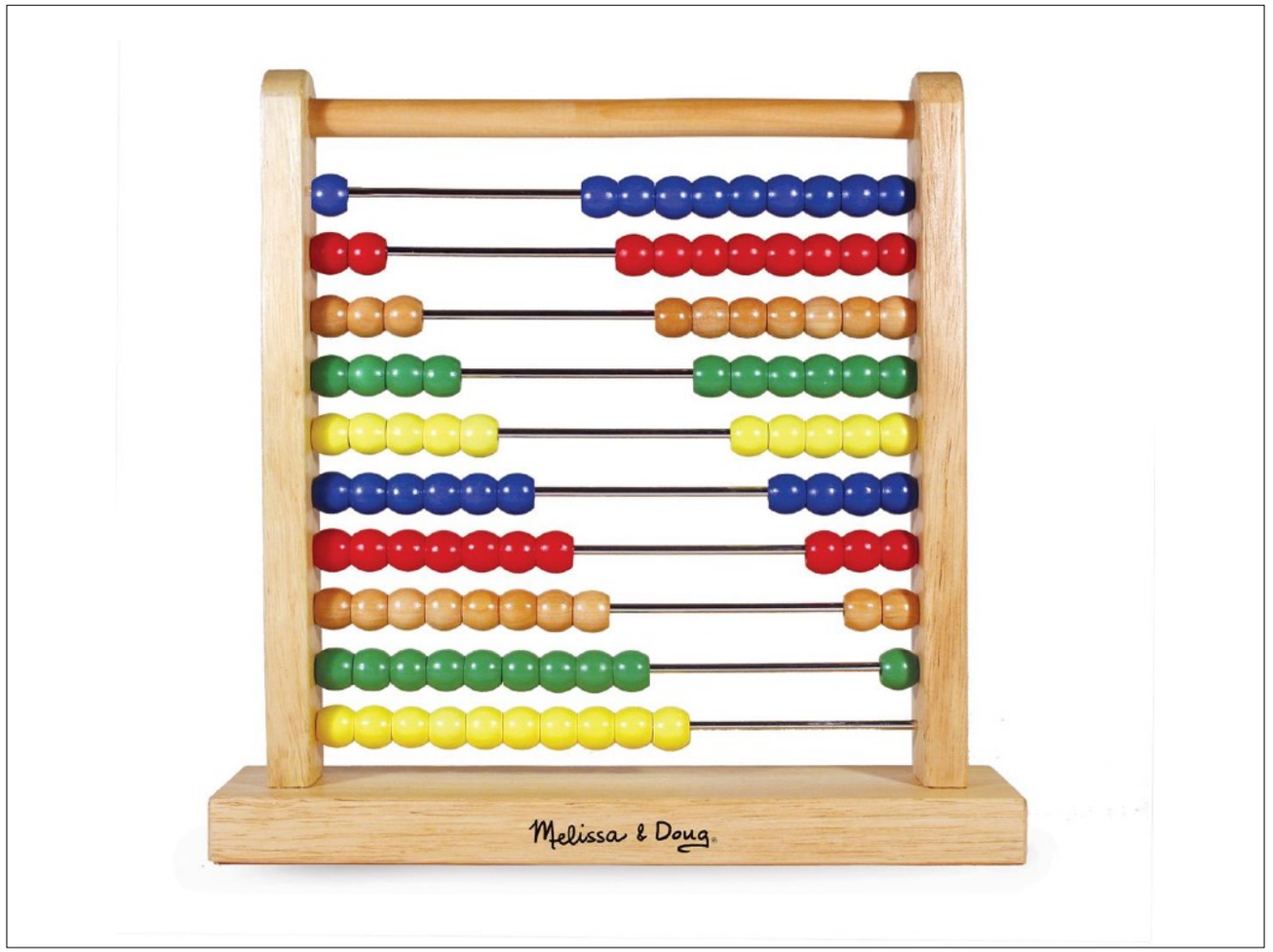
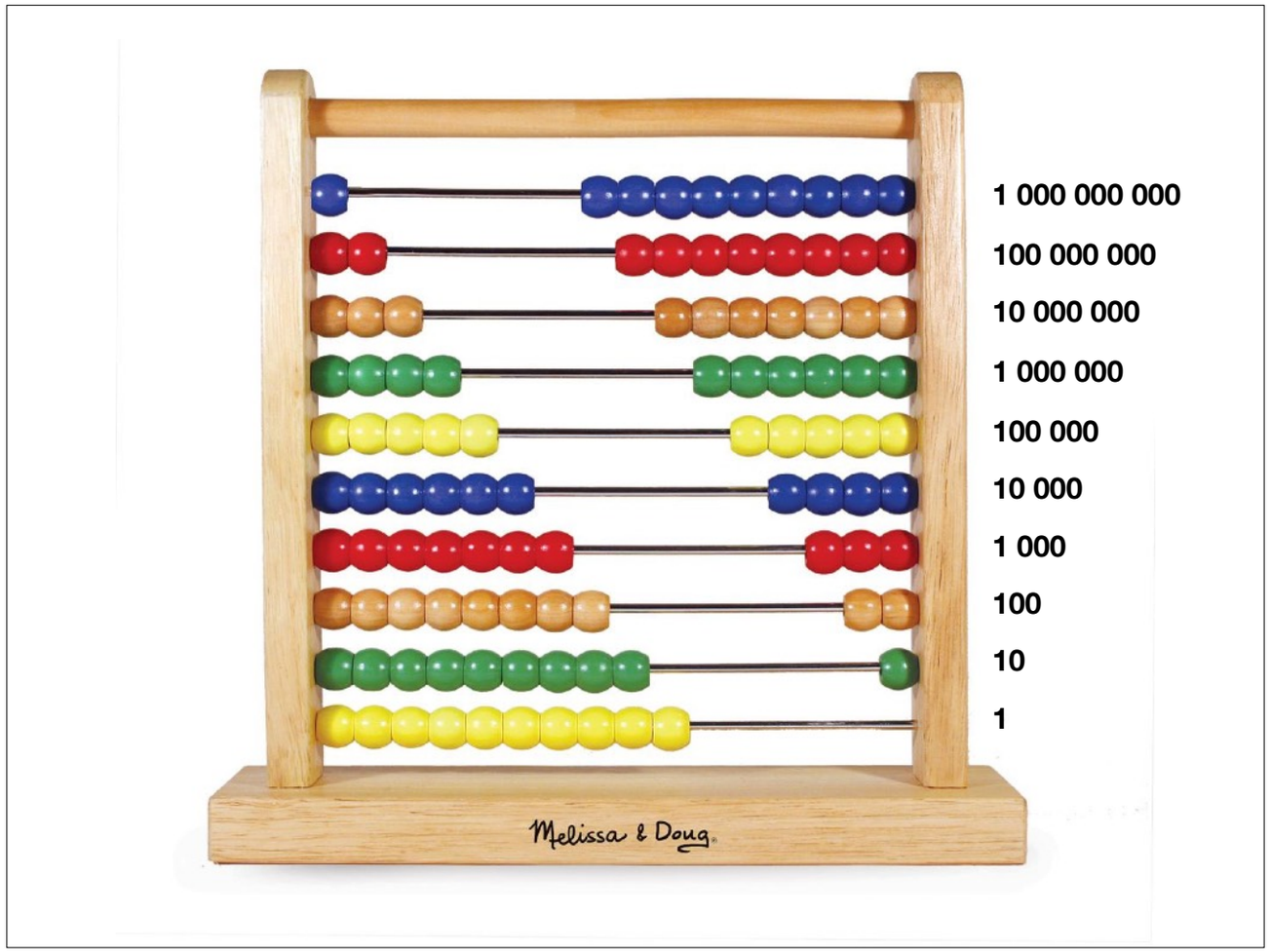
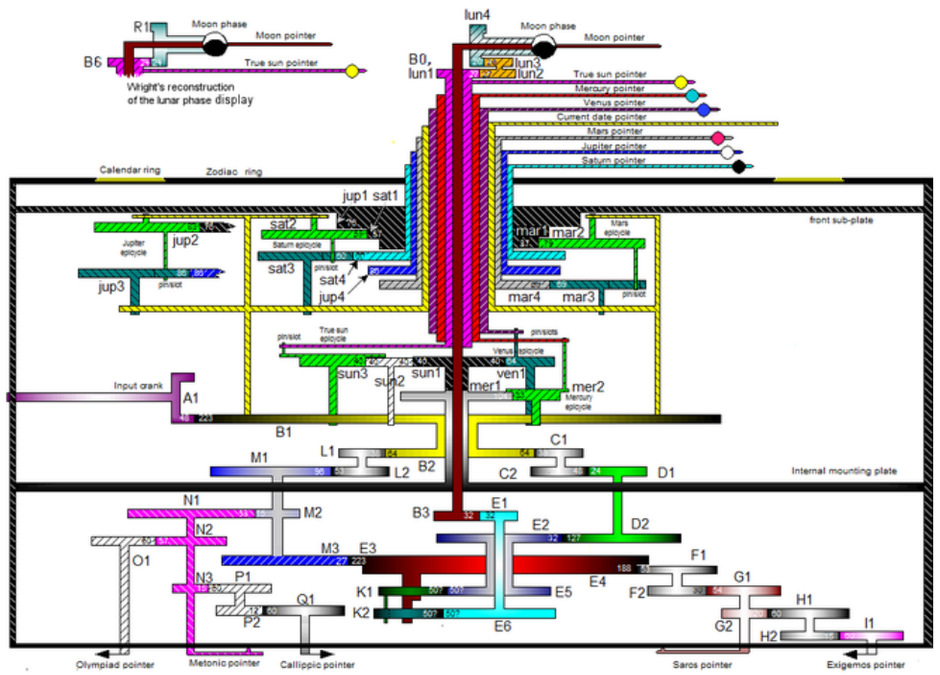
Introduction to Principles of Computing

