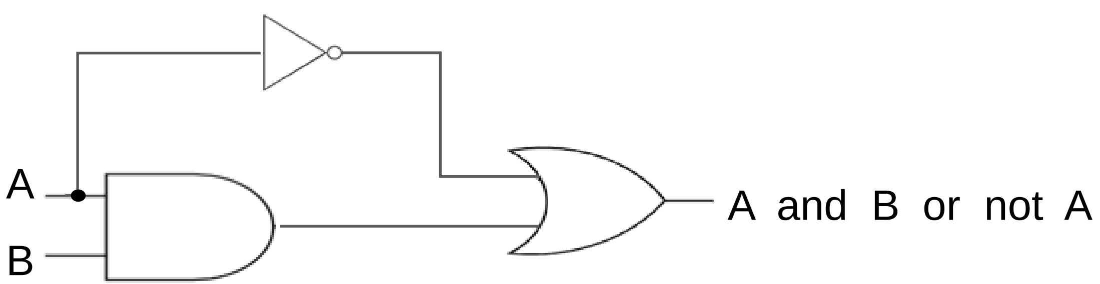
Digital Logic Circuit (1/4)

- 디지털논리회로 예제







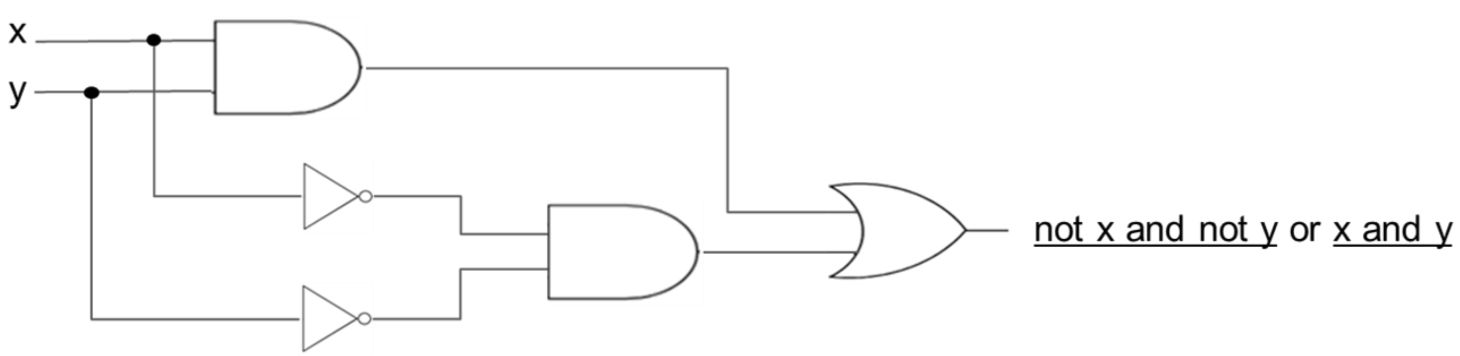


Digital Logic Circuit (2/4)

- 두 입력이 같은지 판정하는 회로
  - T ⇒ 1, F ⇒ 0

x	y	out	
0	0	1	not x and not y
1	1	1	x and y
-	-	0	

(not x and not y) or (x and y)

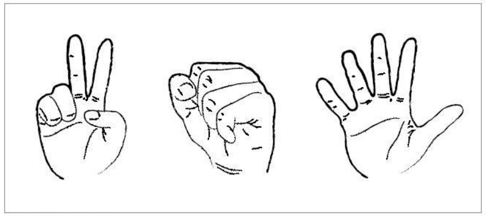


Digital Logic Circuit (3/4)

- 가위바위보

Jane vs. Tom

Input



scissors rock paper

00 01 10

Output

Jane wins	10
Tom wins	01
Draws	11
Otherwise	00

Jane		Tom		out	
w	x	y	z	A	B
0	0	0	0	1	1
0	0	0	1	0	1
0	0	1	0	1	0
0	1	0	0	1	0
0	1	0	1	1	1
0	1	1	0	0	1
1	0	0	0	0	1
1	0	0	1	1	0
1	0	1	0	1	1
-	-	-	-	0	0

Digital Logic Circuit (4/4)

