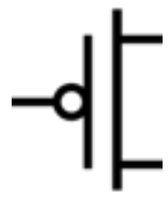
Transistors and gates

Lab Week 2

Transistors

- Work as switches
- The control is the **gate**
- Two sorts: one allows current when the gate is positive, the other allows it when it is negative.

Transistors

	npn	pnp
	n channel	p channel
symbol		
gate 0	off	on
gate 1	on	off

Gates

- Used to compute boolean combinations of inputs

Example: nand gate

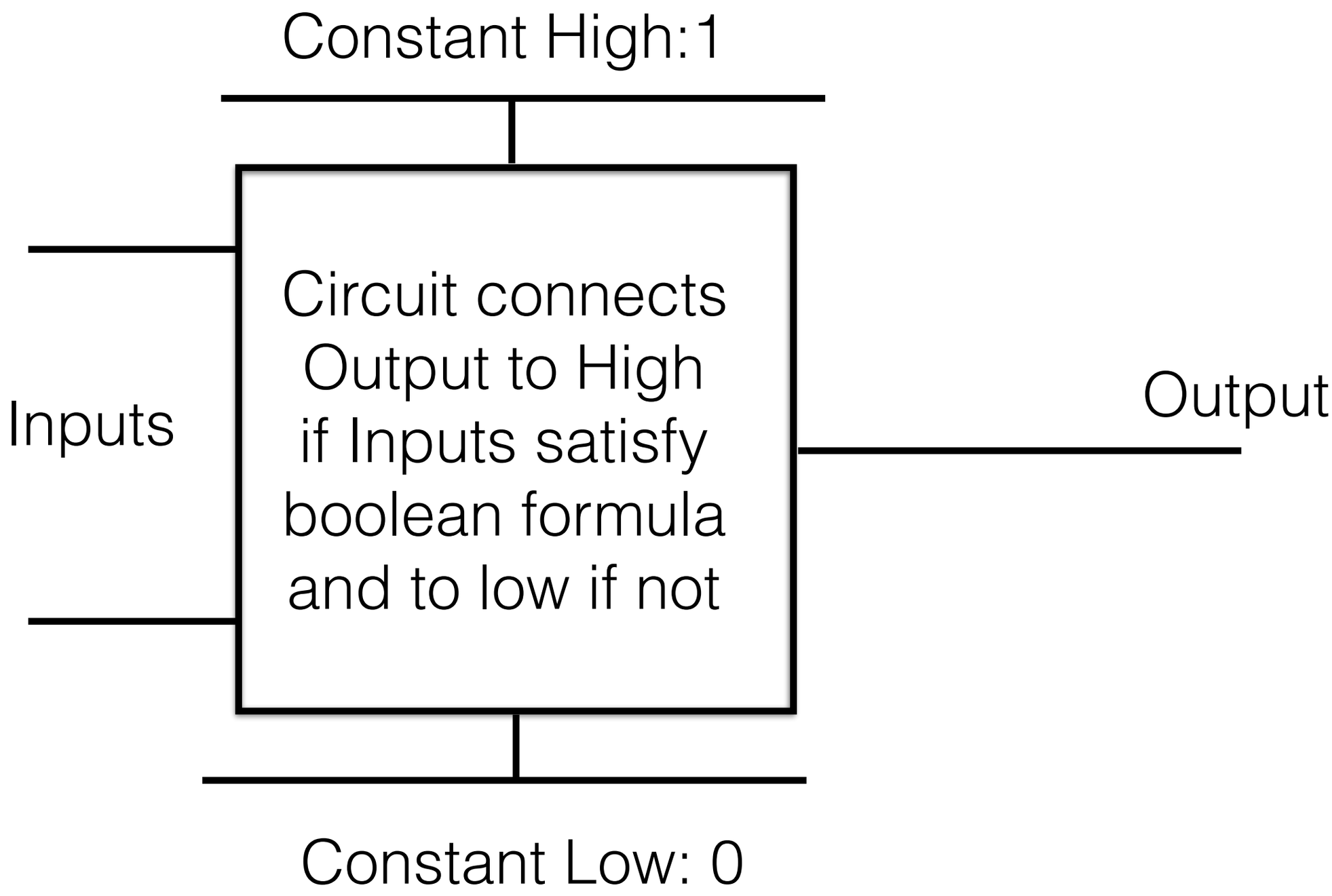
- Computes nand of two inputs

- A nand B = not (A and B)

