/computing

Code and Space
ARC 593 | DMS 606

Fall 2016
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TA: Leonardo Aranda

software

Terminal
Terminal 3

code/space

Rob Kitchen and Martin Dodge

- software and the spatiality of everyday life become mutually constituted, or produced through one another

- spatiality is the product of code, and code exists in order to produce a particular spatiality

Coded Objects

objects that are reliant on software to perform as designed

Coded Infrastructures

- networks that link coded objects together
- infrastructures that are monitored and regulated by software

Coded Processes

- transactions and flows of digital capta across coded infrastructure
- flows are structured capta and processed information

Coded Assemblages

- occur where several different coded infrastructures converge, working together and become integral to one another over time in producing particular environments
- automated warehouses, hospitals, transport systems, and supermarkets

Software Studies

- Galloway, *Protocol* (2004)
- Fuller, *Behind the Blip* (2003),
- *Media Ecologies* (2005), and *Software Studies: A Lexicon* (2008)
- Lessig, *Code and Other Laws of Cyberspace* (1999)
- Manovich, *The Language of New Media* (2000) and *Software Takes Command* (2008)
- Hayles, *My Mother Was a Computer* (2005)
- Mackenzie, *Cutting Code* (2006)

software studies\ a lexicon
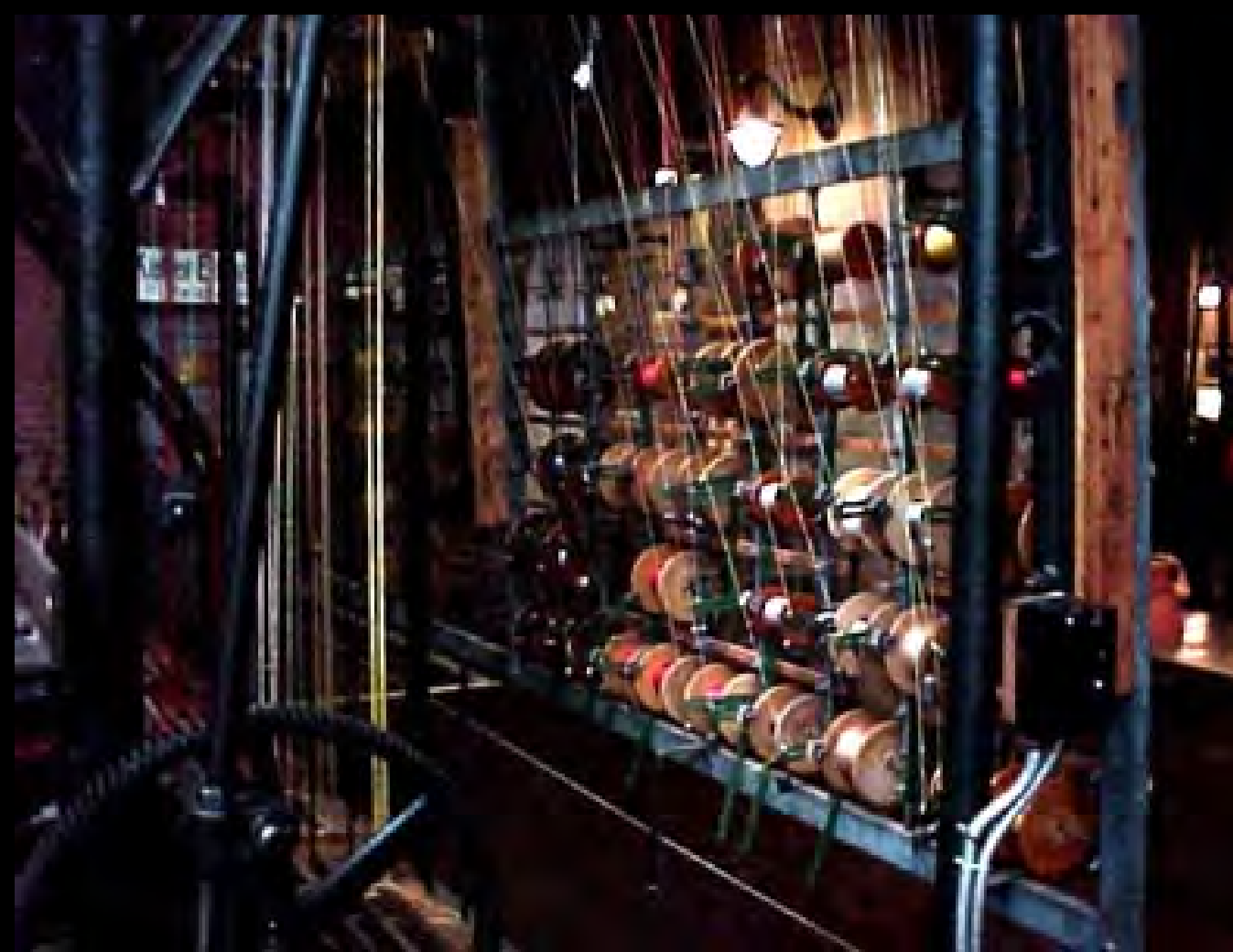
edited by **matthew fuller**
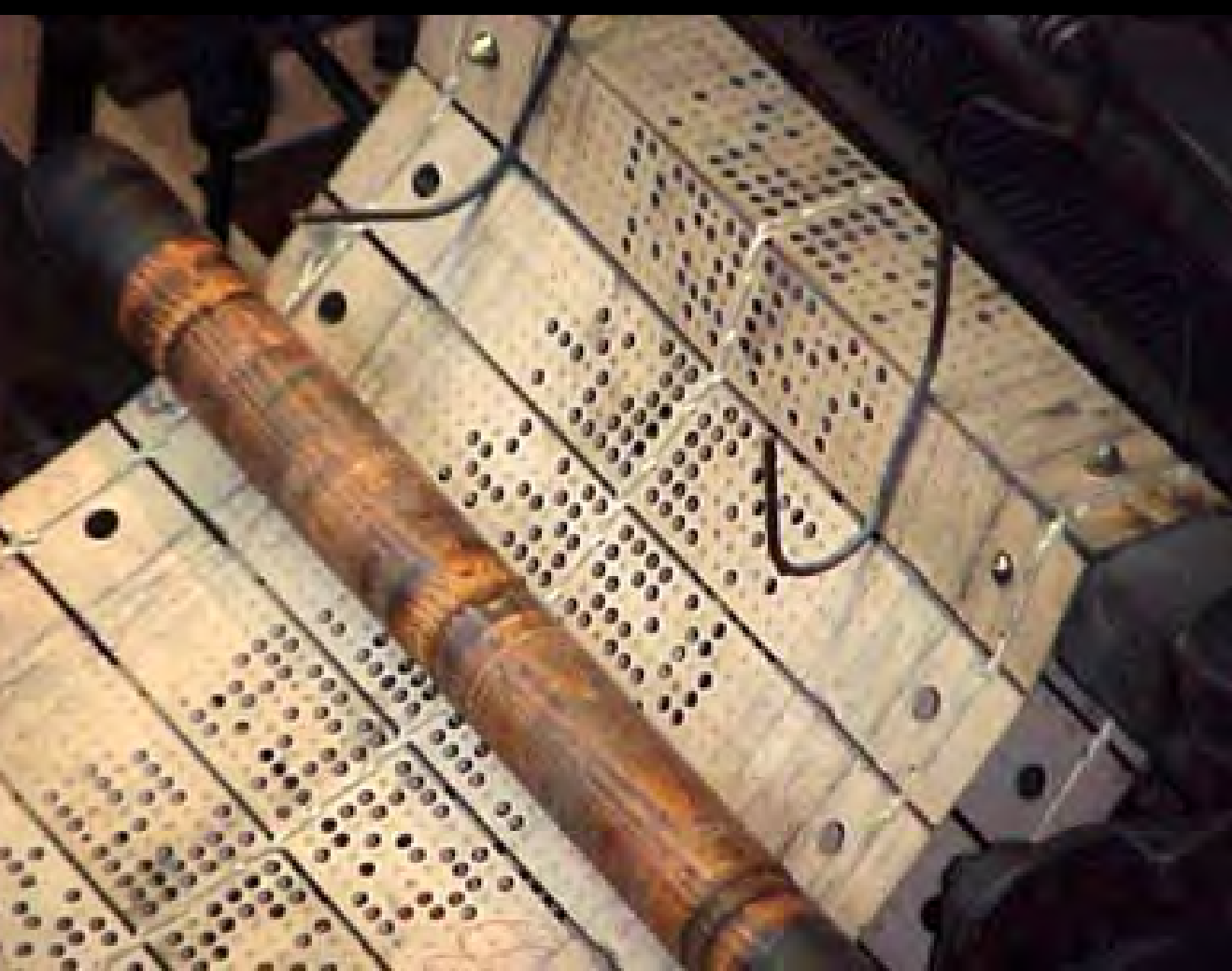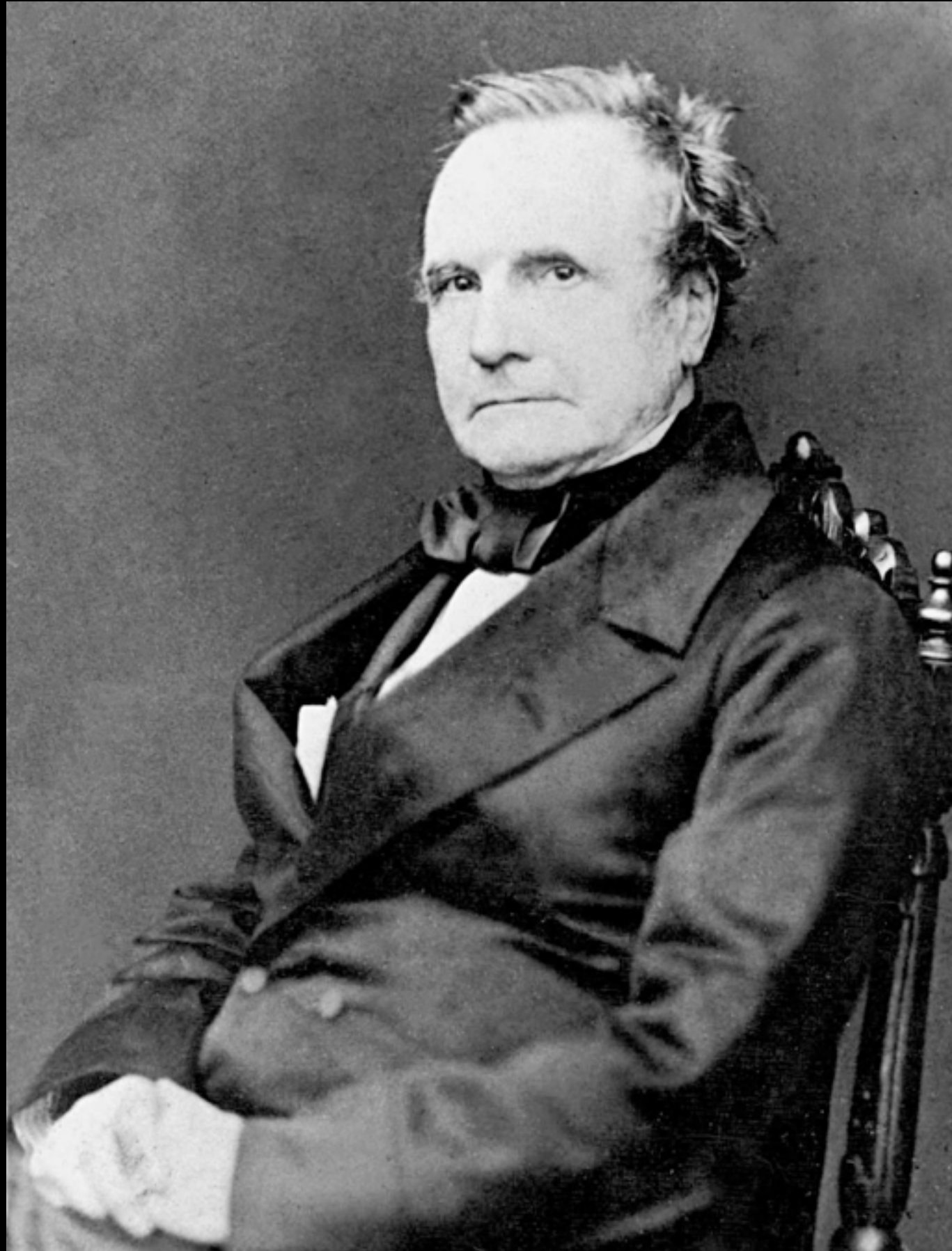
S O F T W A R E S T U D I E S
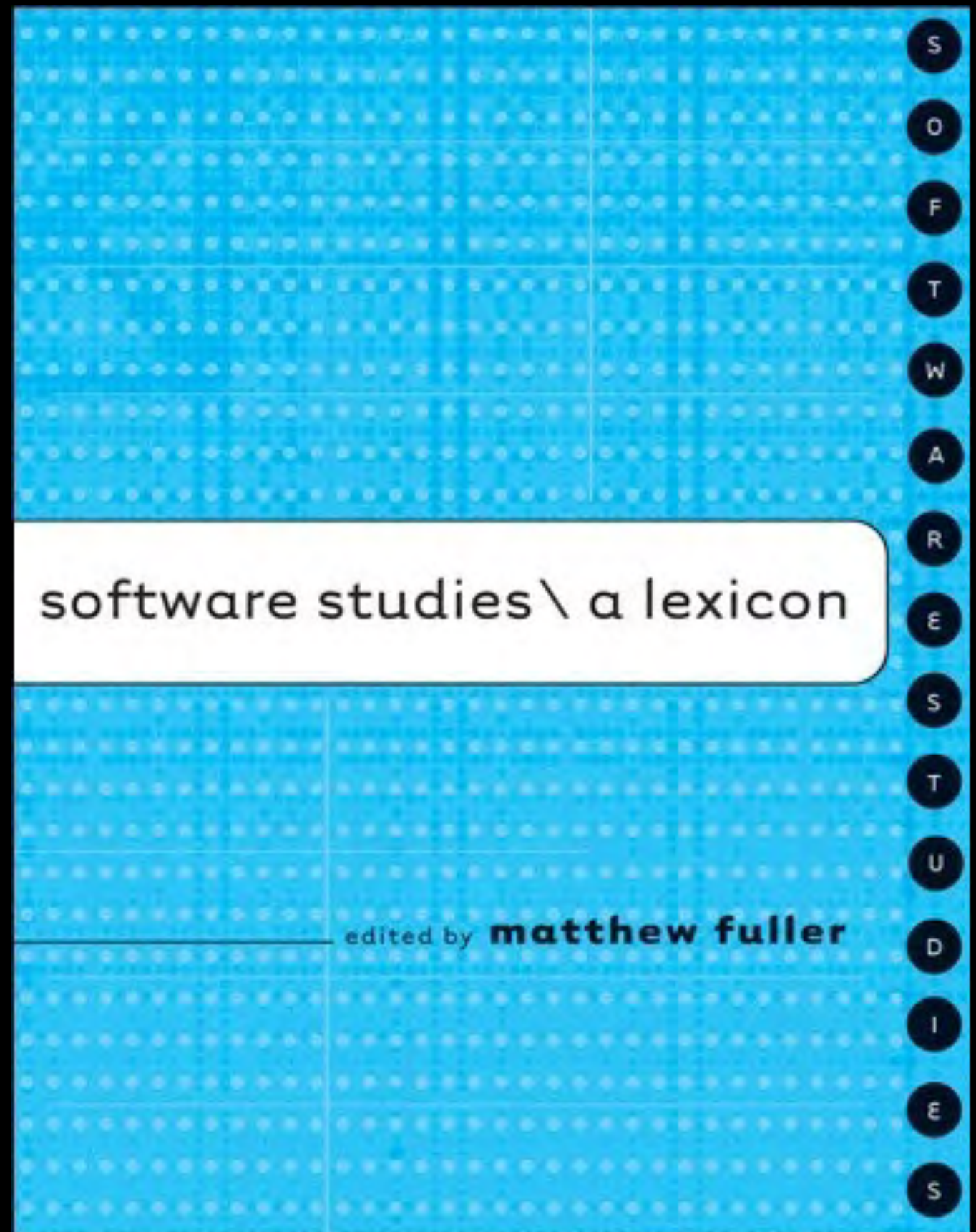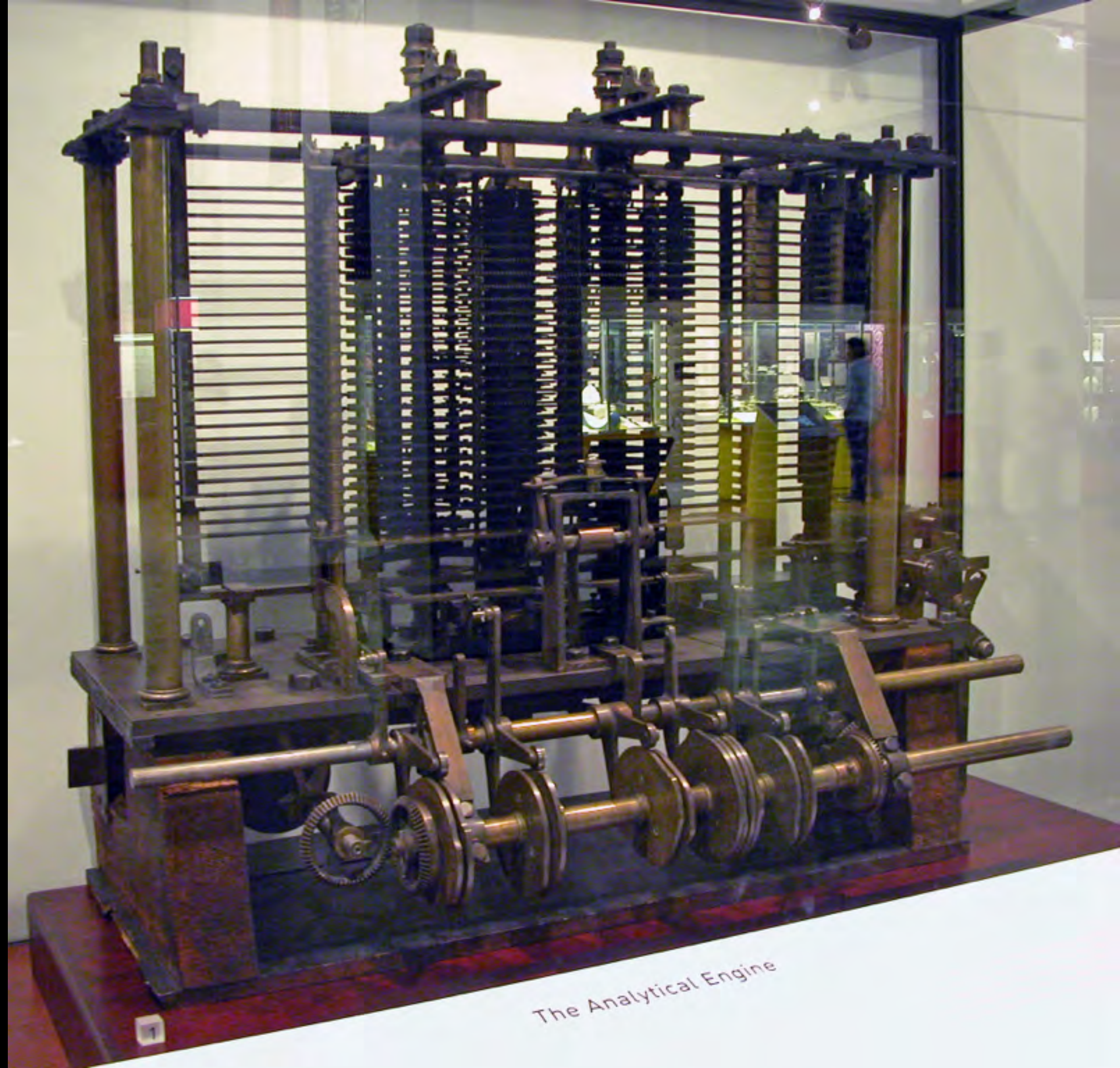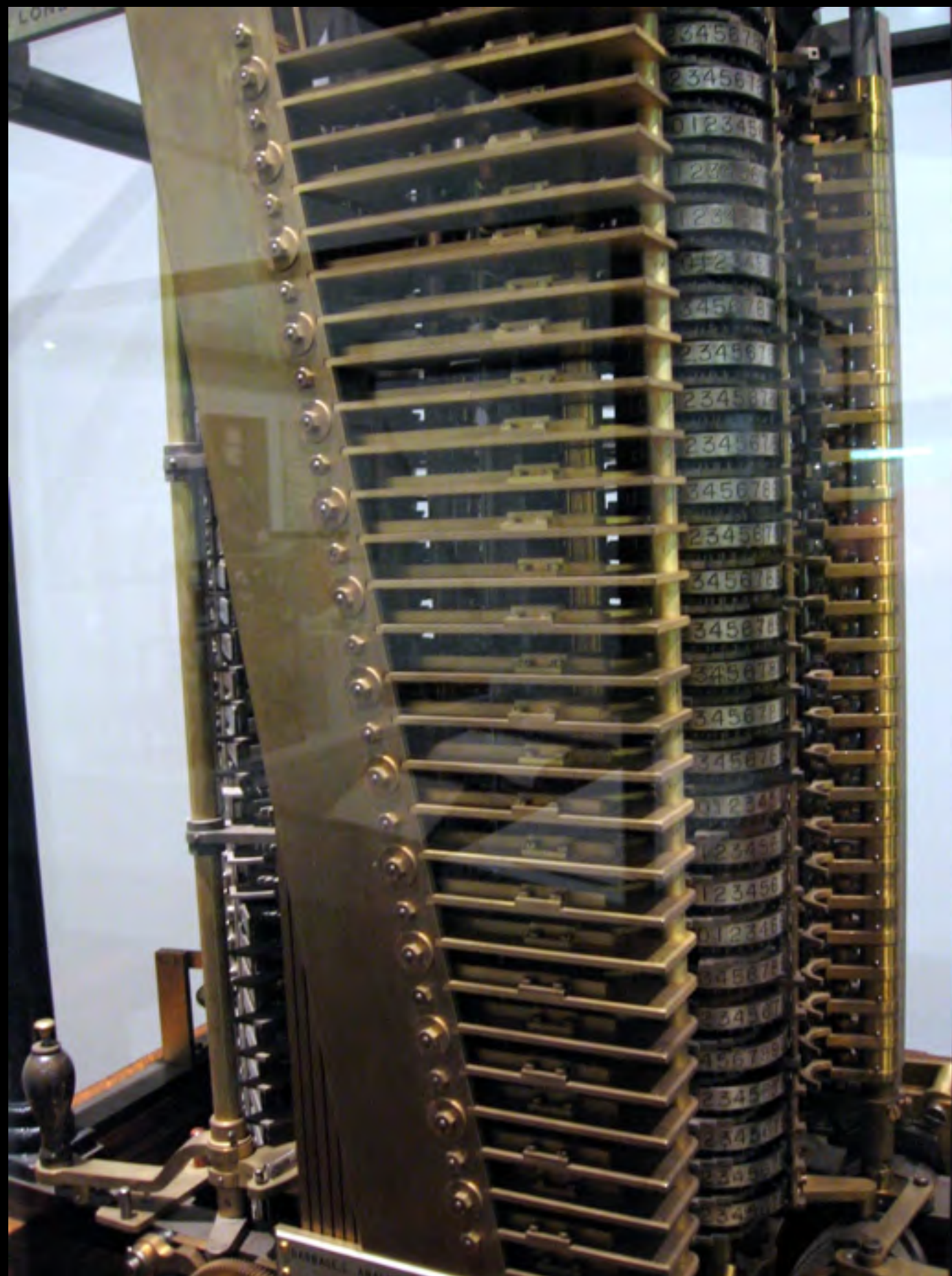
hardware
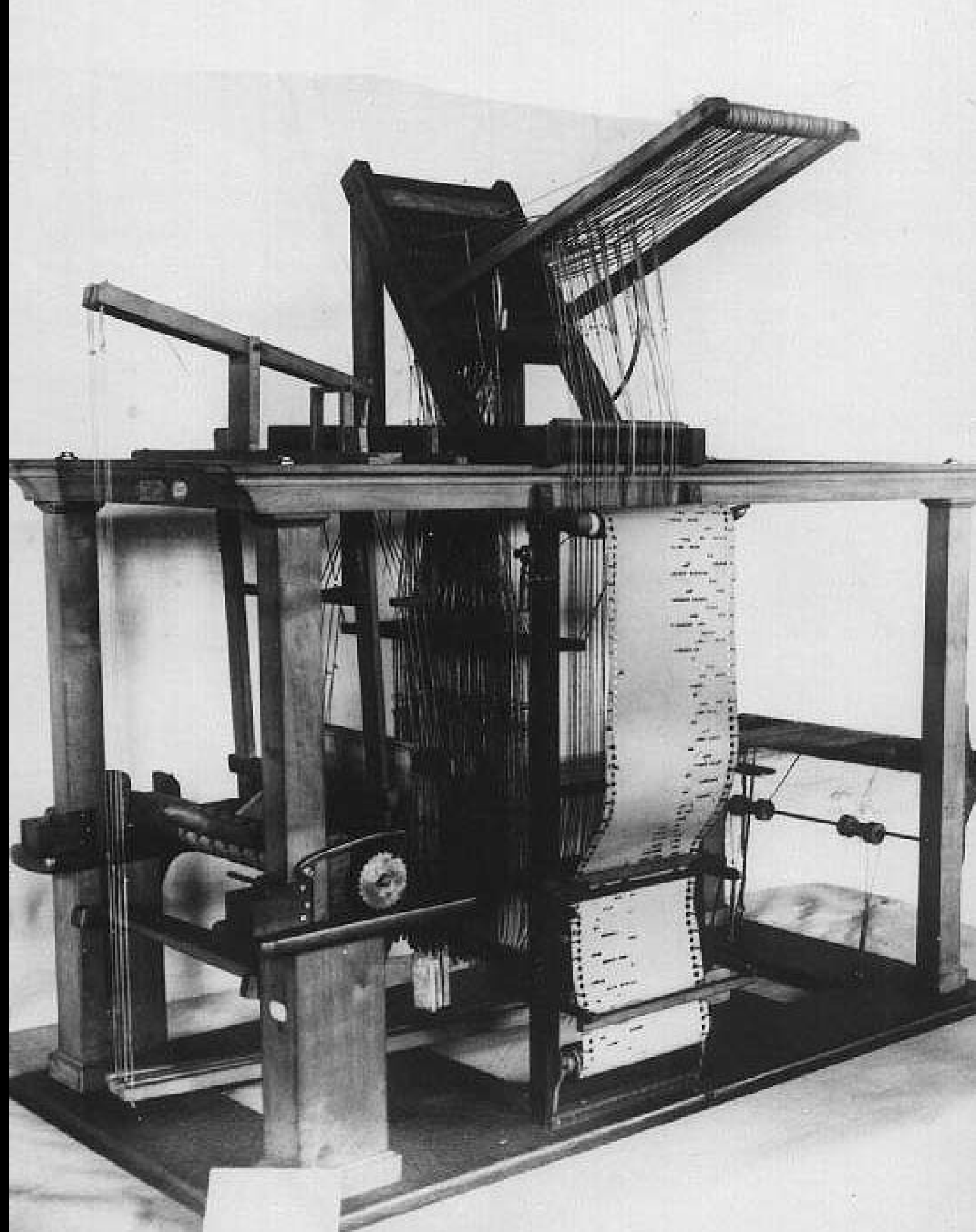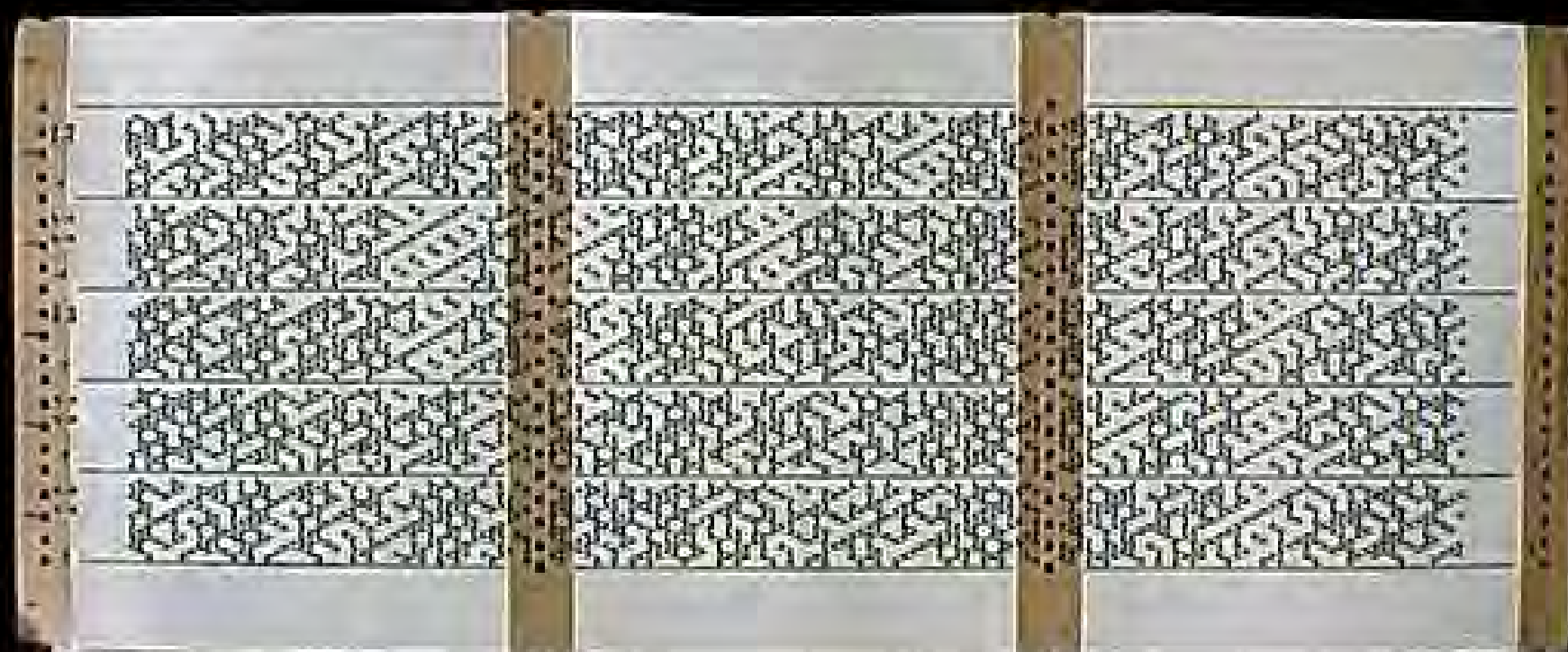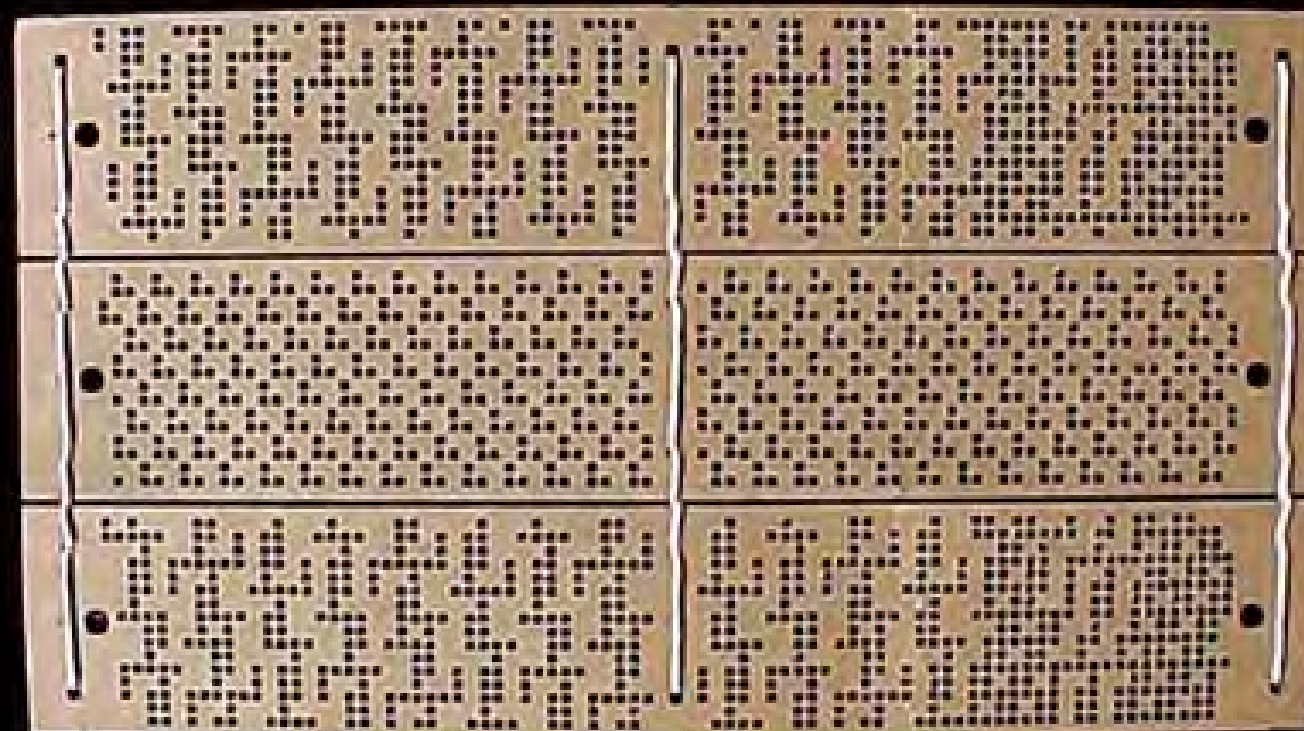
Charles Babbage
1791 - 1871