- 멀티플렉서
  - 둘 입력 중 하나를 조건에 따라 결정

z	x	y	Out	x, y가 입력, z가 선택자
0	0	0	0	
0	0	1	0	
0	1	0	1	x and not y and not z
0	1	1	1	x and y and not z
1	0	0	0	
1	0	1	1	not x and y and z
1	1	0	0	
1	1	1	1	x and y and z

⇨ **x and not z**
or
y and z

프로그램 내장방식

- 폰노이만 구조(von Neuman Architecture)

John von Neumann
1903-1954

프로그램 내장방식
(Stored-Program Computer)

=

폰 노이만 구조
(von Neuman Architecture)

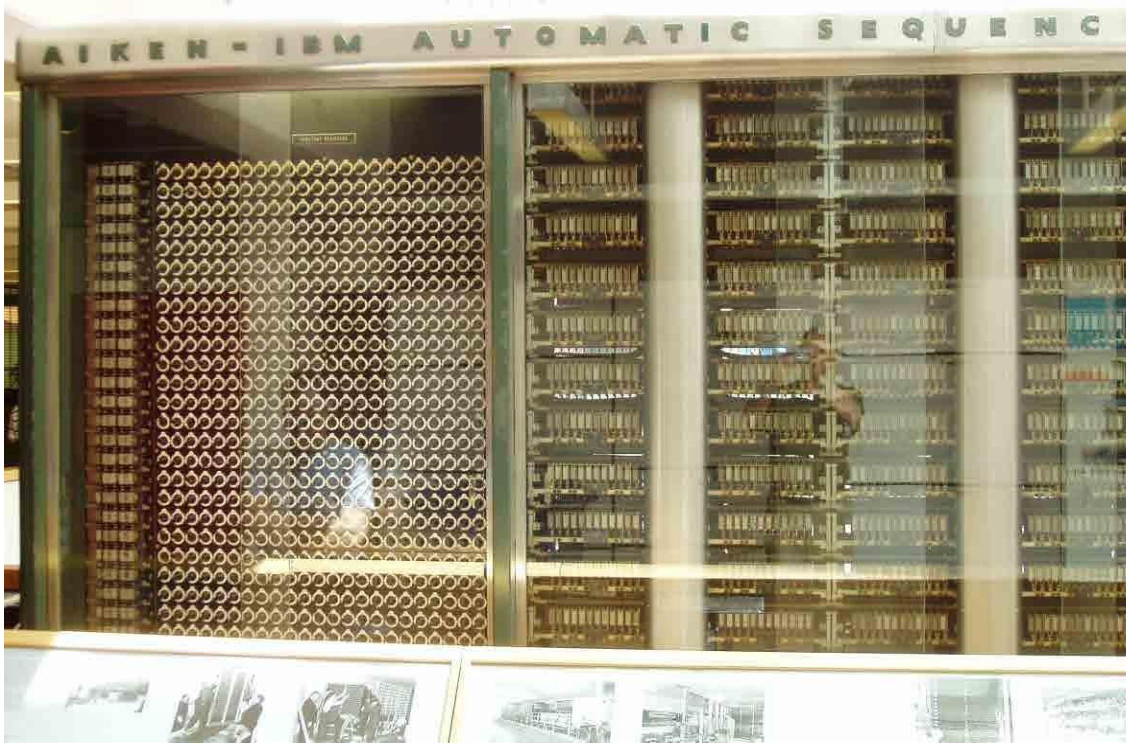
First Draft of a Report on the EDVAC
Electronic Discrete Variable Automatic Calculator