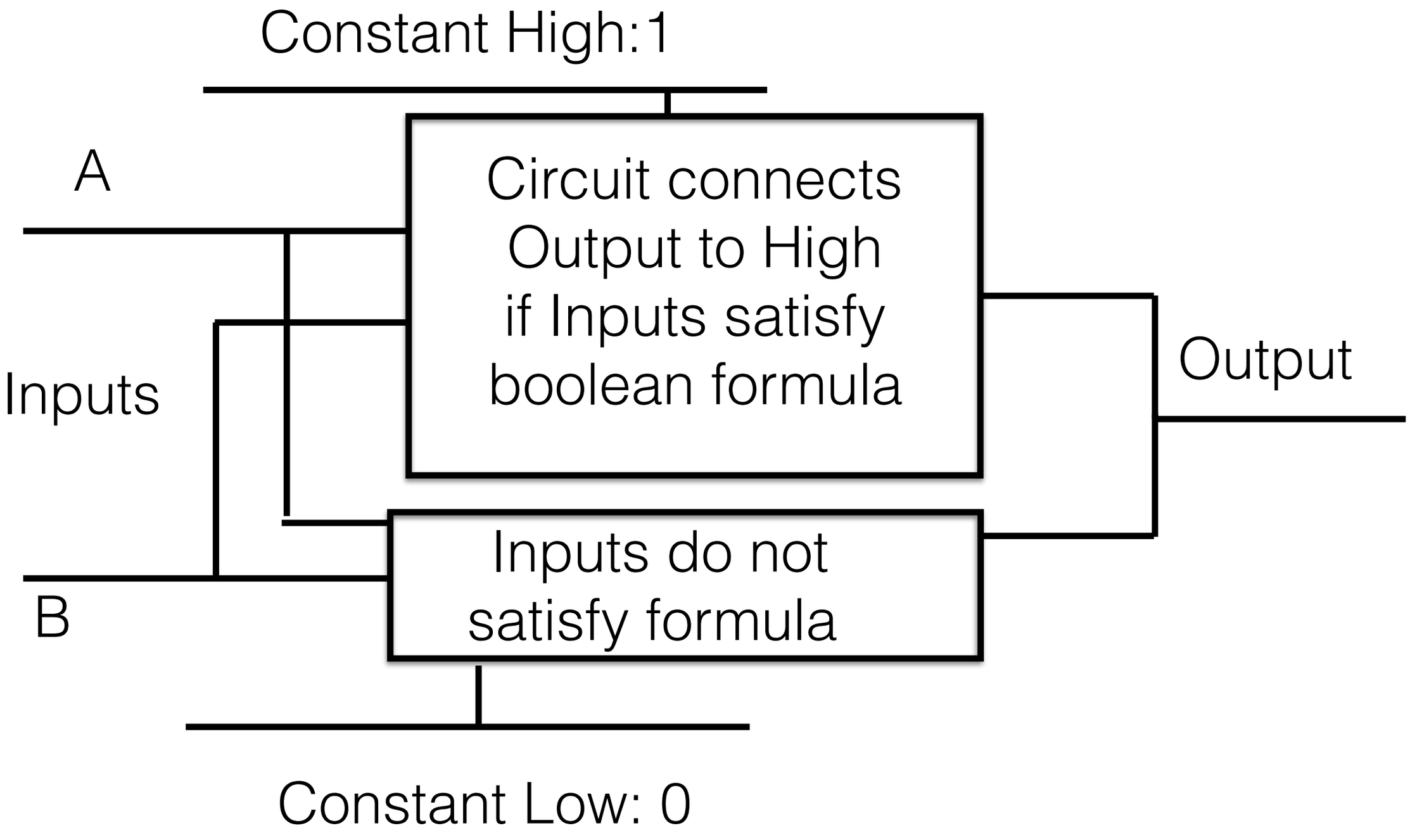
Example: nand gate

A	B	A and B	not(A and B)
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