Simple systems combined into more complex systems through layers of abstraction.


Melissa & Doug

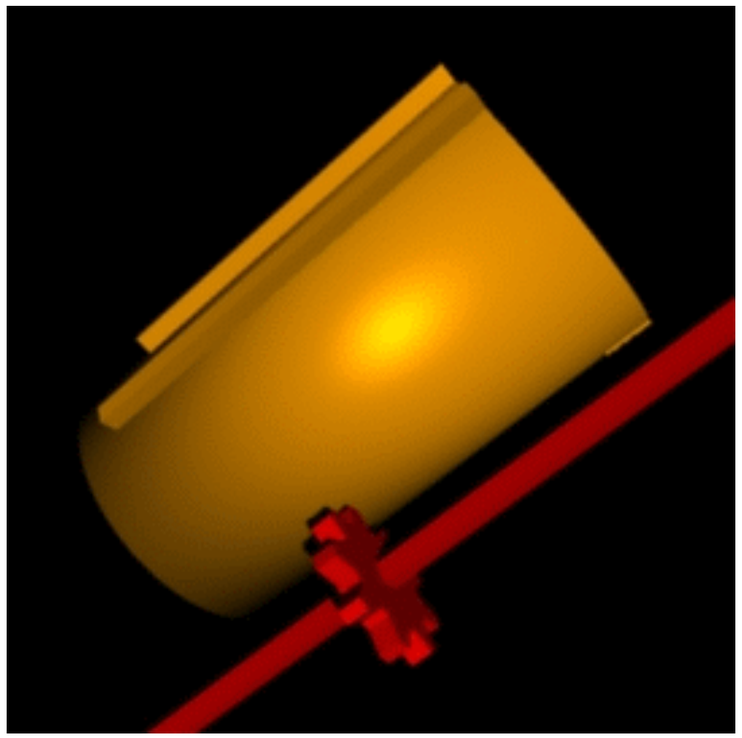


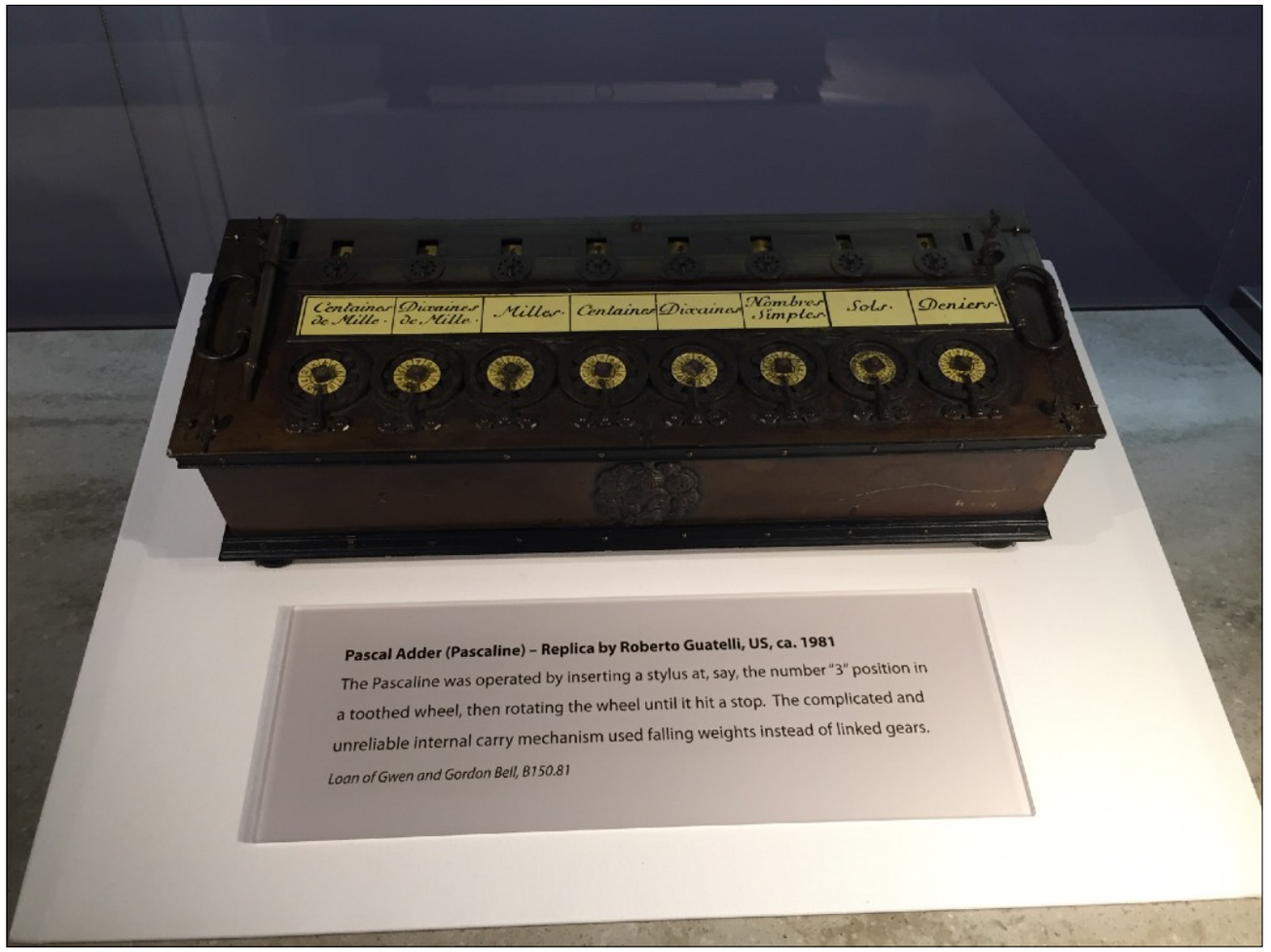
First level of abstraction:
things are represented as pebbles



https://youtu.be/4eUibFQKJqI


Schickard Calculator – Replica, Model by Peter Roubos, Netherlands, ca. 2000
Schickard built two calculators about 1623. One, for his astronomer friend Johannes Kepler, was destroyed by fire. The other is, as far we know, lost. We know about them only from Schickard's handwritten letters, which contain sketches of what he had built.
B1626.01