1945~1952

Mark I

Grace Hopper
1906-1992

- 최초로 컴파일러 개발
- 최초의 여성 프로그래머
- 프로그램 '버그' 개념의 창시자



IBM's Harvard Mark I

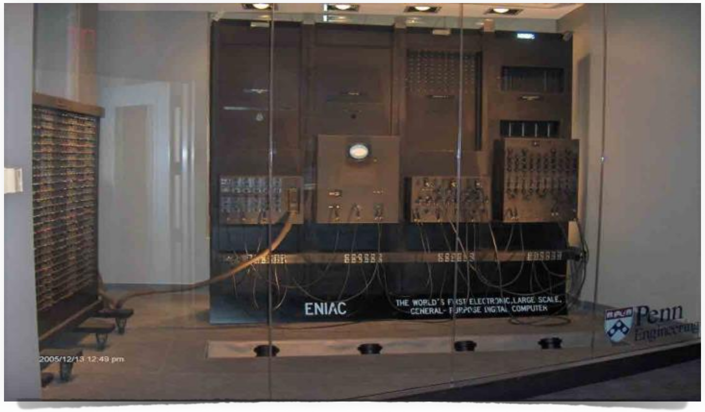
최초의 전기 자동 계산기

1944~1959

by Howard Aiken

ENIAC

- General-Purpose Automatic Electronic Decimal Digital Computer
  - Univ. of Penn, 1945 by John Mauchly and J. Presper Eckert



컴퓨터의 정의

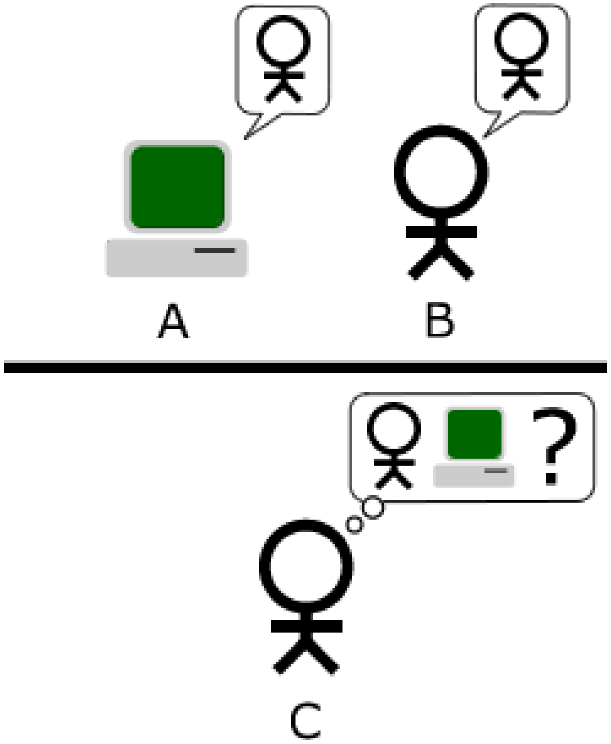
- 현대적 의미의 컴퓨터를 정의하는 특성

since 1937

디지털 방식 (Digital)	이진 체계 (Binary)
전자회로를 사용 (Electronic)	범용 (General Purpose)

튜링테스트

- The Imitation Game
  - Computing Machinery and Intelligence Mind (1950)