The Analytical Engine

Ada Lovelace
1815-1852

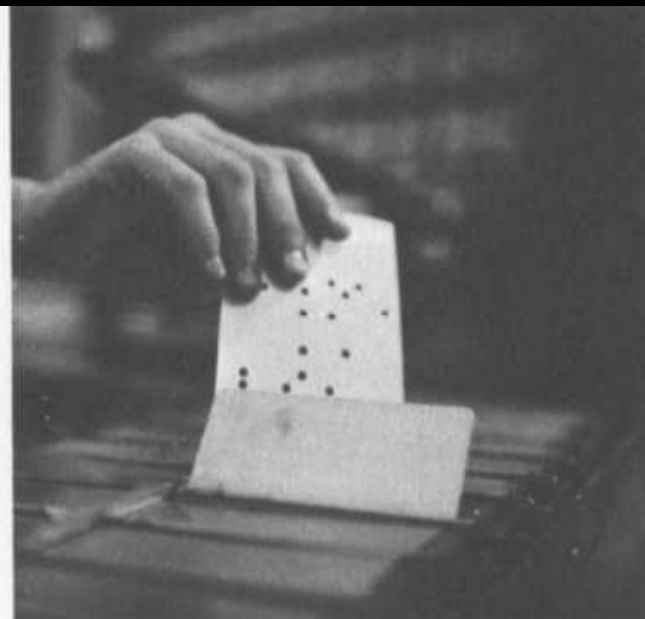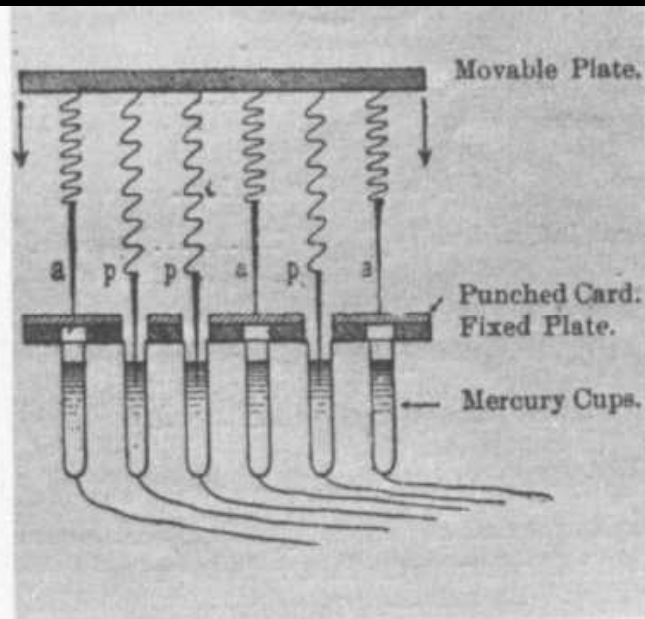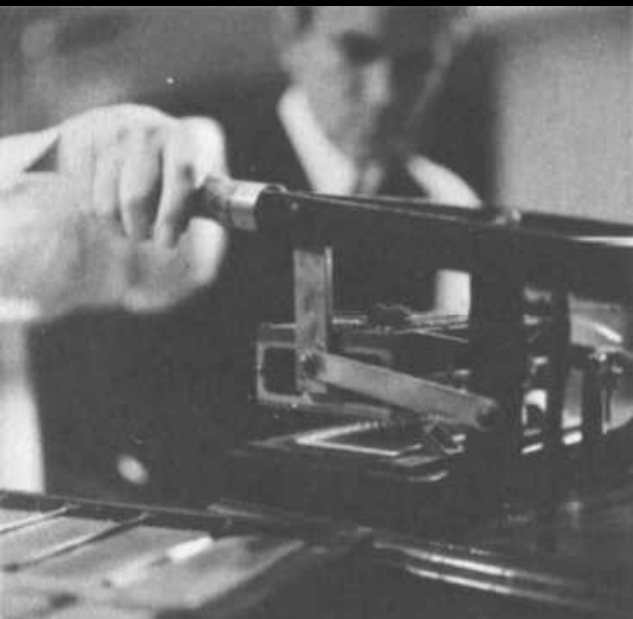## Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 *et seq.*)