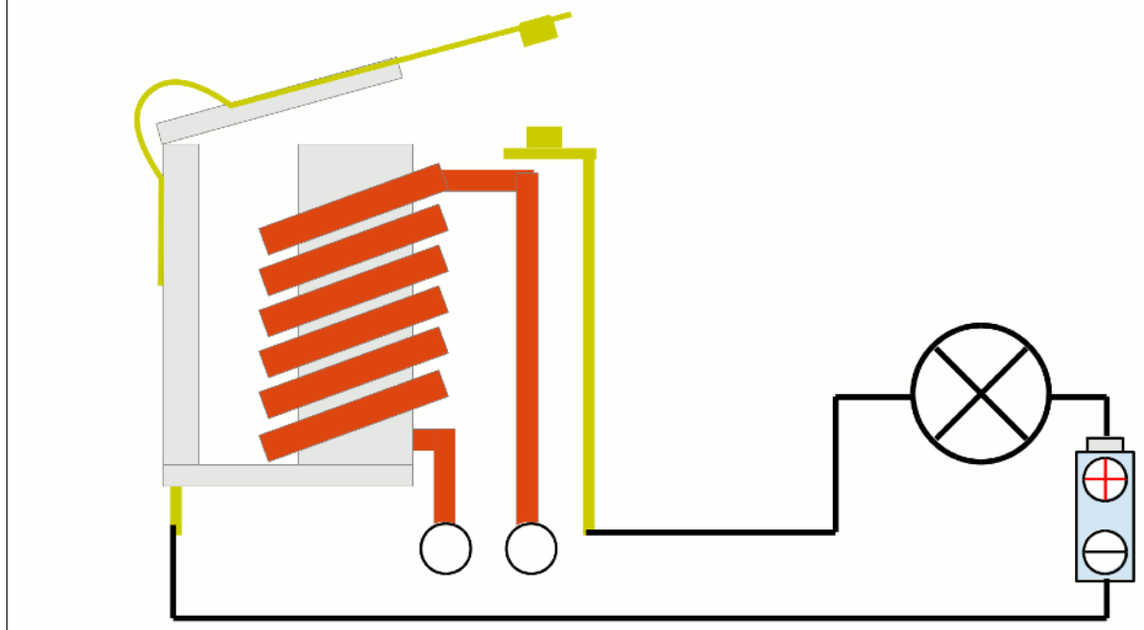
Pascal Adder (Pascaline) – Replica by Roberto Guatelli, US, ca. 1981

The Pascaline was operated by inserting a stylus at, say, the number "3" position in a toothed wheel, then rotating the wheel until it hit a stop. The complicated and unreliable internal carry mechanism used falling weights instead of linked gears.

Loan of Gwen and Gordon Bell, B150.81

- Differential engine
- Analytical engine: could be used for more than one computation, could accept data, could run sequences of commands, had memory and printer

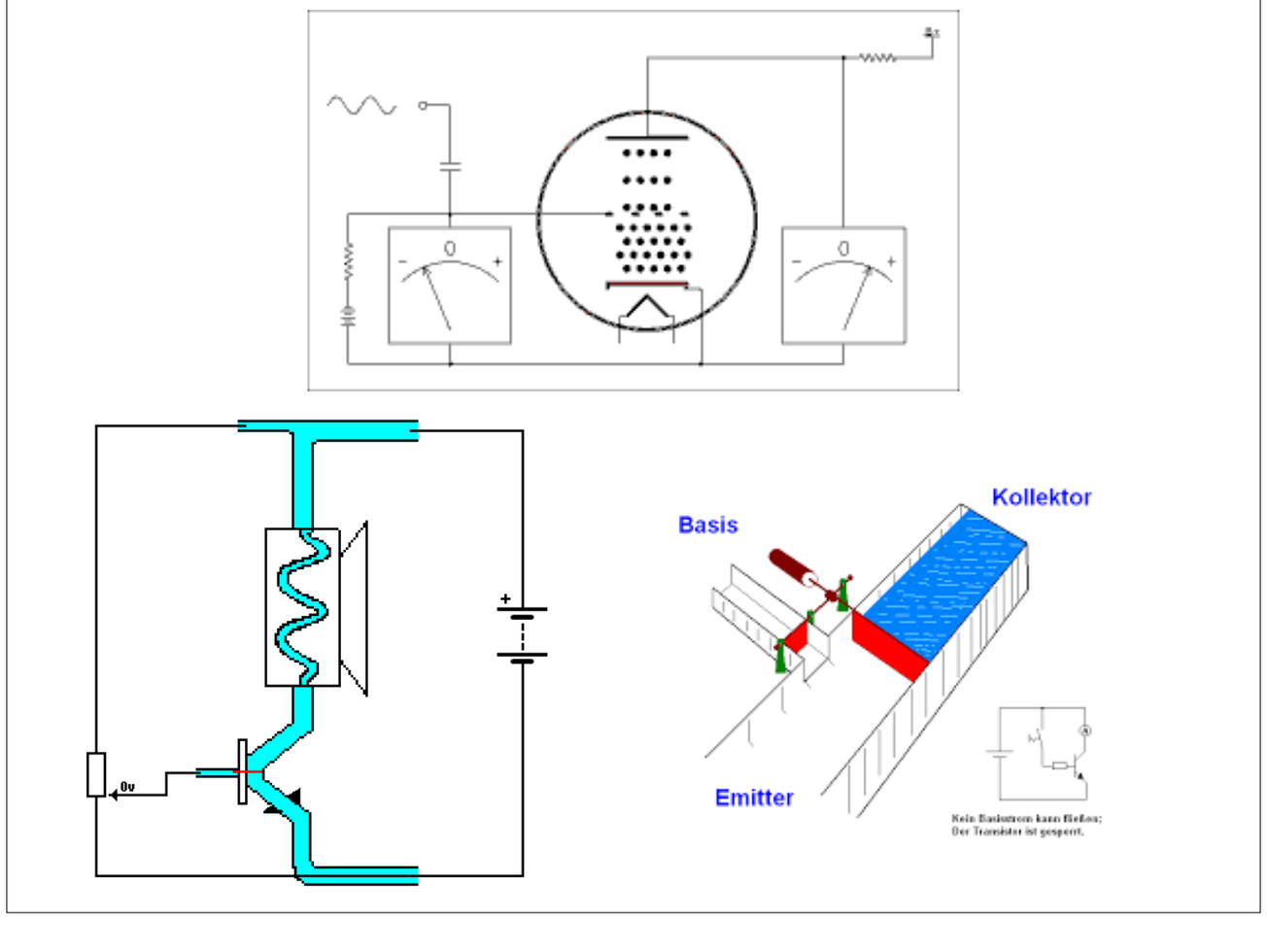
Inspired Hollerith's machine's punch cards