The Transistor & The Microchip

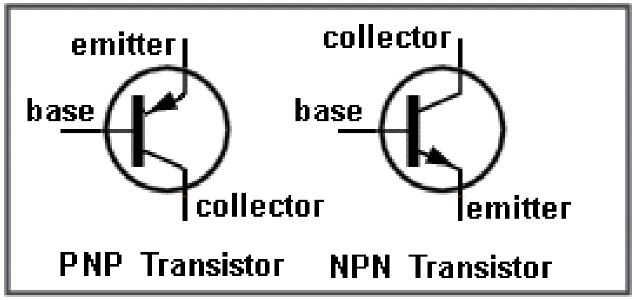
Transistor

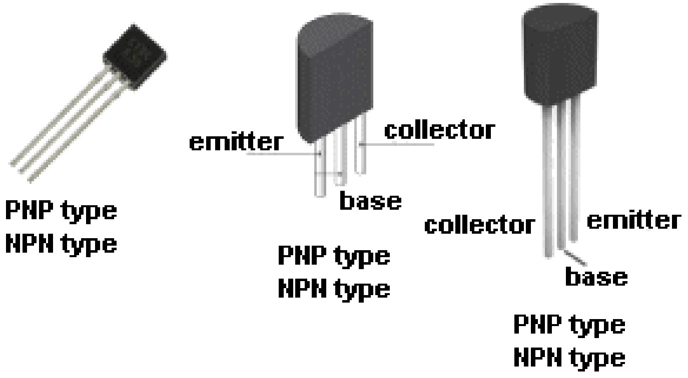
- Bell Labs

John Bardeen
1908-1991

William Shockley
1910-1989

Walter Brattain
1902-1987





Microchip

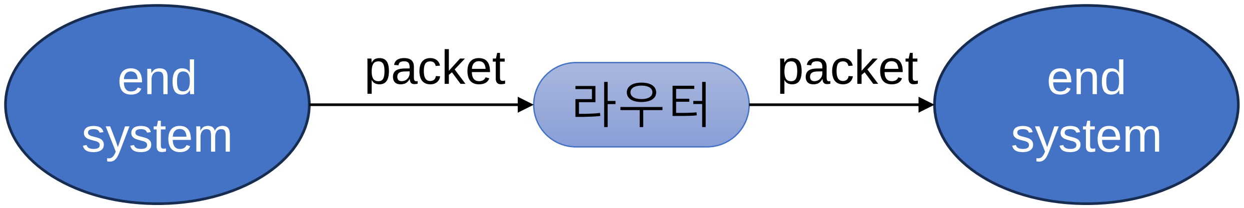
- At Silicon Valley
- Texas instruments
  - 최초로 트랜지스터 라디오 생산
  - Jack Killby : 집적회로(IC, Integrated Chip) 발명
  - 반도체 소자 생산 기업으로 자리매김
- Intel
  - 1971년 general-purpose chip 마이크로프로세서 개발
  - Moore’s law : 칩에 집적할 수 있는 트랜지스터의 개수는 적어도 매18개월마다 두배씩 증가

The Internet

컴퓨터 네트워크

- 컴퓨터 네트워크(Computer network)
  - 여러 컴퓨터가 각각 클라이언트와 서버로 서로 연결되어 구성된 망
- 인터넷(Internet)
  - 컴퓨터 네트워크가 전 세계적인 규모로 수없이 많이 모여서 이루어진 일종의 컴퓨터 네트워크 시스템

<u>한 컴퓨터에서 다른 컴퓨터로 데이터를 보내는 과정</u>



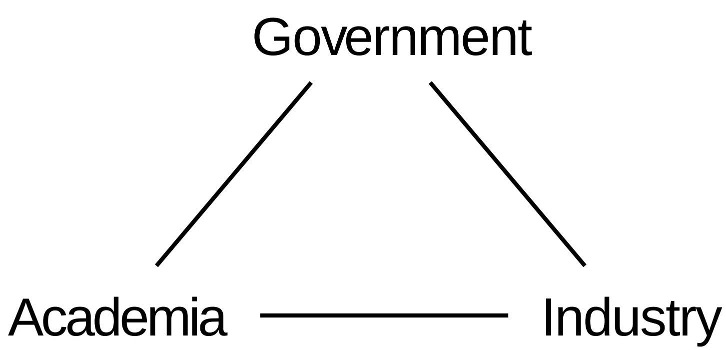
인터넷의 기반 (1/5)

- Memex(MEMory Extender)
  - 1940년 바네바 부시가 개발
  - 마이크로필름에 기록한 자료를 색인화해서 유기적으로 연결해주는 시스템
  - 웹과 HTTP 등 인터넷의 근간

Vannevar Bush
1890-1974

인터넷의 기반 (2/5)

- CSNET(Computer Science Network)
  - 1981년 승인 제한으로 인해 ARPANET에 직접 연결할 수 없는 학술 및 연구 기관의 컴퓨터 과학 부서를 위해 네트워킹 혜택을 확장하기 위한 목적
  - NSF(National Science Foundation)의 지원
  - 5곳의 슈퍼컴퓨터센터를 연결해서 네트워크를 구성



인터넷의 기반 (3/5)

- 1960년 J.C.R. Licklider
  - 오늘날의 인터넷과 유사한 네트워크 시스템인 Intergalactic Computer Network을 제안
  - PC 한대를 여러 사용자가 동시에 활용하는 시분할 시스템 개발에 영향을 줌
  - 실시간 컴퓨팅(realtime-computing) 개념
  - 가까운 미래에는 인간의 뇌와 계산 기계가 밀접하게 결합될 것이라고 언급