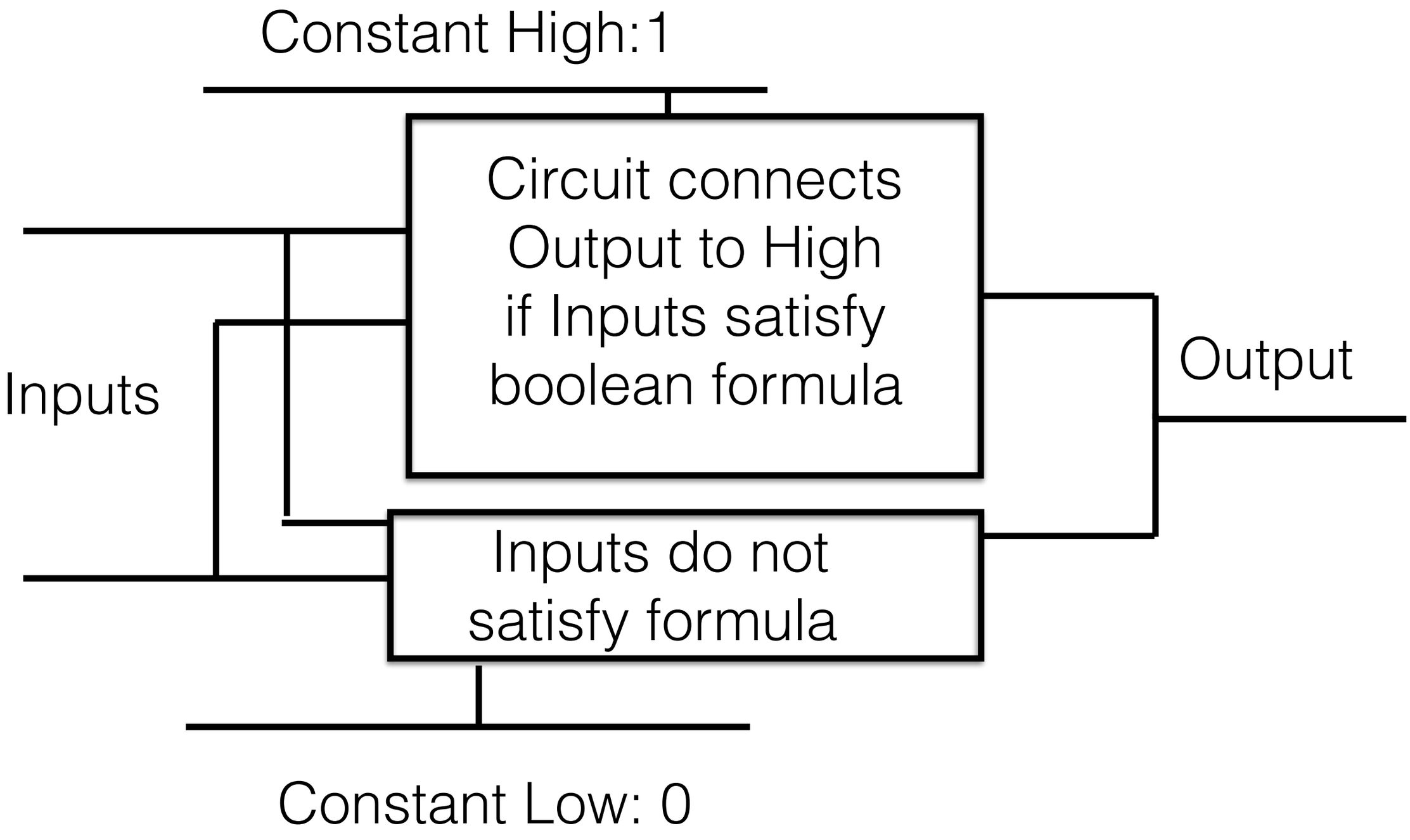
Example: nand gate



Example: nand gate

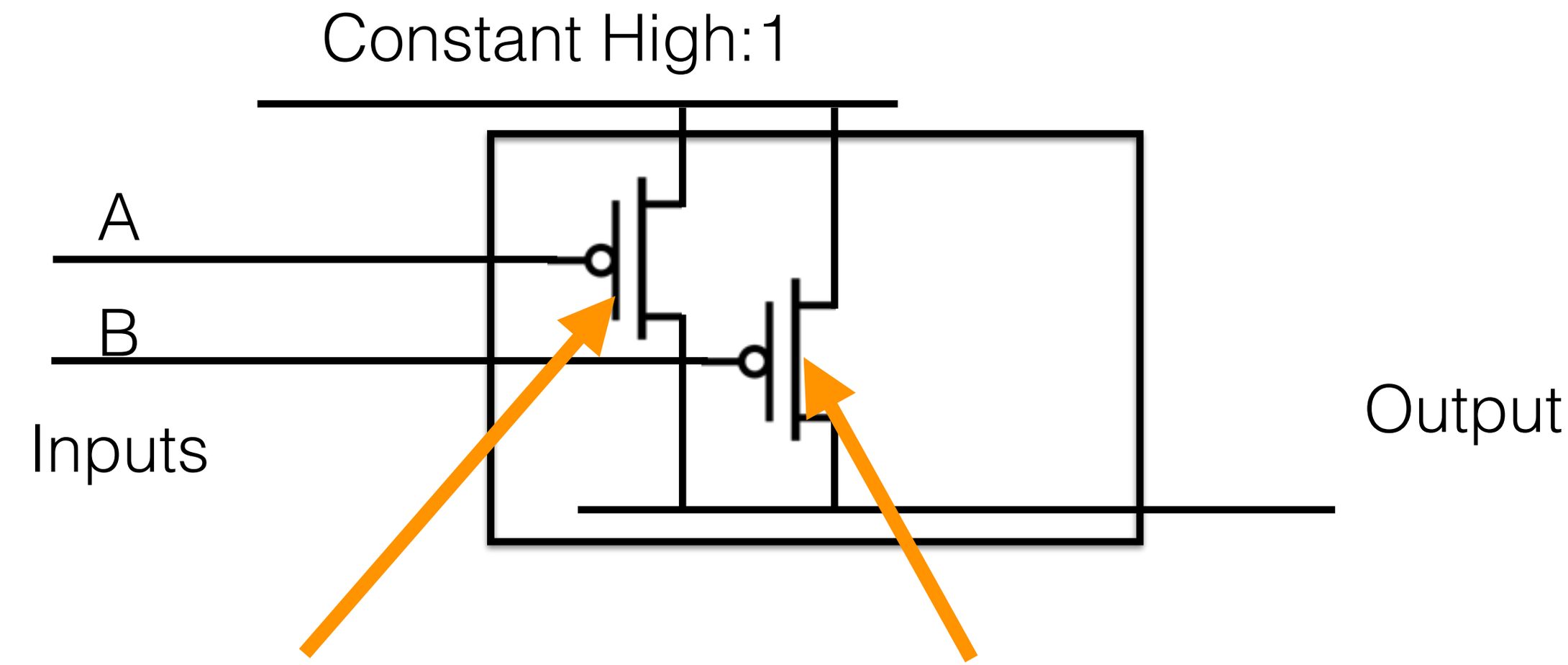


Example: nand gate