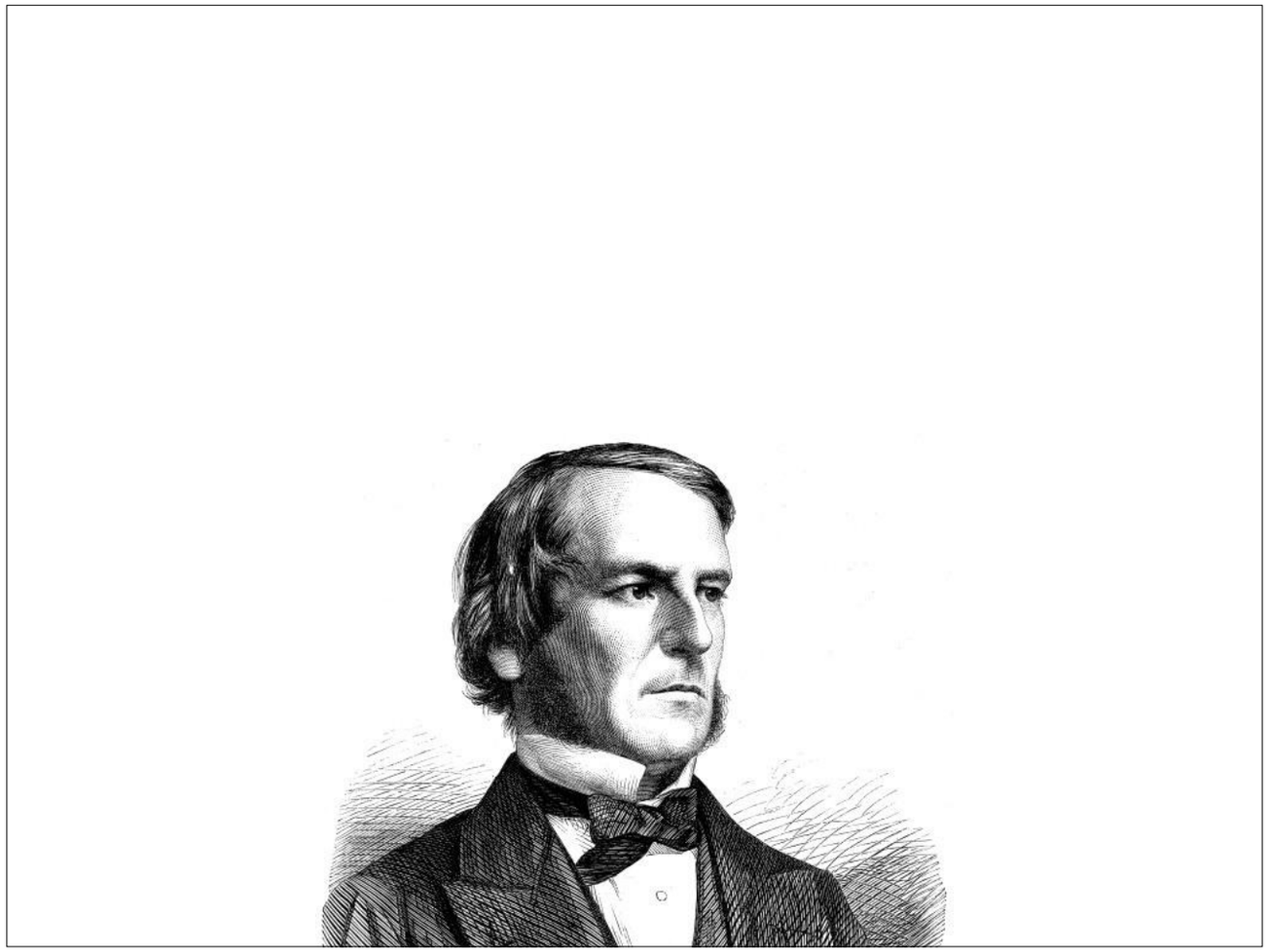
Electromechnical relay

50x second or so

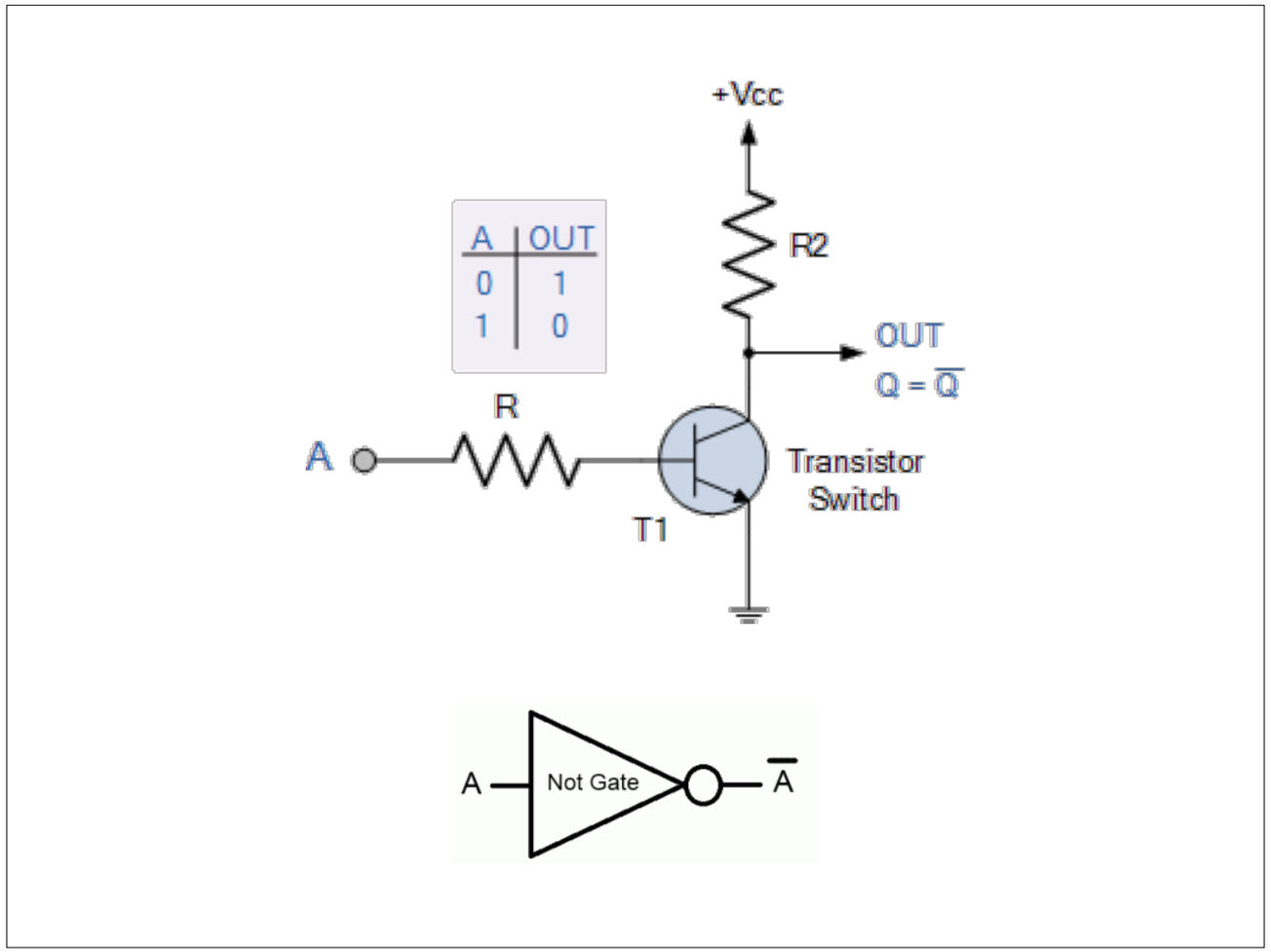
1/3 second - addition
6 seconds - multiplication
15 seconds - division