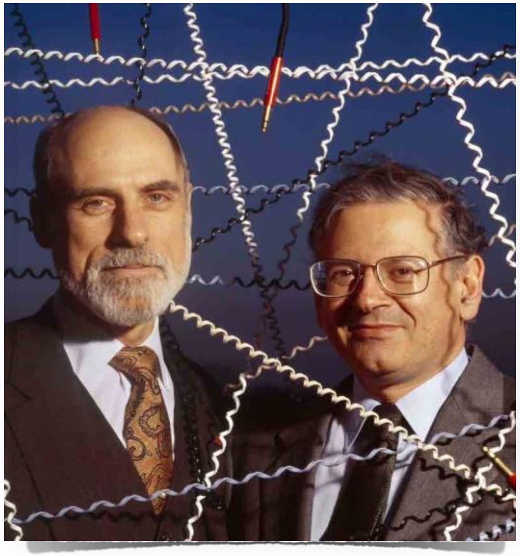
J.C.R. Licklider
1915-1990

인터넷의 기반 (4/5)

- ARPANET
  - 1969년 만들어진 세계 최초의 패킷스위칭 네트워크
  - 현재 인터넷의 원형
- 1964년 폴바란
  - 메시지 블록 데이터를 기반으로 하는 분산네트워크 제안
- 1960년대 말 ~ 1970년대 초
  - 다양한 프로토콜을 이용한 패킷 교환망이 개발 됨

인터넷의 기반 (5/5)

- TCP/IP
  - Transmission Control Protocol / Internet Protocol
  - A Protocol for Packet Network Interconnection
  - TCP/IP 프로토콜과 네트워크 구조를 설계하면서 인터넷이 탄생
  - TCP/IP는 네트워크를 통해 데이터를 패킷으로 전송하는 현재 통신 프로토콜의 핵심 데이터 전송 기술



Vint Cerf
1943-

Bob Kahn
1938-

The Personal Computer

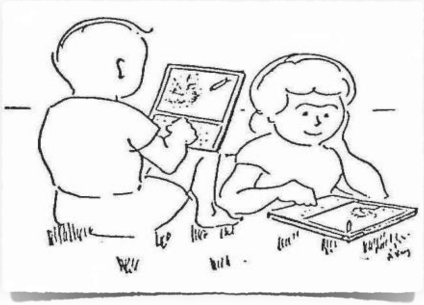
마우스의 개발

- Augmenting Human Intellect (1962)
  - 더글라스 엥겔바트의 “The Mother of All Demos” (1968)

The first prototype of a computer mouse

최초의 태블릿

- 앨랜케이(Alan Kay)
  - 개인용컴퓨터를 구상 => 1972년 Dynabook 개발
  - 1973년 Xerox Alto 개발 : 마우스, 키보드, 모니터를 갖춘 컴퓨터 => GUI의 기초가 됨
  - 객체지향프로그래밍 개념 정립
  - 최초의 객체지향언어인 Smalltalk 개발
  - 중첩되는 윈도우 개념 개발



Dynabook

Xerox Alto

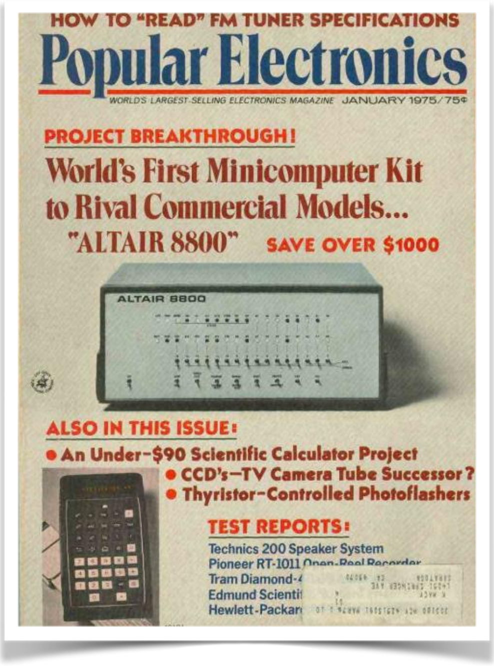
ALTAIR 8800

- 상업적으로 성공한 최초의 개인용 컴퓨터
  - 1975년 에드워즈 로버츠가 개발
  - 인텔 8080 마이크로프로세서를 사용
  - 조립키트형 마이크로컴퓨터