Number of Operations.	Nature of Operation.	Variables acted upon.	Variables receiving results.	Indication of change in the value on any Variable.	Statement of Results.	Data. $^1V_1$	$^1V_2$	$^1V_3$	Working Variables. $^0V_4$	$^0V_5$	$^0V_6$	$^0V_7$	$^0V_8$	$^0V_9$	$^0V_{10}$	$^0V_{11}$	$^0V_{12}$	$^0V_{13}$	Result Variables. $^1V_{21}$	$^1V_{22}$	$^1V_{23}$	$^0V_{24}$
						1	2	n											B_1	B_3	B_5	B_7
1	×	$^1V_2 \times ^1V_3$	$^1V_4, ^1V_5, ^1V_6$	$\begin{Bmatrix} ^1V_2 = ^1V_2 \\ ^1V_3 = ^1V_3 \end{Bmatrix}$	$= 2n$	...	2	n	$2n$	$2n$	$2n$											
2	−	$^1V_4 - ^1V_1$	$^2V_4$	$\begin{Bmatrix} ^1V_4 = ^2V_4 \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= 2n - 1$	1	...	...	$2n-1$													
3	+	$^1V_5 + ^1V_1$	$^2V_5$	$\begin{Bmatrix} ^1V_5 = ^2V_5 \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= 2n + 1$	1	...	...	...	$2n+1$												
4	÷	$^2V_5 \div ^2V_4$	$^1V_{11}$	$\begin{Bmatrix} ^2V_5 = ^0V_5 \\ ^2V_4 = ^0V_4 \end{Bmatrix}$	$= \dfrac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\dfrac{2n-1}{2n+1}$						
5	÷	$^1V_{11} \div ^1V_2$	$^2V_{11}$	$\begin{Bmatrix} ^1V_{11} = ^2V_{11} \\ ^1V_2 = ^1V_2 \end{Bmatrix}$	$= \dfrac{1}{2} \cdot \dfrac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\dfrac{1}{2} \cdot \dfrac{2n-1}{2n+1}$						
6	−	$^0V_{13} - ^2V_{11}$	$^1V_{13}$	$\begin{Bmatrix} ^2V_{11} = ^0V_{11} \\ ^0V_{13} = ^1V_{13} \end{Bmatrix}$	$= -\dfrac{1}{2} \cdot \dfrac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	...	$-\dfrac{1}{2} \cdot \dfrac{2n-1}{2n+1} = A_0$				
7	−	$^1V_3 - ^1V_1$	$^1V_{10}$	$\begin{Bmatrix} ^1V_3 = ^1V_3 \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= n - 1 (= 3)$	1	...	n	...	...	...	...	...	...	$n-1$							
8	+	$^1V_2 + ^0V_7$	$^1V_7$	$\begin{Bmatrix} ^1V_2 = ^1V_2 \\ ^0V_7 = ^1V_7 \end{Bmatrix}$	$= 2 + 0 = 2$	...	2	...	...	...	...	2										
9	+	$^1V_6 + ^1V_7$	$^3V_{11}$	$\begin{Bmatrix} ^1V_6 = ^1V_6 \\ ^0V_{11} = ^3V_{11} \end{Bmatrix}$	$= \dfrac{2n}{2} = A_1$	...	...	...	...	...	$2n$	2	...	...	...	$\dfrac{2n}{2} = A_1$						
10	×	$^1V_{21} \times ^3V_{11}$	$^1V_{12}$	$\begin{Bmatrix} ^1V_{21} = ^1V_{21} \\ ^3V_{11} = ^3V_{11} \end{Bmatrix}$	$= B_1 \cdot \dfrac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\dfrac{2n}{2} = A_1$	$B_1 \cdot \dfrac{2n}{2} = B_1 A_1$	...	B_1			
11	+	$^1V_{12} + ^1V_{13}$	$^2V_{13}$	$\begin{Bmatrix} ^1V_{12} = ^0V_{12} \\ ^1V_{13} = ^2V_{13} \end{Bmatrix}$	$= -\dfrac{1}{2} \dfrac{2n-1}{2n+1} + B_1 \cdot \dfrac{2n}{2}$	...	...	...	...	...	...	...	...	...	...	...	0	$\left\{ -\dfrac{1}{2} \dfrac{2n-1}{2n+1} + B_1 \cdot \dfrac{2n}{2} \right\}$				
12	−	$^1V_{10} - ^1V_1$	$^2V_{10}$	$\begin{Bmatrix} ^1V_{10} = ^2V_{10} \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= n - 2 (= 2)$	1	...	...	...	...	...	...	...	...	$n-2$							
13	−	$^1V_6 - ^1V_1$	$^2V_6$	$\begin{Bmatrix} ^1V_6 = ^2V_6 \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= 2n - 1$	1	...	...	...	...	$2n-1$											
14	+	$^1V_1 + ^1V_7$	$^2V_7$	$\begin{Bmatrix} ^1V_1 = ^1V_1 \\ ^1V_7 = ^2V_7 \end{Bmatrix}$	$= 2 + 1 = 3$	1	...	...	...	...	...	3										
15	÷	$^2V_6 \div ^2V_7$	$^1V_8$	$\begin{Bmatrix} ^2V_6 = ^2V_6 \\ ^2V_7 = ^2V_7 \end{Bmatrix}$	$= \dfrac{2n-1}{3}$	...	...	...	...	...	$2n-1$	3	$\dfrac{2n-1}{3}$								
16	×	$^1V_8 \times ^3V_{11}$	$^4V_{11}$	$\begin{Bmatrix} ^1V_8 = ^0V_8 \\ ^3V_{11} = ^4V_{11} \end{Bmatrix}$	$= \dfrac{2n}{2} \cdot \dfrac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\dfrac{2n}{2} \cdot \dfrac{2n-1}{3}$						
17	−	$^2V_6 - ^1V_1$	$^3V_6$	$\begin{Bmatrix} ^2V_6 = ^3V_6 \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= 2n - 2$	1	...	...	...	...	$2n-2$											
18	+	$^1V_1 + ^2V_7$	$^3V_7$	$\begin{Bmatrix} ^2V_7 = ^3V_7 \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= 3 + 1 = 4$	1	...	...	...	...	...	4										
19	÷	$^3V_6 \div ^3V_7$	$^1V_9$	$\begin{Bmatrix} ^3V_6 = ^3V_6 \\ ^3V_7 = ^3V_7 \end{Bmatrix}$	$= \dfrac{2n-2}{4}$	...	...	...	...	...	$2n-2$	4	...	$\dfrac{2n-2}{4}$	...	$\left\{ \dfrac{2n}{2} \cdot \dfrac{2n-1}{3} \cdot \dfrac{2n-2}{3} \right\}$						
20	×	$^1V_9 \times ^4V_{11}$	$^5V_{11}$	$\begin{Bmatrix} ^1V_9 = ^0V_9 \\ ^4V_{11} = ^5V_{11} \end{Bmatrix}$	$= \dfrac{2n}{2} \cdot \dfrac{2n-1}{3} \cdot \dfrac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0	...	$\dfrac{2n}{2} \cdot \dfrac{2n-1}{3} \cdot \dfrac{2n-2}{4} = A_3$						
21	×	$^1V_{22} \times ^5V_{11}$	$^0V_{12}$	$\begin{Bmatrix} ^1V_{22} = ^1V_{22} \\ ^0V_{12} = ^2V_{12} \end{Bmatrix}$	$= B_3 \cdot \dfrac{2n}{2} \cdot \dfrac{2n-1}{3} \cdot \dfrac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	...	...	B_3	
22	+	$^2V_{12} + ^2V_{13}$	$^3V_{13}$	$\begin{Bmatrix} ^2V_{12} = ^0V_{12} \\ ^2V_{13} = ^3V_{13} \end{Bmatrix}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	...	0	$\left\{ A_0 + B_1 A_1 + B_3 A_3 \right\}$				
23	−	$^2V_{10} - ^1V_1$	$^2V_{10}$	$\begin{Bmatrix} ^2V_{10} = ^3V_{10} \\ ^1V_1 = ^1V_1 \end{Bmatrix}$	$= n - 3 (= 1)$	1	...	...	...	...	...	...	...	...	$n-3$							

Here follows a repetition of Operations thirteen to twenty-three.

| 24 | + | $^4V_{13} + ^0V_{24}$ | $^1V_{24}$ | $\begin{Bmatrix} ^4V_{13} = ^0V_{13} \\ ^0V_{24} = ^1V_{24} \end{Bmatrix}$ | $= B_7$ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | B_7 |
| 25 | + | $^1V_1 + ^1V_3$ | $^1V_3$ | $\begin{Bmatrix} ^1V_1 = ^1V_1 \\ ^1V_3 = ^1V_3 \\ ^5V_6 = ^0V_6 \\ ^4V_7 = ^0V_7 \end{Bmatrix}$ | $= n + 1 = 4 + 1 = 5$
 by a Variable-card.
 by a Variable card. | 1 | ... | $n+1$ | ... | ... | 0 | 0 | | | | | | | | | | |

1	2	3	4	CM	UM	Jp	Ch	Oc	In	20	50	80	Dv	Un	3	4	3	4	A	E	L	a	g
5	6	7	8	CL	UL	O	Mu	Qd	Mo	25	55	85	Wd	CY	1	2	1	2	B	F	M	b	h
1	2	3	4	CS	US	Mb	B	M	0	30	60	0	2	Mr	0	15	0	15	C	G	N	c	1
5	6	7	8	No	Hd	Wf	W	F	5	35	65	1	3	Sg	5	10	5	10	D	H	O	d	k
1	2	3	4	Fh	Ff	Fm	7	1	10	40	70	90	4	0	1	3	0	2	St	I	P	e	l
5	6	7	8	Hh	Hf	Hm	8	2	15	45	75	95	100	Un	2	4	1	3	4	K	Un	f	m
1	2	3	4	X	Un	Ft	9	3	i	c	X	R	L	E	A	6	0	US	Ir	Sc	US	Ir	Sc
5	6	7	8	Ot	En	Mt	10	4	k	d	Y	S	M	F	B	10	1	Gr	En	Wa	Gr	En	Wa
1	2	3	4	W	R	OK	11	5	l	e	Z	T	N	G	C	15	2	Sw	FC	EC	Sw	FC	EC
5	6	7	8	7	4	1	12	6	m	f	NG	U	O	H	D	Un	3	Nw	Bo	Hu	Nw	Bo	Hu
1	2	3	4	8	5	2	Oc	0	n	g	a	V	P	I	Al	Na	4	Dk	Fr	It	Dk	Fr	It
5	6	7	8	9	6	3	O	p	o	h	b	W	Q	X	Un	Pa	5	Ru	Ot	Un	Ru	Ot	Un

Movable Plate.

a p p a p a

Punched Card.
Fixed Plate.