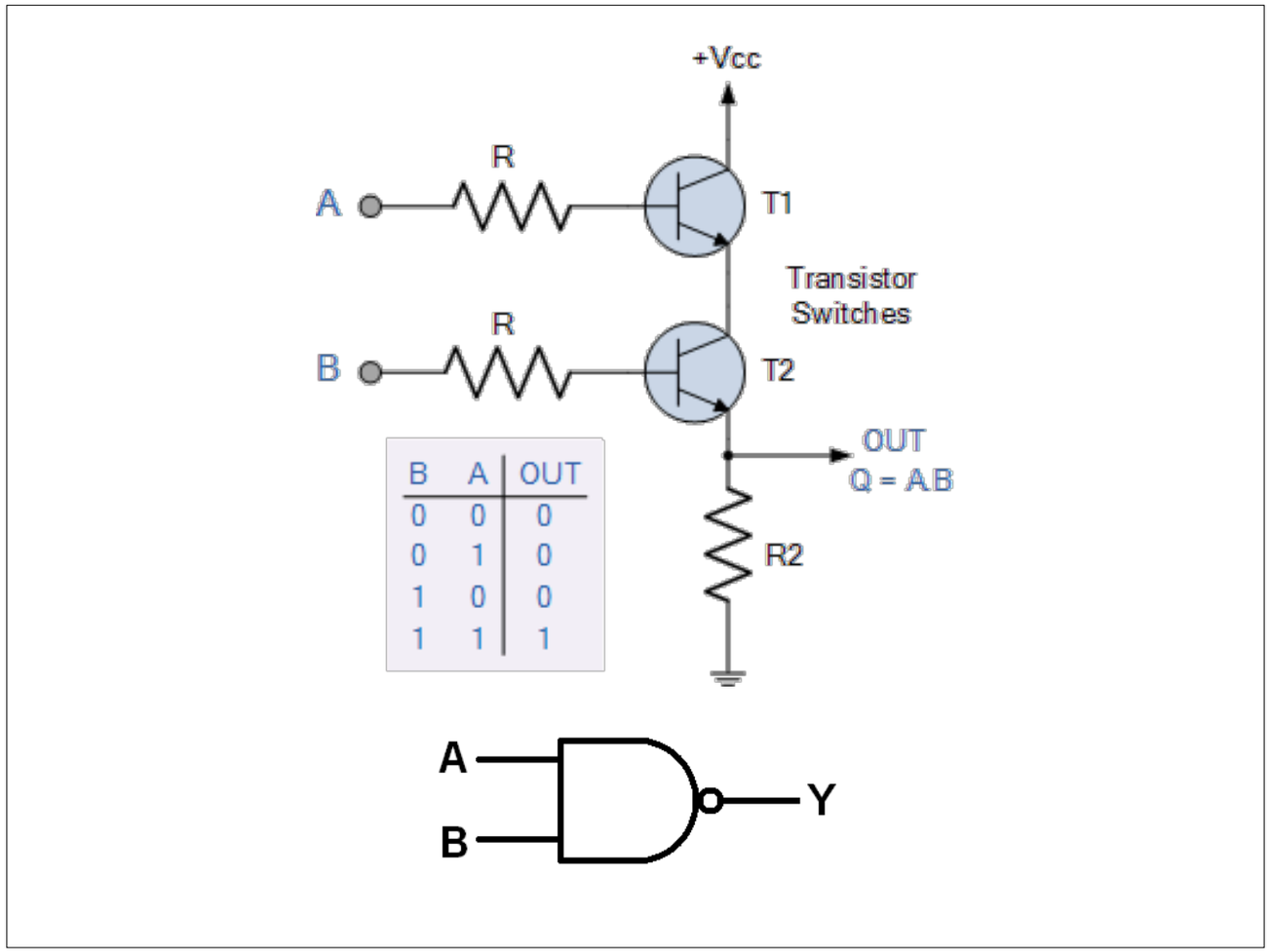
Vacuum tube
transistor



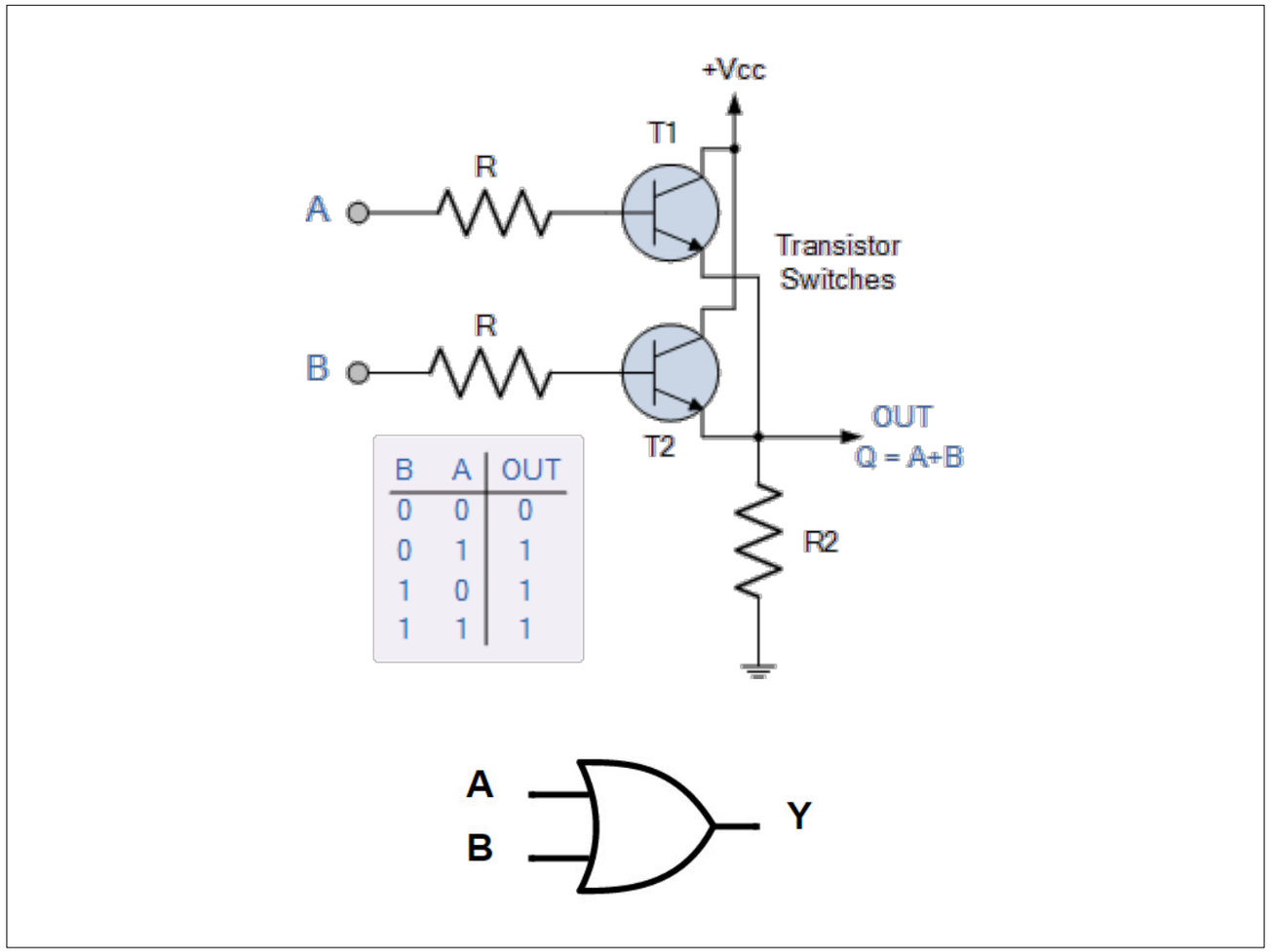
Boolean logic: NOT, AND, OR


+Vcc
A OUT
0 1
1 0
R2
OUT
Q = $\overline{Q}$
R
A
Transistor
Switch
T1
A
Not Gate
$\overline{A}$

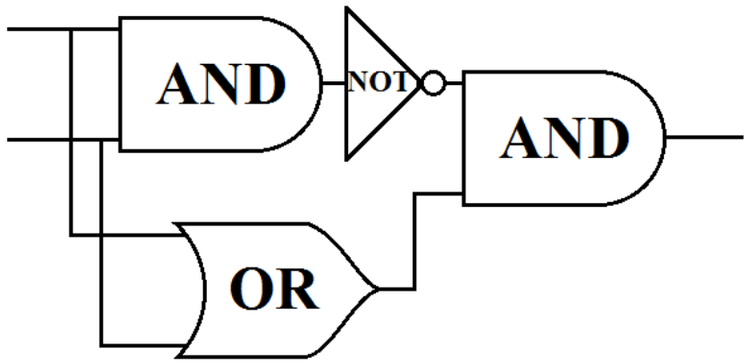
NOT


+Vcc
R
A
T1
Transistor
Switches
R
B
T2
OUT
Q = AB
R2
B A OUT
0 0 0
0 1 0
1 0 0
1 1 1
A
B
Y

AND


+Vcc
T1
R
A
Transistor
Switches
R
B
OUT
Q = A+B
T2
R2
B A OUT
0 0 0
0 1 1
1 0 1
1 1 1
A
B
Y

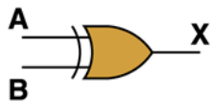
OR



Boolean Expression

$X = A \oplus B$

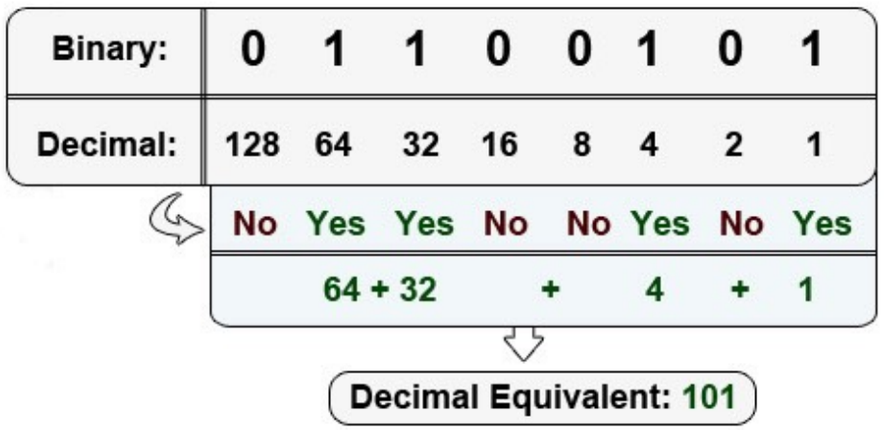
Logic Diagram Symbol



Truth Table

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

Data and statement evaluation


Binary: 0 1 1 0 0 1 0 1
Decimal: 128 64 32 16 8 4 2 1
No Yes Yes No No Yes No Yes
64 + 32 + 4 + 1
Decimal Equivalent: 101