do-it-yourself rocket kit

do-it-yourself pocket calculator

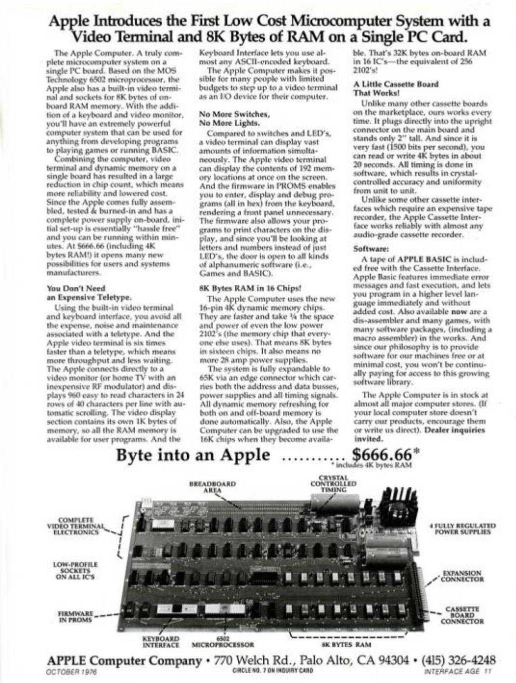
do-it-yourself computer
ALTAIR 8800



Apple I

- Homebrew Computer Club
  - 개인용 컴퓨터 개발을 목적
  - 클럽의 회원들을 통해 23개 컴퓨터 회사가 탄생

SOL computer



Apple Introduces the First Low Cost Microcomputer System with a Video Terminal and 8K Bytes of RAM on a Single PC Card.

The Apple Computer. A truly complete microcomputer system on a single PC board. Based on the MOS Technology 6502 microprocessor, the Apple also has a built-in video terminal and sockets for 8K bytes of onboard RAM memory. With the addition of a keyboard and video monitor, you'll have an extremely powerful computer system that can be used for anything from developing programs to playing games or running BASIC.

Combining the computer, video terminal and dynamic memory on a single board has resulted in a large reduction in chip count, which means more reliability and lowered cost. Since the Apple comes fully assembled, tested & burned-in and has a complete power supply on-board, initial set-up is essentially "hassle free" and you can be running within minutes. At $666.66 (including 4K bytes RAM!) it opens many new possibilities for users and systems manufacturers.

You Don't Need an Expensive Teletype.

Using the built-in video terminal and keyboard interface, you avoid all the expense, noise and maintenance associated with a teletype. And the Apple video terminal is six times faster than a teletype, which means more throughput and less waiting. The Apple connects directly to a video monitor (or home TV with an inexpensive RF modulator) and displays 960 easy to read characters in 24 rows of 40 characters per line with automatic scrolling. The video display section contains its own 1K bytes of memory, so all the RAM memory is available for user programs. And the Keyboard Interface lets you use almost any ASCII-encoded keyboard.

The Apple Computer makes it possible for many people with limited budgets to step up to a video terminal as an I/O device for their computer.

No More Switches, No More Lights.

Compared to switches and LED's, a video terminal can display vast amounts of information simultaneously. The Apple video terminal can display the contents of 192 memory locations at once on the screen. And the firmware in PROMS enables you to enter, display and debug programs (all in hex) from the keyboard, rendering a front panel unnecessary. The firmware also allows your programs to print characters on the display, and since you'll be looking at letters and numbers instead of just LED's, the door is open to all kinds of alphanumeric software (i.e., Games and BASIC).

8K Bytes RAM in 16 Chips!

The Apple Computer uses the new 16-pin 4K dynamic memory chips. They are faster and take ¼ the space and power of even the low power 2102's (the memory chip that everyone else uses). That means 8K bytes in sixteen chips. It also means no more 28 amp power supplies.