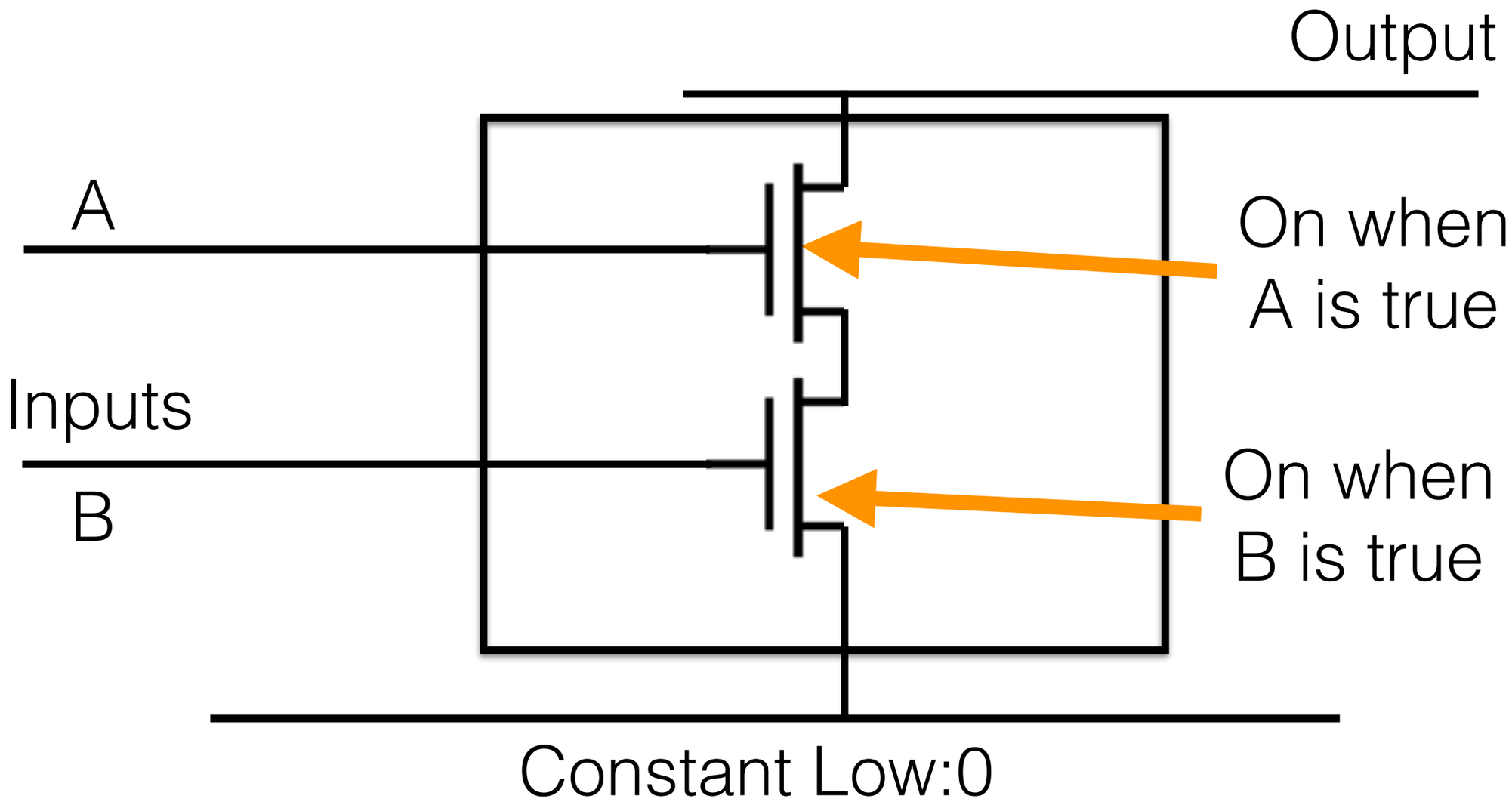
Example: nand gate

A nand B holds when either A or B is false



Example: nand gate

A nand B fails when both A and B are true