00101010

ASCII TABLE

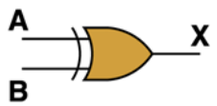
Decimal	Hexadecimal	Binary	Octal	Char
0	0	0	0	*[NULL]*
1	1	1	1	*[START OF HEADING]*
2	2	10	2	*[START OF TEXT]*
3	3	11	3	*[END OF TEXT]*
4	4	100	4	*[END OF TRANSMISSION]*
5	5	101	5	*[ENQUIRY]*
6	6	110	6	*[ACKNOWLEDGE]*
7	7	111	7	*[BELL]*
8	8	1000	10	*[BACKSPACE]*
9	9	1001	11	*[HORIZONTAL TAB]*
10	A	1010	12	*[LINE FEED]*
11	B	1011	13	*[VERTICAL TAB]*
12	C	1100	14	*[FORM FEED]*
13	D	1101	15	*[CARRIAGE RETURN]*
14	E	1110	16	*[SHIFT OUT]*
15	F	1111	17	*[SHIFT IN]*
16	10	10000	20	*[DATA LINK ESCAPE]*
17	11	10001	21	*[DEVICE CONTROL 1]*
18	12	10010	22	*[DEVICE CONTROL 2]*
19	13	10011	23	*[DEVICE CONTROL 3]*
20	14	10100	24	*[DEVICE CONTROL 4]*
21	15	10101	25	*[NEGATIVE ACKNOWLEDGE]*
22	16	10110	26	*[SYNCHRONOUS IDLE]*
23	17	10111	27	*[ENG OF TRANS. BLOCK]*
24	18	11000	30	*[CANCEL]*
25	19	11001	31	*[END OF MEDIUM]*
26	1A	11010	32	*[SUBSTITUTE]*
27	1B	11011	33	*[ESCAPE]*
28	1C	11100	34	*[FILE SEPARATOR]*
29	1D	11101	35	*[GROUP SEPARATOR]*
30	1E	11110	36	*[RECORD SEPARATOR]*
31	1F	11111	37	*[UNIT SEPARATOR]*
32	20	100000	40	*[SPACE]*
33	21	100001	41	!
34	22	100010	42	"
35	23	100011	43	#
36	24	100100	44	$
37	25	100101	45	%
38	26	100110	46	&
39	27	100111	47	'
40	28	101000	50	(
41	29	101001	51	)
42	2A	101010	52	*
43	2B	101011	53	+
44	2C	101100	54	,
45	2D	101101	55	-
46	2E	101110	56	.
47	2F	101111	57	/
48	30	110000	60	**0**
49	31	110001	61	**1**
50	32	110010	62	**2**
51	33	110011	63	**3**
52	34	110100	64	**4**
53	35	110101	65	**5**
54	36	110110	66	**6**
55	37	110111	67	**7**
56	38	111000	70	**8**
57	39	111001	71	**9**
58	3A	111010	72	:
59	3B	111011	73	;
60	3C	111100	74	<
61	3D	111101	75	=
62	3E	111110	76	>
63	3F	111111	77	?
64	40	1000000	100	@
65	41	1000001	101	**A**
66	42	1000010	102	**B**
67	43	1000011	103	**C**
68	44	1000100	104	**D**
69	45	1000101	105	**E**
70	46	1000110	106	**F**
71	47	1000111	107	**G**
72	48	1001000	110	**H**
73	49	1001001	111	**I**
74	4A	1001010	112	**J**
75	4B	1001011	113	**K**
76	4C	1001100	114	**L**
77	4D	1001101	115	**M**
78	4E	1001110	116	**N**
79	4F	1001111	117	**O**
80	50	1010000	120	**P**
81	51	1010001	121	**Q**
82	52	1010010	122	**R**
83	53	1010011	123	**S**
84	54	1010100	124	**T**
85	55	1010101	125	**U**
86	56	1010110	126	**V**
87	57	1010111	127	**W**
88	58	1011000	130	**X**
89	59	1011001	131	**Y**
90	5A	1011010	132	**Z**
91	5B	1011011	133	[
92	5C	1011100	134	\
93	5D	1011101	135	]
94	5E	1011110	136	^
95	5F	1011111	137	_
96	60	1100000	140	`
97	61	1100001	141	**a**
98	62	1100010	142	**b**
99	63	1100011	143	**c**
100	64	1100100	144	**d**
101	65	1100101	145	**e**
102	66	1100110	146	**f**
103	67	1100111	147	**g**
104	68	1101000	150	**h**
105	69	1101001	151	**i**
106	6A	1101010	152	**j**
107	6B	1101011	153	**k**
108	6C	1101100	154	**l**
109	6D	1101101	155	**m**
110	6E	1101110	156	**n**
111	6F	1101111	157	**o**
112	70	1110000	160	**p**
113	71	1110001	161	**q**
114	72	1110010	162	**r**
115	73	1110011	163	**s**
116	74	1110100	164	**t**
117	75	1110101	165	**u**
118	76	1110110	166	**v**
119	77	1110111	167	**w**
120	78	1111000	170	**x**
121	79	1111001	171	**y**
122	7A	1111010	172	**z**
123	7B	1111011	173	{
124	7C	1111100	174	|
125	7D	1111101	175	}
126	7E	1111110	176	~
127	7F	1111111	177	*[DEL]*

0+0 = 0
1+0 = 1
0+1 = 1

Boolean Expression

$$X = A \oplus B$$

Logic Diagram Symbol



Truth Table

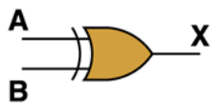
A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