The system is fully expandable to 65K via an edge connector which carries both the address and data busses, power supplies and all timing signals. All dynamic memory refreshing for both on and off-board memory is done automatically. Also, the Apple Computer can be upgraded to use the 16K chips when they become available. That's 32K bytes on-board RAM in 16 IC's—the equivalent of 256 2102's!

A Little Cassette Board That Works!

Unlike many other cassette boards on the marketplace, ours works every time. It plugs directly into the upright connector on the main board and stands only 2" tall. And since it is very fast (1500 bits per second), you can read or write 4K bytes in about 20 seconds. All timing is done in software, which results in crystal-controlled accuracy and uniformity from unit to unit.

Unlike some other cassette interfaces which require an expensive tape recorder, the Apple Cassette Interface works reliably with almost any audio-grade cassette recorder.

Software:

A tape of **APPLE BASIC** is included free with the Cassette Interface. Apple Basic features immediate error messages and fast execution, and lets you program in a higher level language immediately and without added cost. Also available **now** are a dis-assembler and many games, with many software packages, (including a macro assembler) in the works. And since our philosophy is to provide software for our machines free or at minimal cost, you won't be continually paying for access to this growing software library.

The Apple Computer is in stock at almost all major computer stores. (If your local computer store doesn't carry our products, encourage them or write us direct). **Dealer inquiries invited.**