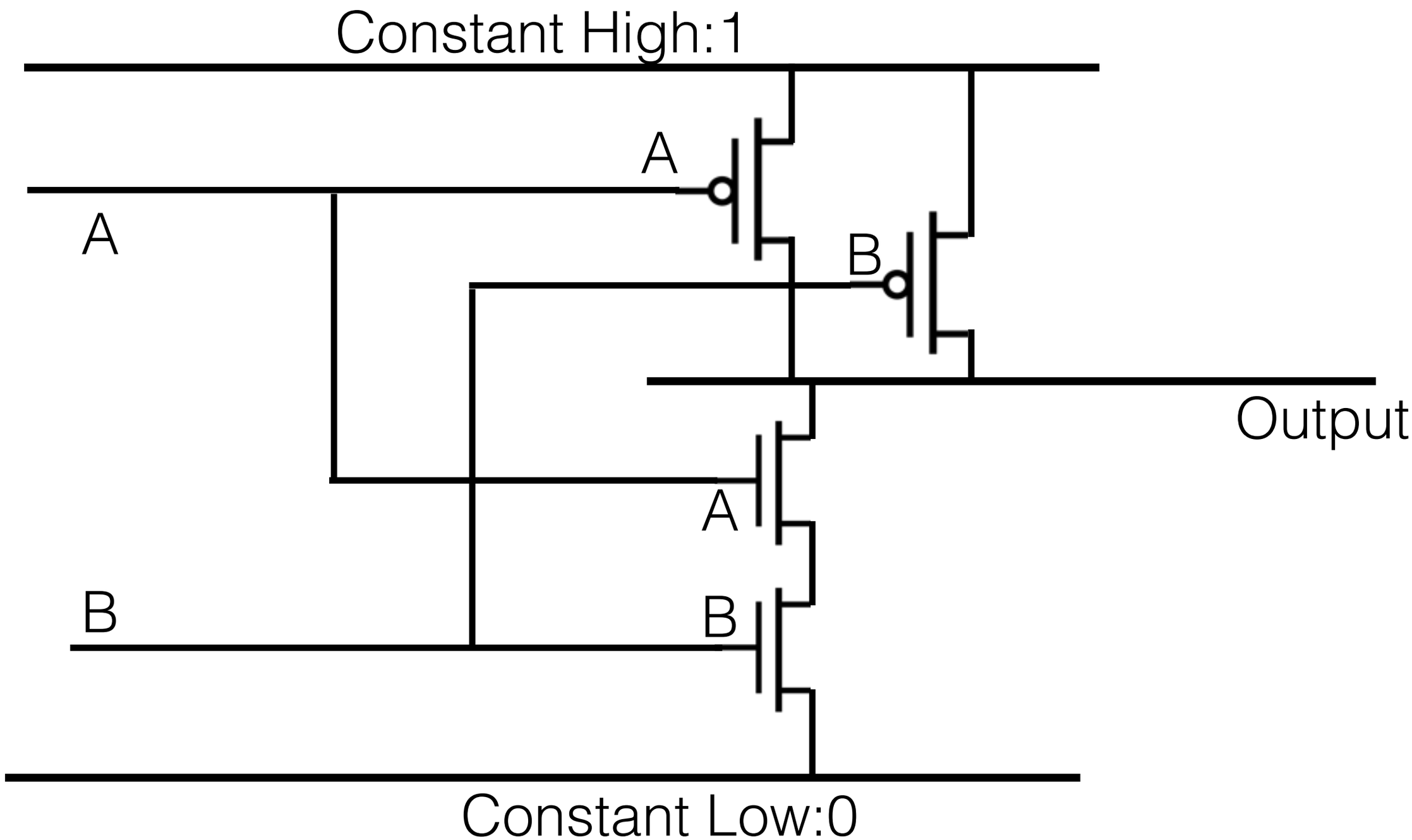
Example: nand gate

A	B	Top	Bot	Output	A nand B
0	0	y	n	1	1
0	1	y	n	1	1
1	0	y	n	1	1
1	1	n	y	0	0