1+1 = 10

Boolean Expression

$X = A \oplus B$

Logic Diagram Symbol

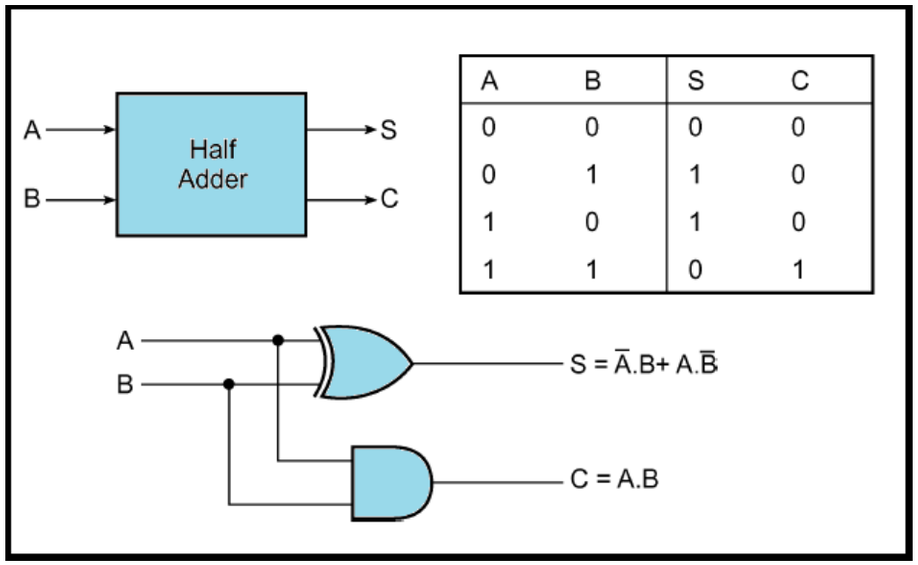


Truth Table

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

Truth Table			
Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

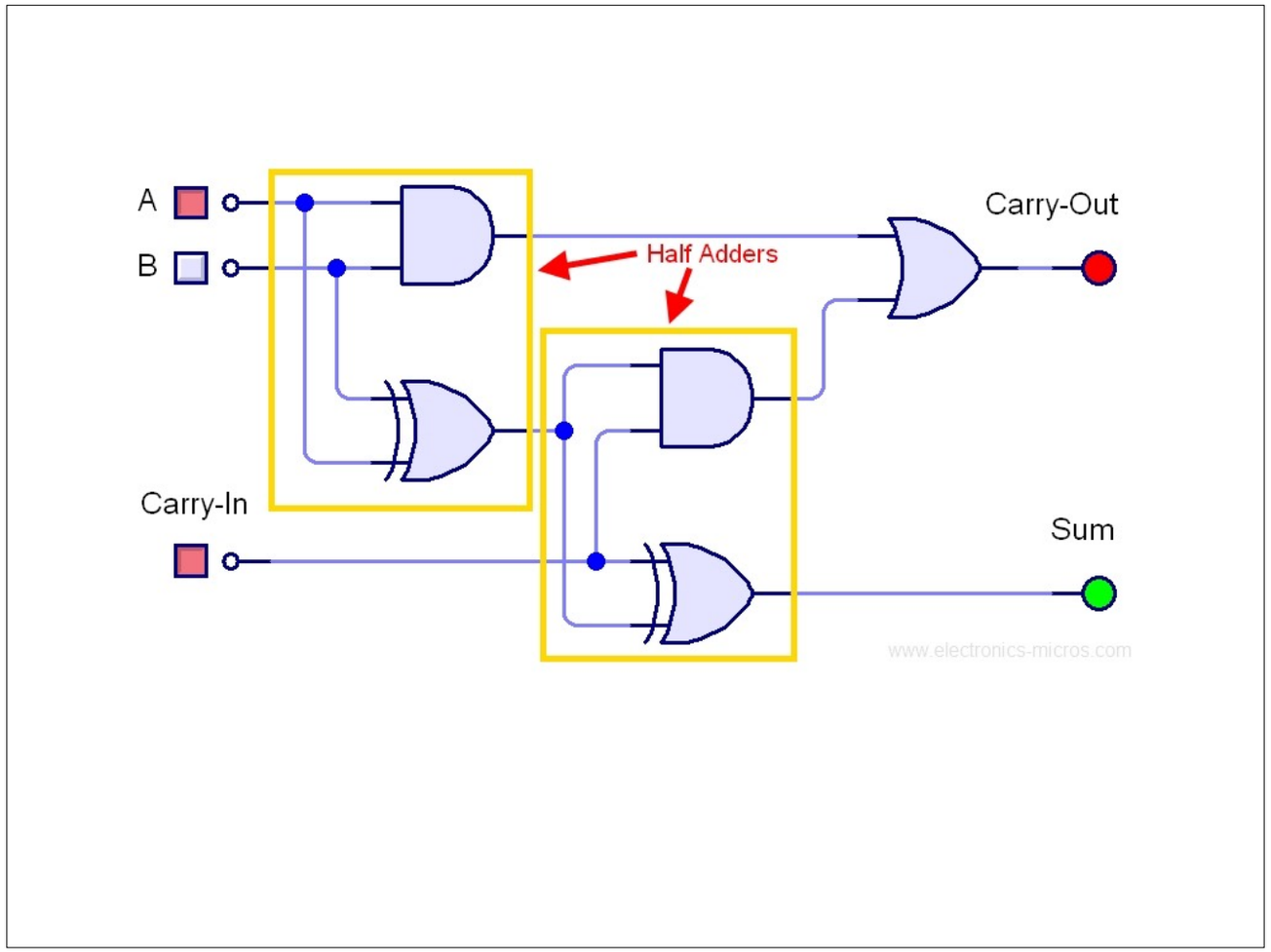
1+1 = 10

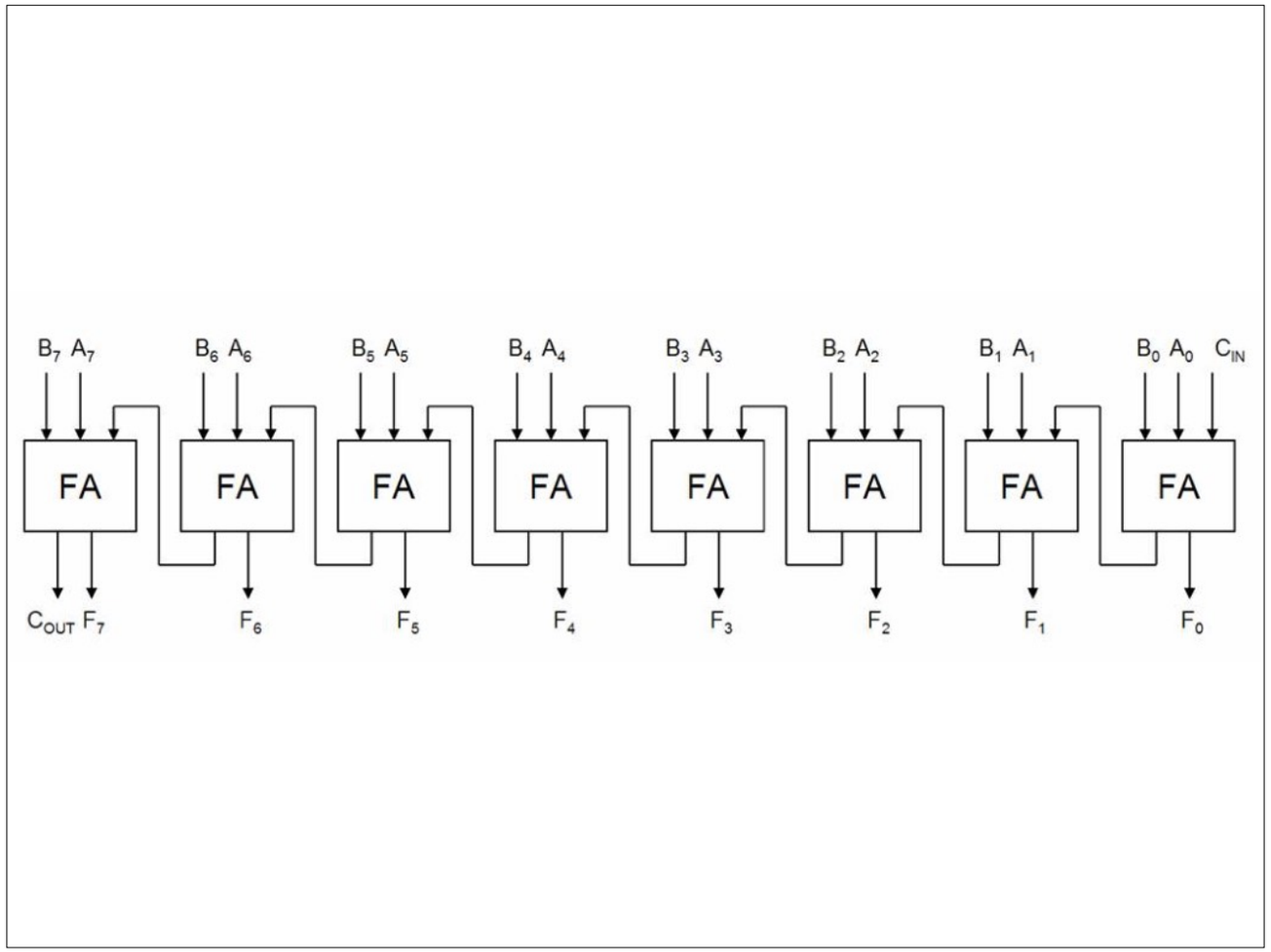


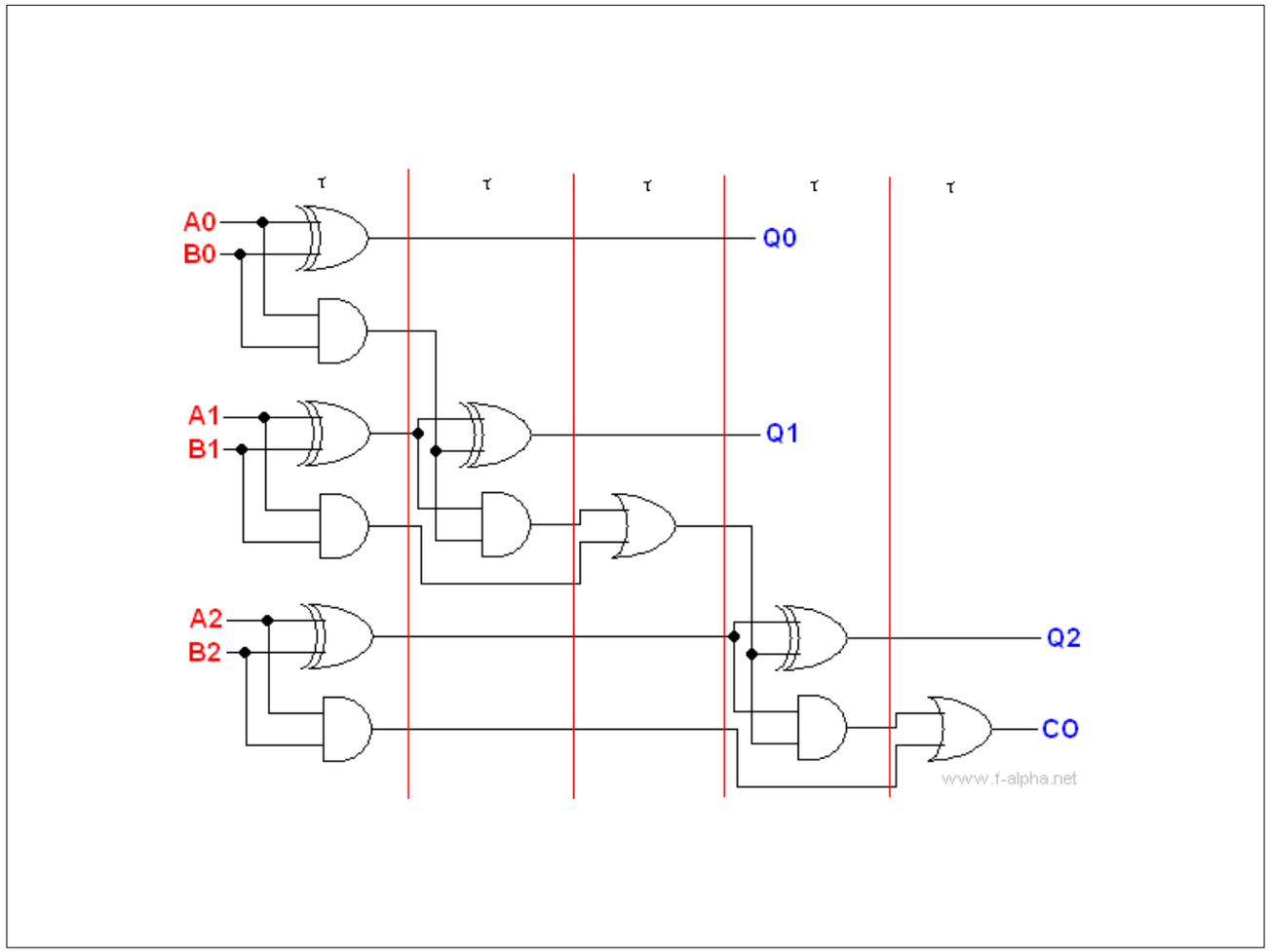
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