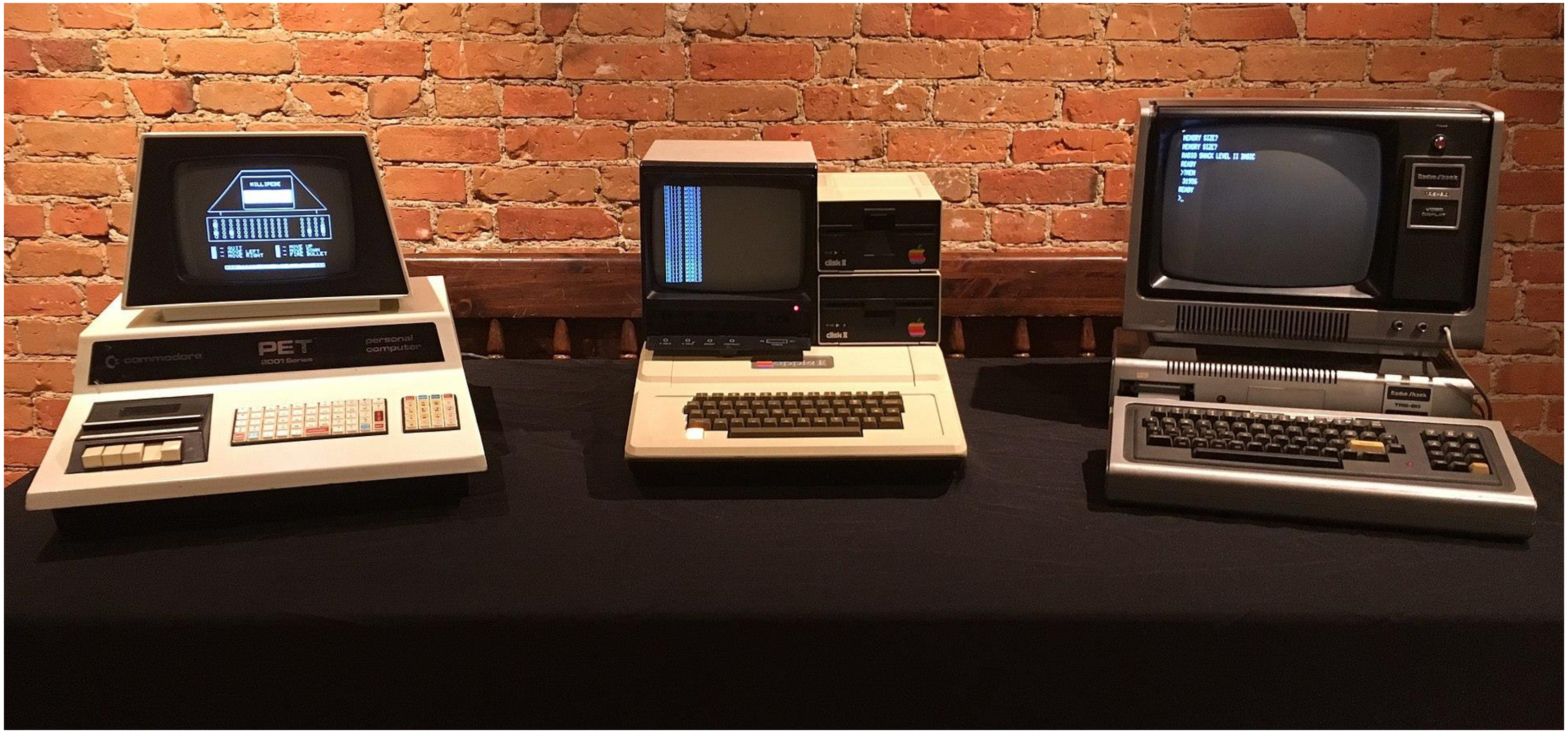
Byte into an Apple $666.66*

* includes 4K bytes RAM

APPLE Computer Company • 770 Welch Rd., Palo Alto, CA 94304 • (415) 326-4248

OCTOBER 1976 — CIRCLE NO. 7 ON INQUIRY CARD — INTERFACE AGE 11

Apple I
by Steve Jobs &
Steve Wozniak



The three personal computers referred to by Byte Magazine as the "1977 Trinity" of home computing: The Commodore PET, the Apple II, and the TRS-80 Model I.

Software

The IBM Operating System

- IBM PC의 등장 (1981)

IBM into personal computer business
contact Bill Gates, Microsoft (1980)

↓

Tim Paterson QDOS

↓

Microsoft bought at $50,000 outright

↓

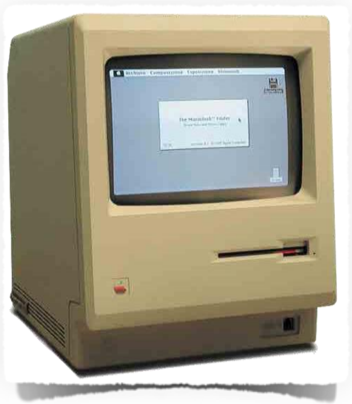
MS-DOS

then licensed it to IBM at $186,000
non-exclusive
and kept control of source code

IBM PC

GUI

- Graphical User Interface
  - envisioned by Vannevar Bush at MIT,
    J.C.R. Licklider at MIT,
    Doug Engelbert at SRI,
    Alan Kay at Xerox PARC



Apple

Lisa (1983)

Macintosh (1984)

Microsoft

Windows (1985)

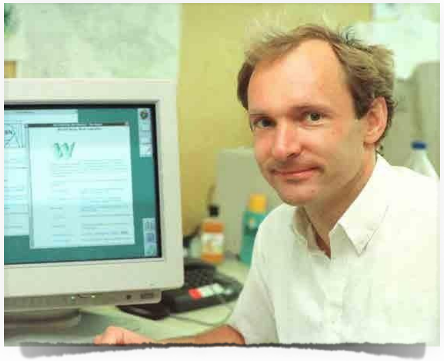
Software free? or not free?

- Free Open-Source Software Movement
  - “소프트웨어는 공동으로 제작해서 자유롭게 공유할 수 있어야 한다”
  - Free Software Foundation : GNU 프로젝트
  - GPL(General Public License) : “Copyleft”

the commercial ethics	the hacker ethics
proprietary	free sharing

The Web

World Wide Web



Tim Berners-Lee

- 1991년 팀 버너스 리가 개발
  - hypertext + the Internet
  - URL(Uniform Resource Locators)
  - HTTP(Hypertext Transfer Protocol)
  - HTML(Hypertext Markup Language)
  - 1993년 W3C 재단 창설 : 웹 관련 표준과 기술버전을 제정해서 발표
  - 최초의 웹브라우저 = Mosaic (1993)

Jerry Yang
1973-

Yahoo!
1994

David Filo
1973-

Sergey Brin
1973-

Larry Page
1973-

BackRub
PageRank

The Anatomy of a Large-Scale Hyper-textual Web Search Engine (1998)

Google
한국

Augmented Intelligence

Collaborative Creativity