Mercury Cups.

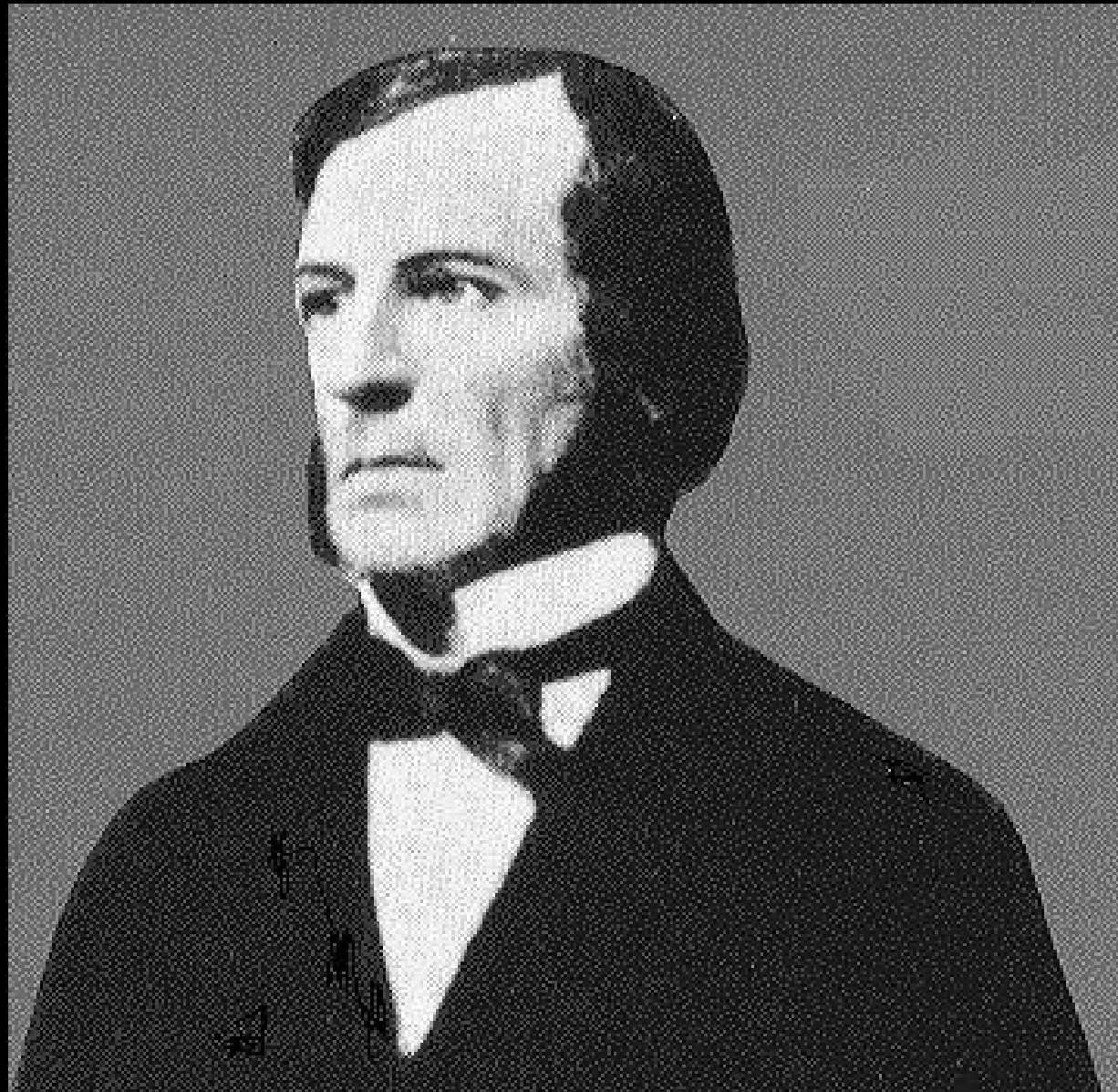# bits, bytes and binary operations
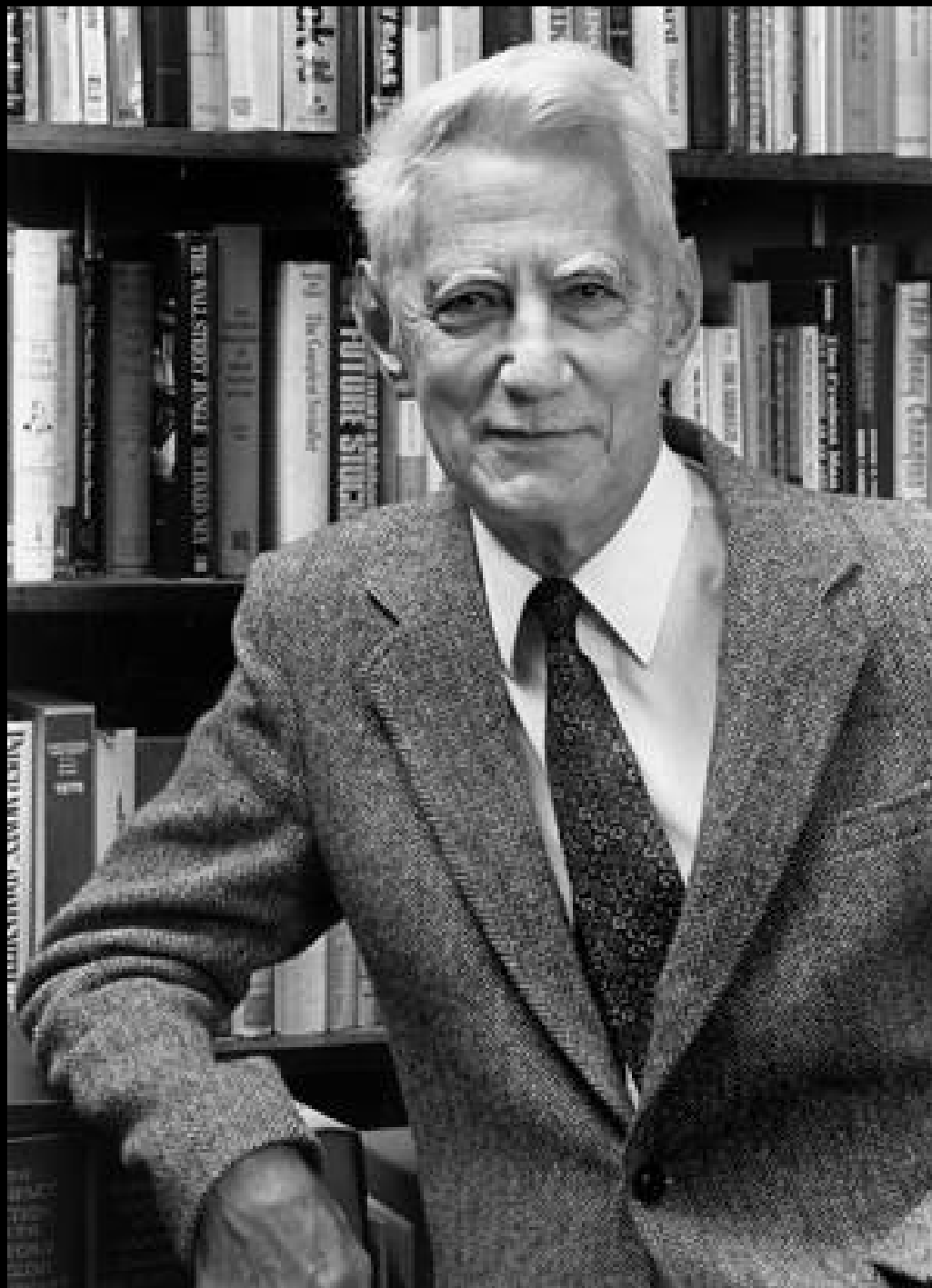
bit = **b**inary dig**it**

Claude E. Shannon
1916 - 2001

George Boole
1815 – 1864

Whereas elementary algebra is based on numeric operations such as

multiplication: xy
addition: x + y
and negation: –x

Boolean algebra is customarily based on logical counterparts to those operations, namely:

conjunction: x∧y (AND)
disjunction: x∨y (OR)
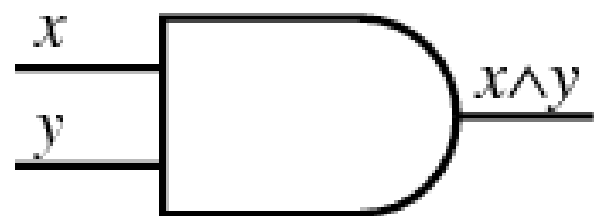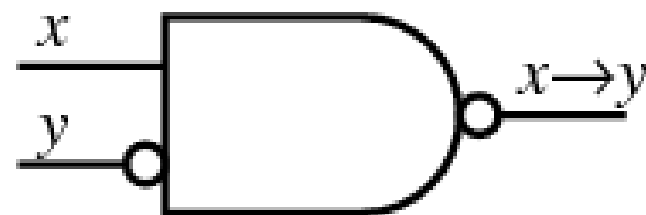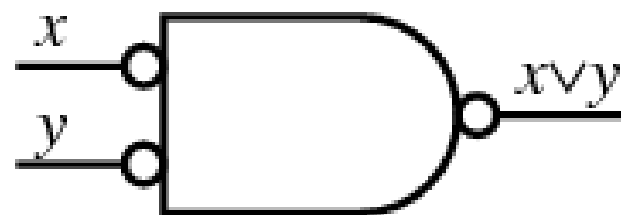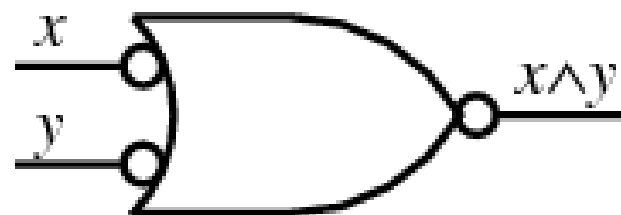**and complement or negation: ¬x (NOT).**