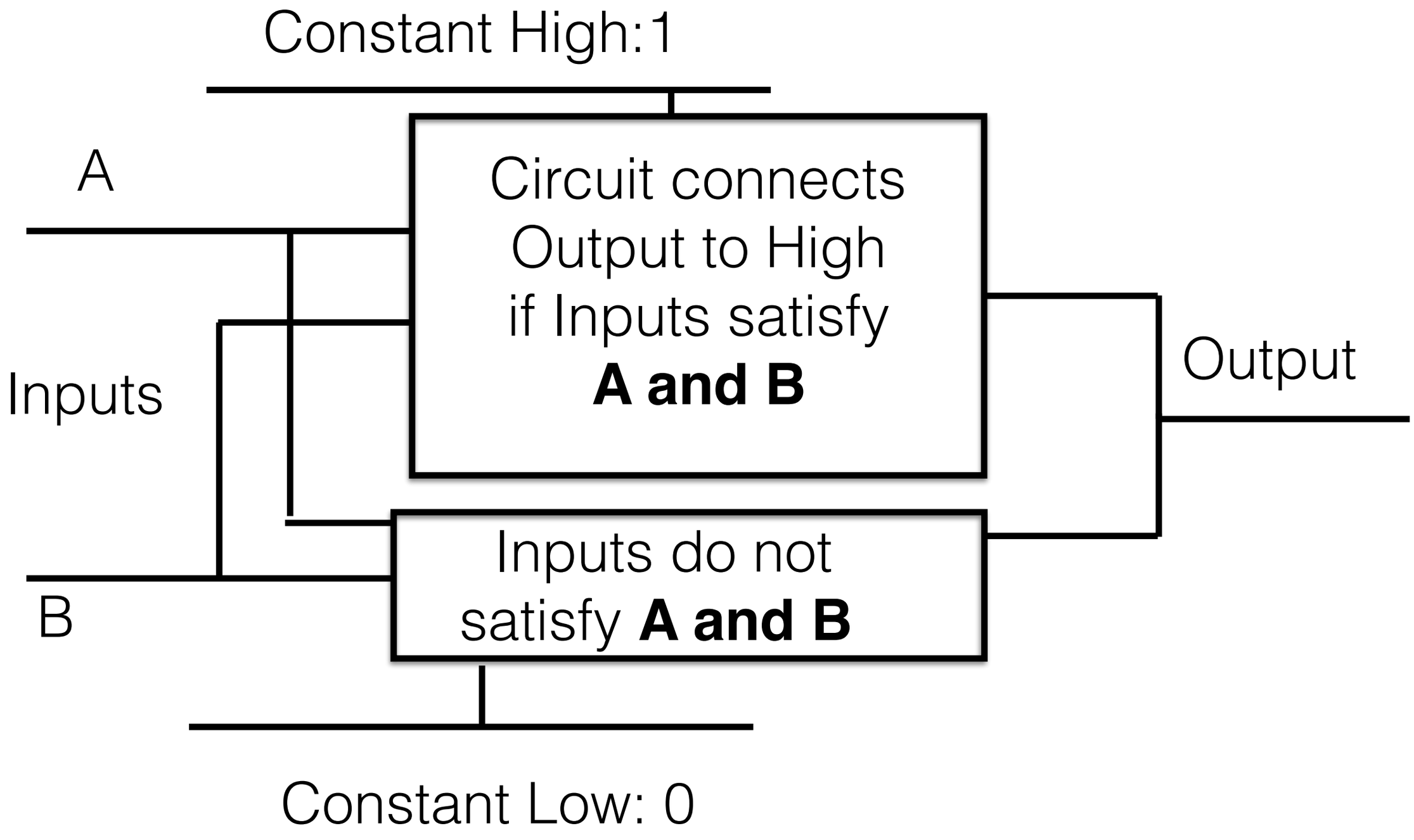
Computed by circuit

Computed by logic

Example: nand gate: putting top and bottom together