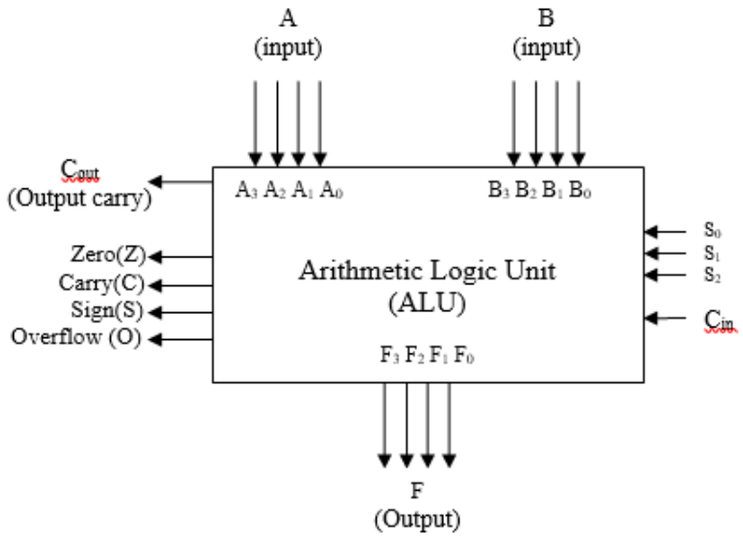
The carry bit might need to be added to another a/b combination

Input			Output	
A	B	Cin	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

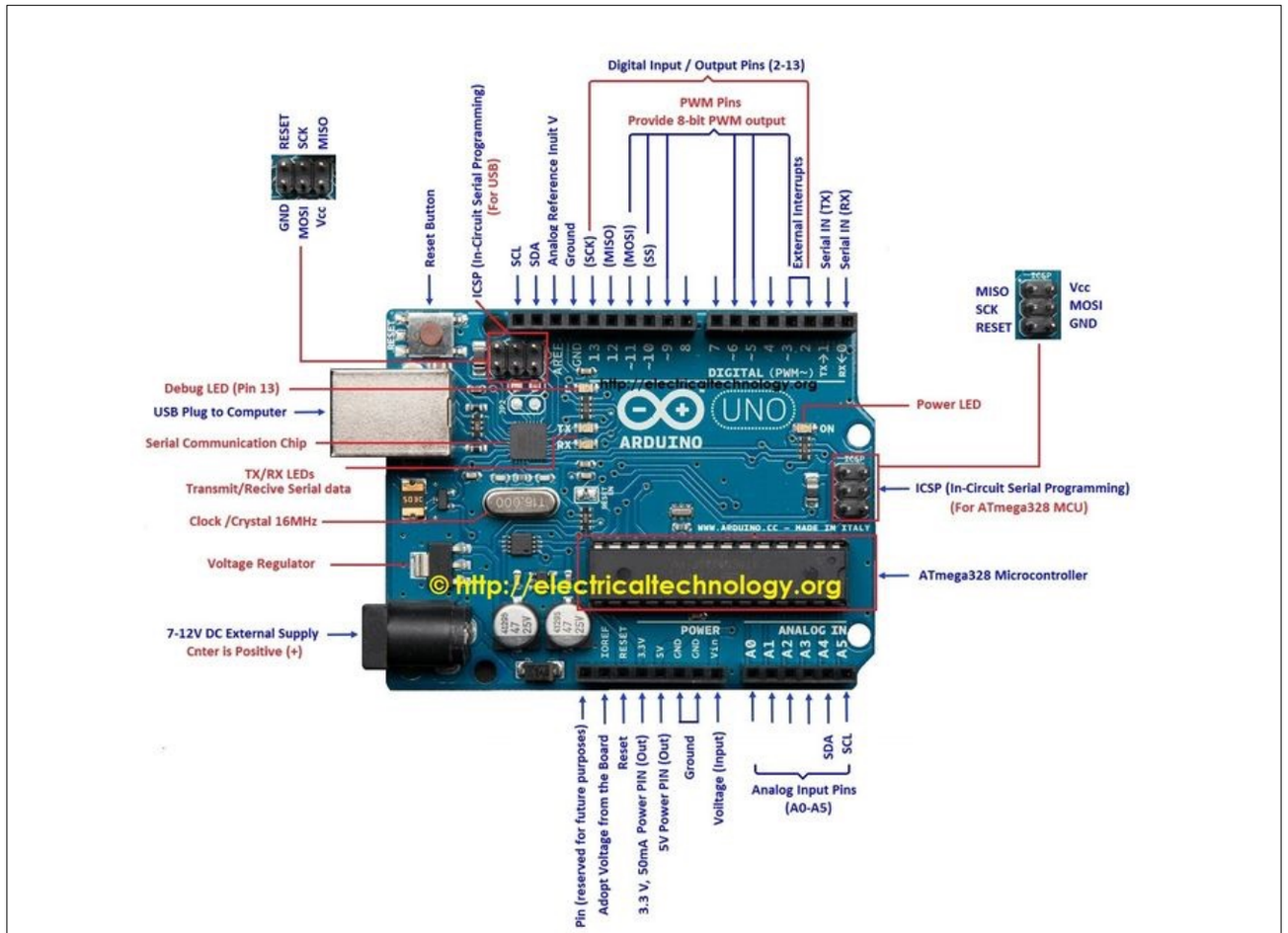

A
B
Carry-In
Half Adders
Carry-Out
Sum
www.electronics-micros.com


B7 A7
B6 A6
B5 A5
B4 A4
B3 A3
B2 A2
B1 A1
B0 A0
CIN
FA
FA
FA
FA
FA
FA
FA
FA
COUT F7
F6
F5
F4
F3
F2
F1
F0


τ
τ
τ
τ
τ
A0
B0
A1
B1
A2
B2
Q0
Q1
Q2
CO
www.f-alpha.net



Are the numbers the same? Subtract one from the other and see is the Z flag is 1.
Is A smaller than B? If A - B sets S flag to true, then it’s true.


Digital Input / Output Pins (2-13)
PWM Pins
Provide 8-bit PWM output
RESET
SCK
MISO
GND
MOSI
Vcc
Reset Button
ICSP (In-Circuit Serial Programming)
(For USB)
SCL
SDA
Analog Reference Inuit V
Ground
(SCK)
(MISO)
(MOSI)
(SS)
External Interrupts
Serial IN (TX)
Serial IN (RX)
MISO
SCK
RESET
Vcc
MOSI
GND
Debug LED (Pin 13)
USB Plug to Computer
Serial Communication Chip
TX/RX LEDs
Transmit/Recive Serial data
Clock /Crystal 16MHz
Voltage Regulator
7-12V DC External Supply
Cnter is Positive (+)
Power LED
ICSP (In-Circuit Serial Programming)
(For ATmega328 MCU)
ATmega328 Microcontroller
DIGITAL (PWM~)
UNO
ARDUINO
POWER
ANALOG IN
© http://electricaltechnology.org
Pin (reserved for future purposes)
Adopt Voltage from the Board
Reset
3.3 V, 50mA Power PIN (Out)
5V Power PIN (Out)
Ground
Voltage (Input)
Analog Input Pins
(A0-A5)