Figure 1. Truth tables

Figure 2. Logic gates

Figure 3. De Morgan equivalents
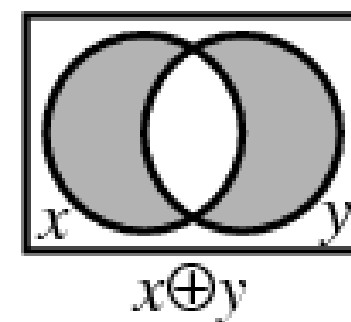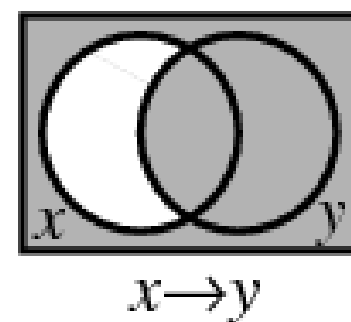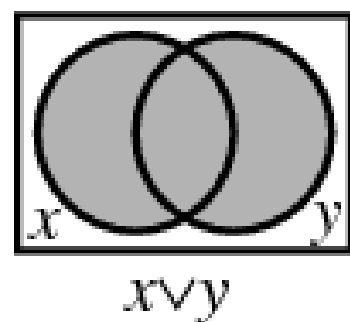
Figure 4. Venn diagrams
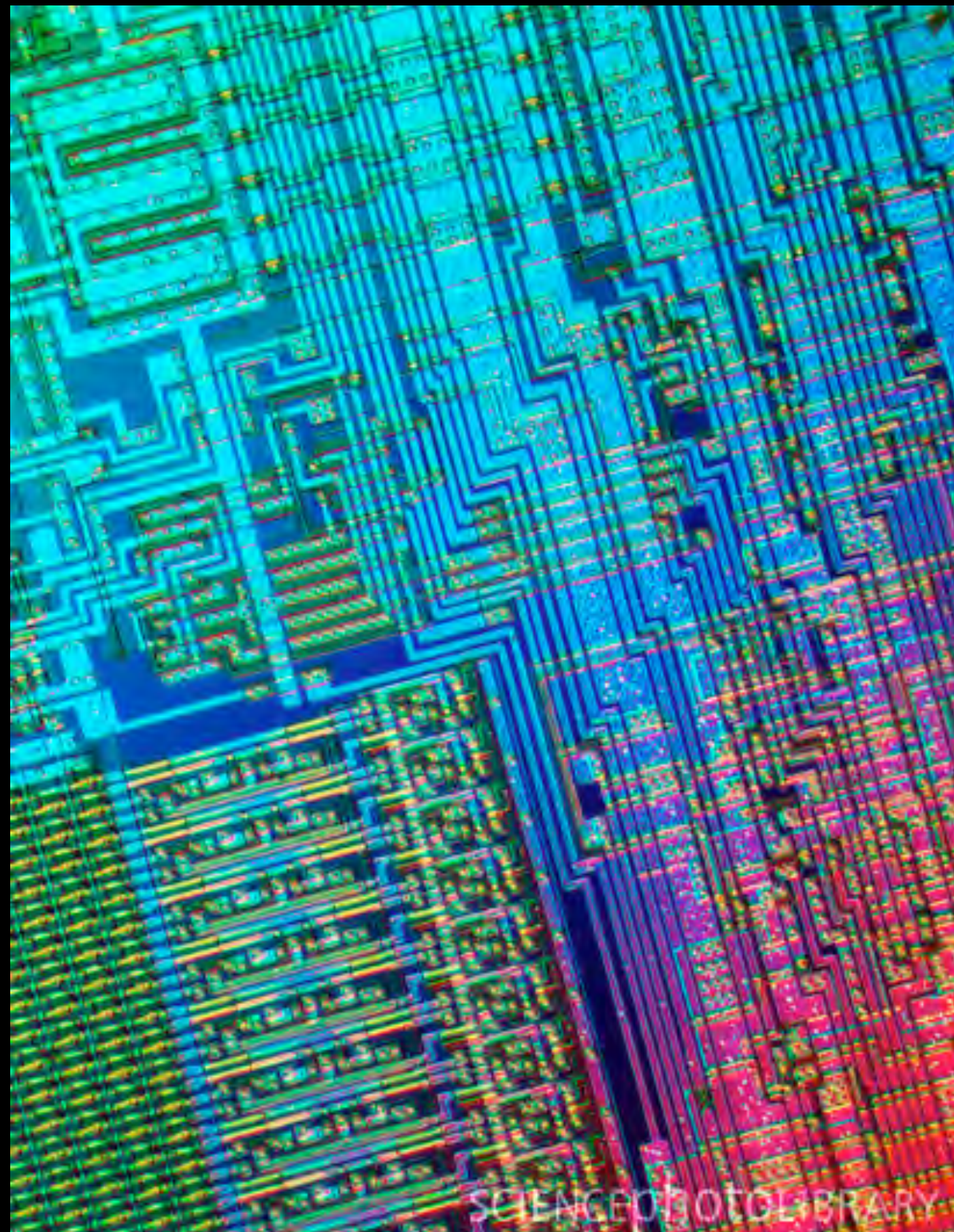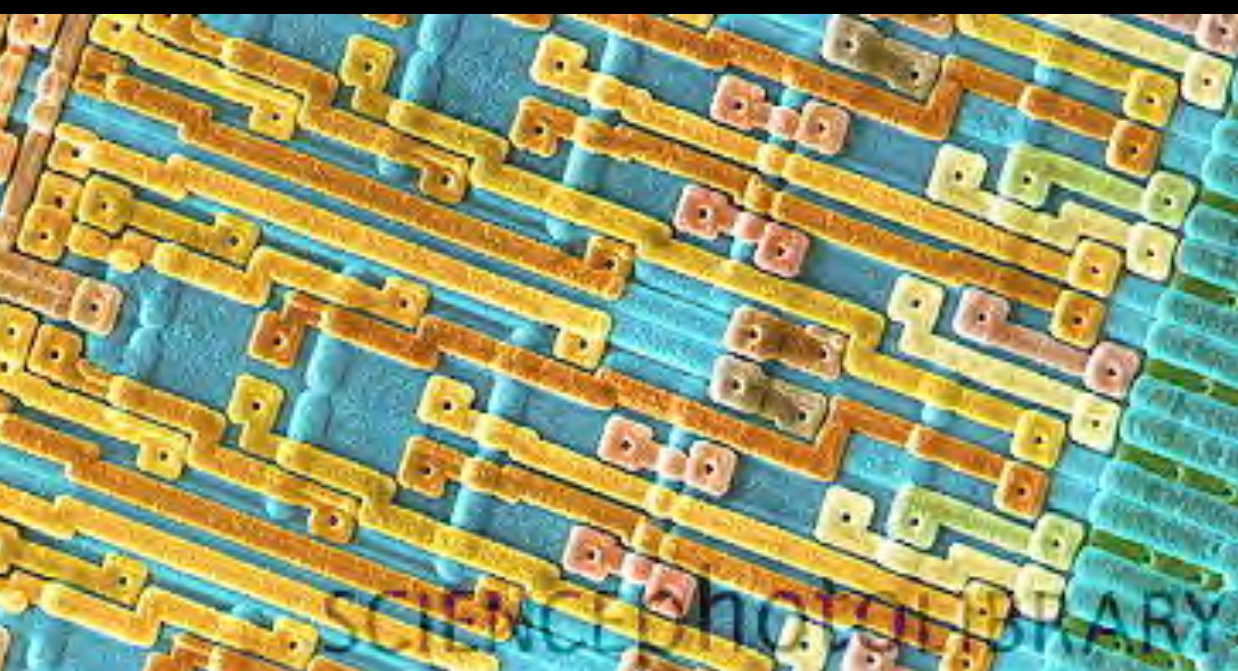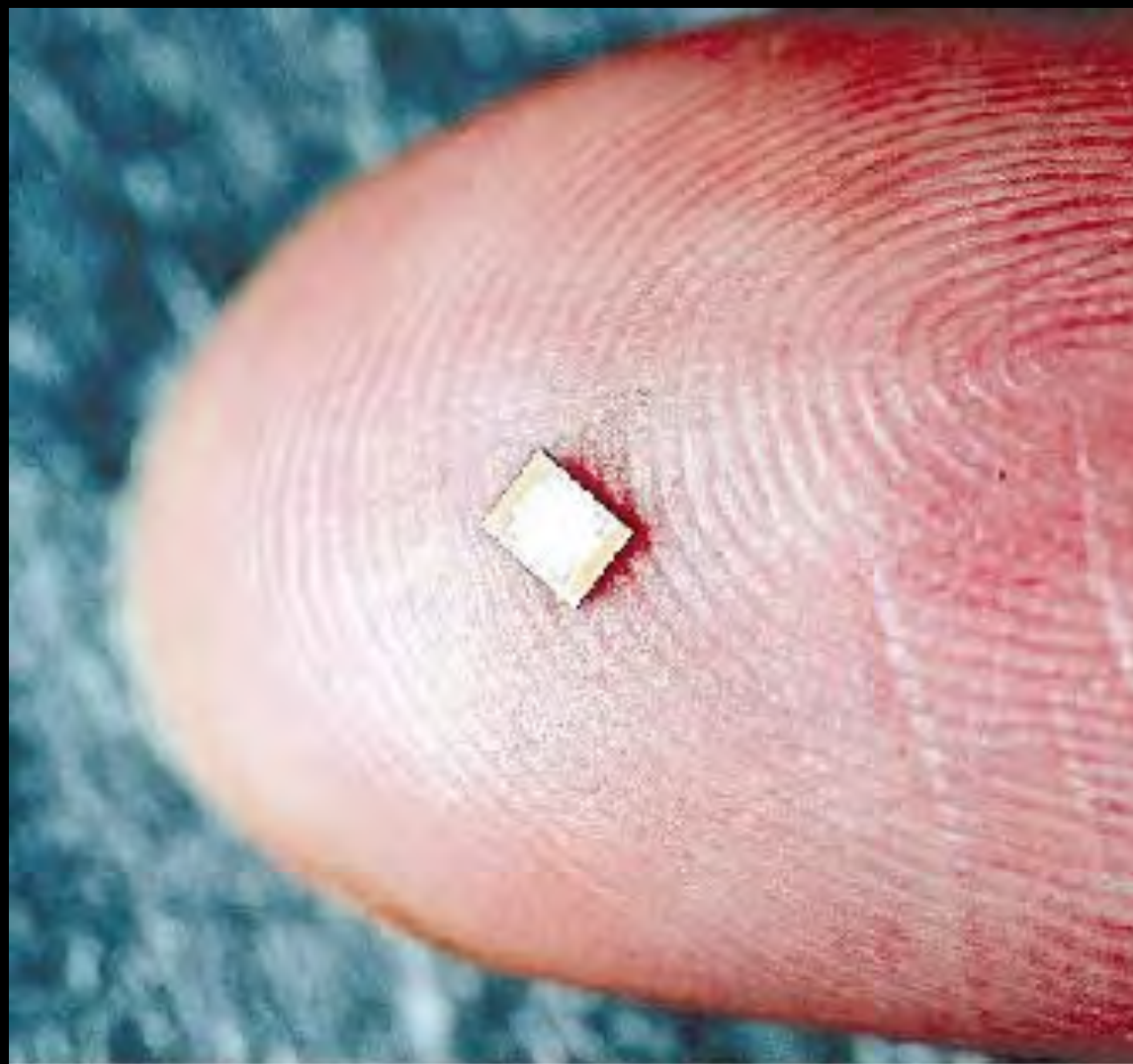
Regular ASCII Chart (character codes 0 - 127)