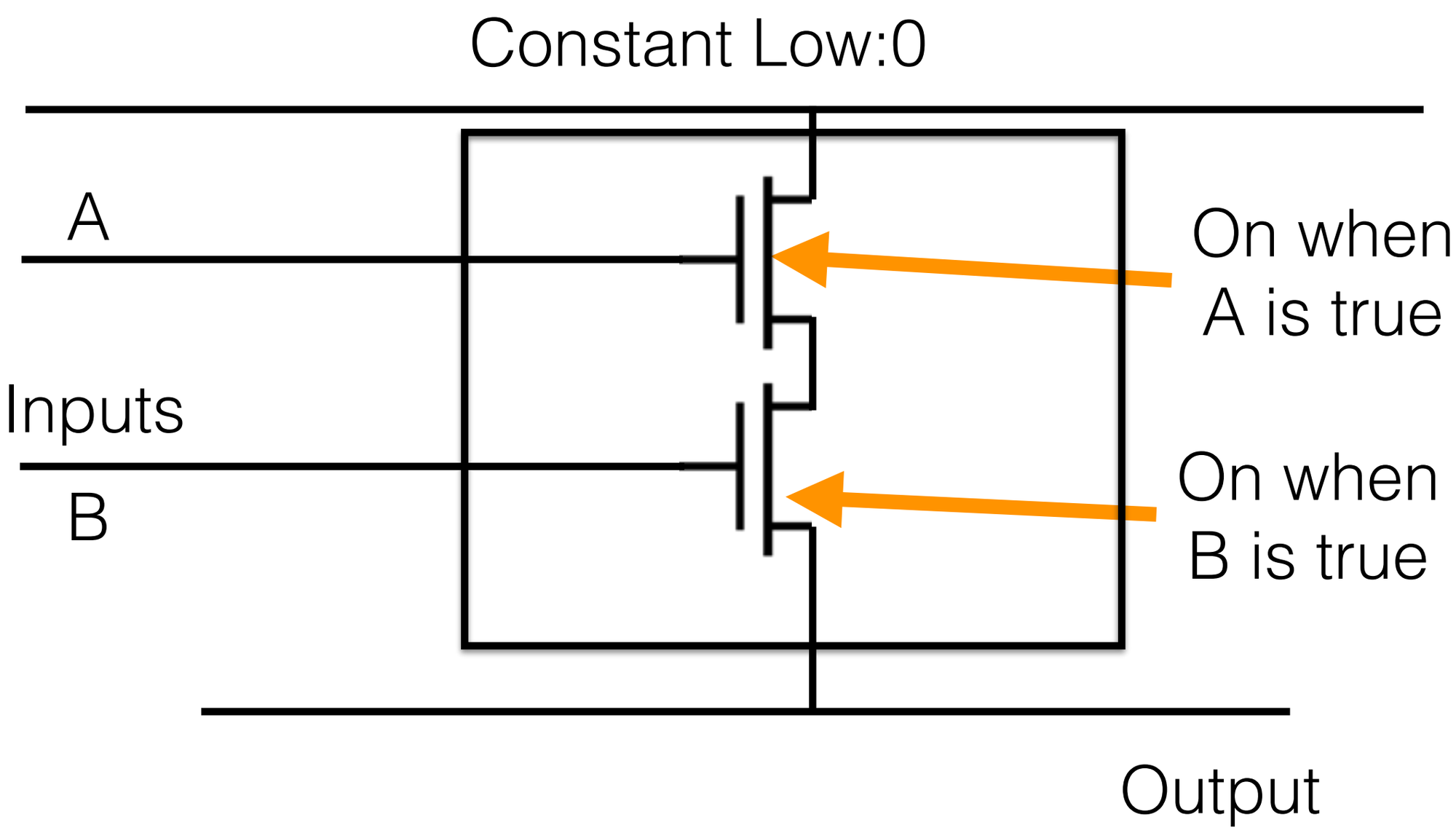


Example: and gate



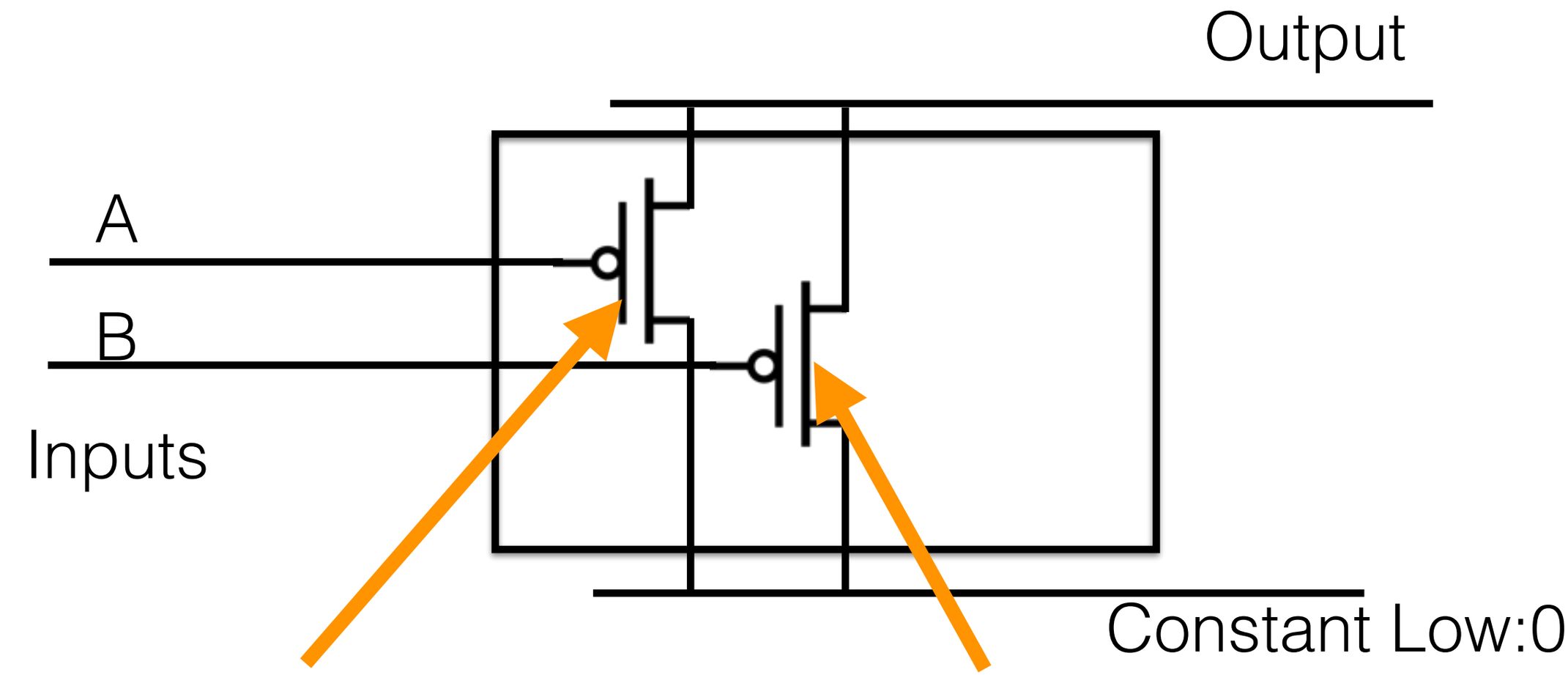
Example: nand gate

A and B holds when both A and B are true