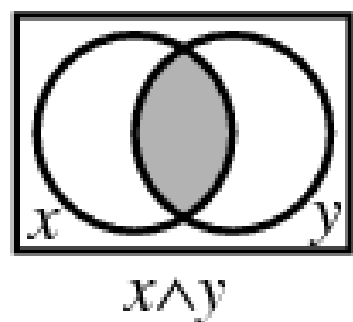| Dec	Hex	Char	Name	Dec	Hex	Char	Name	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
000d	00h		(nul)	016d	10h	▶	(dle)	032d	20h	sp	048d	30h	0	064d	40h	@	080d	50h	P	096d	60h	`	112d	70h	p
001d	01h	☺	(soh)	017d	11h	◀	(dc1)	033d	21h	!	049d	31h	1	065d	41h	A	081d	51h	Q	097d	61h	a	113d	71h	q
002d	02h	●	(stx)	018d	12h	↕	(dc2)	034d	22h	"	050d	32h	2	066d	42h	B	082d	52h	R	098d	62h	b	114d	72h	r
003d	03h	♥	(etx)	019d	13h	‼	(dc3)	035d	23h	#	051d	33h	3	067d	43h	C	083d	53h	S	099d	63h	c	115d	73h	s
004d	04h	♦	(eot)	020d	14h	¶	(dc4)	036d	24h	$	052d	34h	4	068d	44h	D	084d	54h	T	100d	64h	d	116d	74h	t
005d	05h	♣	(enq)	021d	15h	§	(nak)	037d	25h	%	053d	35h	5	069d	45h	E	085d	55h	U	101d	65h	e	117d	75h	u
006d	06h	♠	(ack)	022d	16h	▬	(syn)	038d	26h	&	054d	36h	6	070d	46h	F	086d	56h	V	102d	66h	f	118d	76h	v
007d	07h	●	(bel)	023d	17h	↨	(etb)	039d	27h	'	055d	37h	7	071d	47h	G	087d	57h	W	103d	67h	g	119d	77h	w
008d	08h	◘	(bs)	024d	18h	↑	(can)	040d	28h	(	056d	38h	8	072d	48h	H	088d	58h	X	104d	68h	h	120d	78h	x
009d	09h		(tab)	025d	19h	↓	(em)	041d	29h	)	057d	39h	9	073d	49h	I	089d	59h	Y	105d	69h	i	121d	79h	y
010d	0Ah		(lf)	026d	1Ah		(eof)	042d	2Ah	*	058d	3Ah	:	074d	4Ah	J	090d	5Ah	Z	106d	6Ah	j	122d	7Ah	z
011d	0Bh	♂	(vt)	027d	1Bh	←	(esc)	043d	2Bh	+	059d	3Bh	;	075d	4Bh	K	091d	5Bh	[	107d	6Bh	k	123d	7Bh	{
012d	0Ch	♀	(np)	028d	1Ch	∟	(fs)	044d	2Ch	,	060d	3Ch	<	076d	4Ch	L	092d	5Ch	\	108d	6Ch	l	124d	7Ch	|
013d	0Dh		(cr)	029d	1Dh	↔	(gs)	045d	2Dh	-	061d	3Dh	=	077d	4Dh	M	093d	5Dh	]	109d	6Dh	m	125d	7Dh	}
014d	0Eh	♫	(so)	030d	1Eh	▲	(rs)	046d	2Eh	.	062d	3Eh	>	078d	4Eh	N	094d	5Eh	^	110d	6Eh	n	126d	7Eh	~
015d	0Fh	☼	(si)	031d	1Fh	▼	(us)	047d	2Fh	/	063d	3Fh	?	079d	4Fh	O	095d	5Fh	_	111d	6Fh	o	127d	7Fh	⌂

Extended ASCII Chart (character codes 128 – 255; Codepage 850)

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
128d	80h	Ç	144d	90h	É	160d	A0h	á	176d	B0h	░	192d	C0h	└	208d	D0h	Ð	224d	E0h	Ó	240d	F0h	-
129d	81h	ü	145d	91h	æ	161d	A1h	í	177d	B1h	▒	193d	C1h	┴	209d	D1h	Ð	225d	E1h	ß	241d	F1h	±
130d	82h	é	146d	92h	Æ	162d	A2h	ó	178d	B2h	▓	194d	C2h	┬	210d	D2h	Ê	226d	E2h	Ô	242d	F2h	=
131d	83h	â	147d	93h	ô	163d	A3h	ú	179d	B3h	│	195d	C3h	├	211d	D3h	Ë	227d	E3h	Ò	243d	F3h	¾
132d	84h	ä	148d	94h	ö	164d	A4h	ñ	180d	B4h	┤	196d	C4h	─	212d	D4h	È	228d	E4h	õ	244d	F4h	¶
133d	85h	à	149d	95h	ò	165d	A5h	Ñ	181d	B5h	Á	197d	C5h	┼	213d	D5h	ı	229d	E5h	Õ	245d	F5h	§
134d	86h	å	150d	96h	û	166d	A6h	ª	182d	B6h	Â	198d	C6h	ã	214d	D6h	Ì	230d	E6h	µ	246d	F6h	÷
135d	87h	ç	151d	97h	ù	167d	A7h	º	183d	B7h	À	199d	C7h	Ã	215d	D7h	Î	231d	E7h	þ	247d	F7h	
136d	88h	ê	152d	98h	ÿ	168d	A8h	¿	184d	B8h	©	200d	C8h	╚	216d	D8h	Ï	232d	E8h	Þ	248d	F8h	°
137d	89h	ë	153d	99h	Ö	169d	A9h	®	185d	B9h	╣	201d	C9h	╔	217d	D9h	┘	233d	E9h	Ú	249d	F9h	¨
138d	8Ah	è	154d	9Ah	Ü	170d	AAh	¬	186d	BAh	║	202d	CAh	╩	218d	DAh	┌	234d	EAh	Û	250d	FAh	·
139d	8Bh	ï	155d	9Bh	ø	171d	ABh	½	187d	BBh	╗	203d	CBh	╦	219d	DBh	█	235d	EBh	Ù	251d	FBh	¹
140d	8Ch	î	156d	9Ch	£	172d	ACh	¼	188d	BCh	╝	204d	CCh	╠	220d	DCh	▄	236d	ECh	ý	252d	FCh	²
141d	8Dh	ì	157d	9Dh	Ø	173d	ADh	¡	189d	BDh	¢	205d	CDh	═	221d	DDh	▌	237d	EDh	Ý	253d	FDh	³
142d	8Eh	Ä	158d	9Eh	×	174d	AEh	«	190d	BEh	¥	206d	CEh	╬	222d	DEh	Ì	238d	EEh	¯	254d	FEh	■
143d	8Fh	Å	159d	9Fh	ƒ	175d	AFh	»	191d	BFh	┐	207d	CFh	¤	223d	DFh	▀	239d	EFh	´	255d	FFh	

Hexadecimal to Binary

0	0000		8	1000
1	0001		9	1001
2	0010		A	1010
3	0011		B	1011
4	0100		C	1100
5	0101		D	1101
6	0110		E	1110
7	0111		F	1111

Groups of ASCII-Code in Binary

Bit 6	Bit 5	Group
0	0	Control Characters
0	1	Digits and Punctuation
1	0	Upper Case and Special
1	1	Lower Case and Special