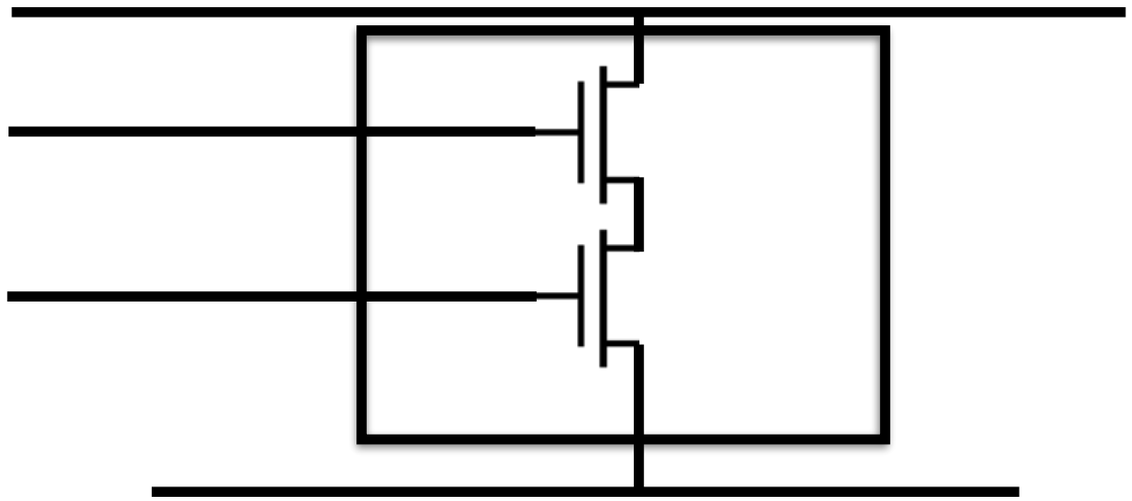


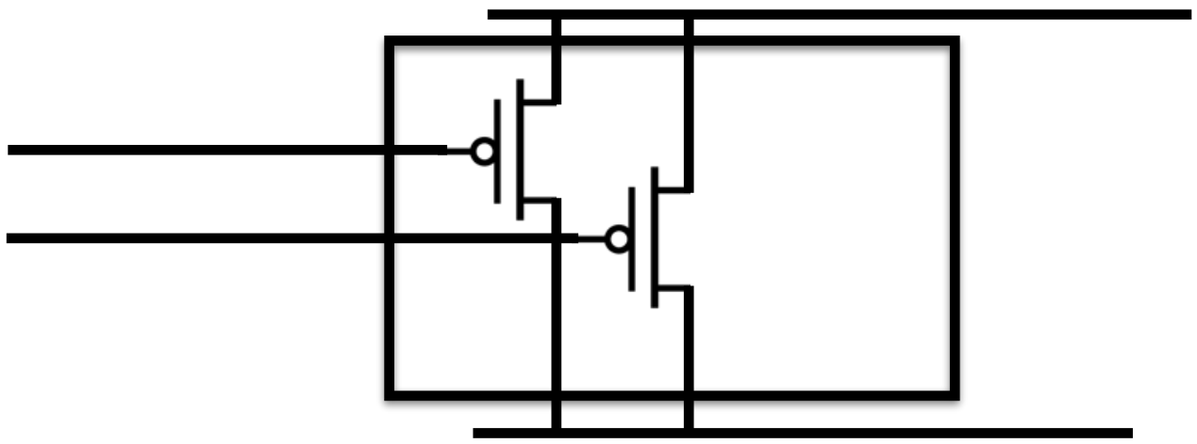
Example: nand gate

A and B fails when either A or B is false

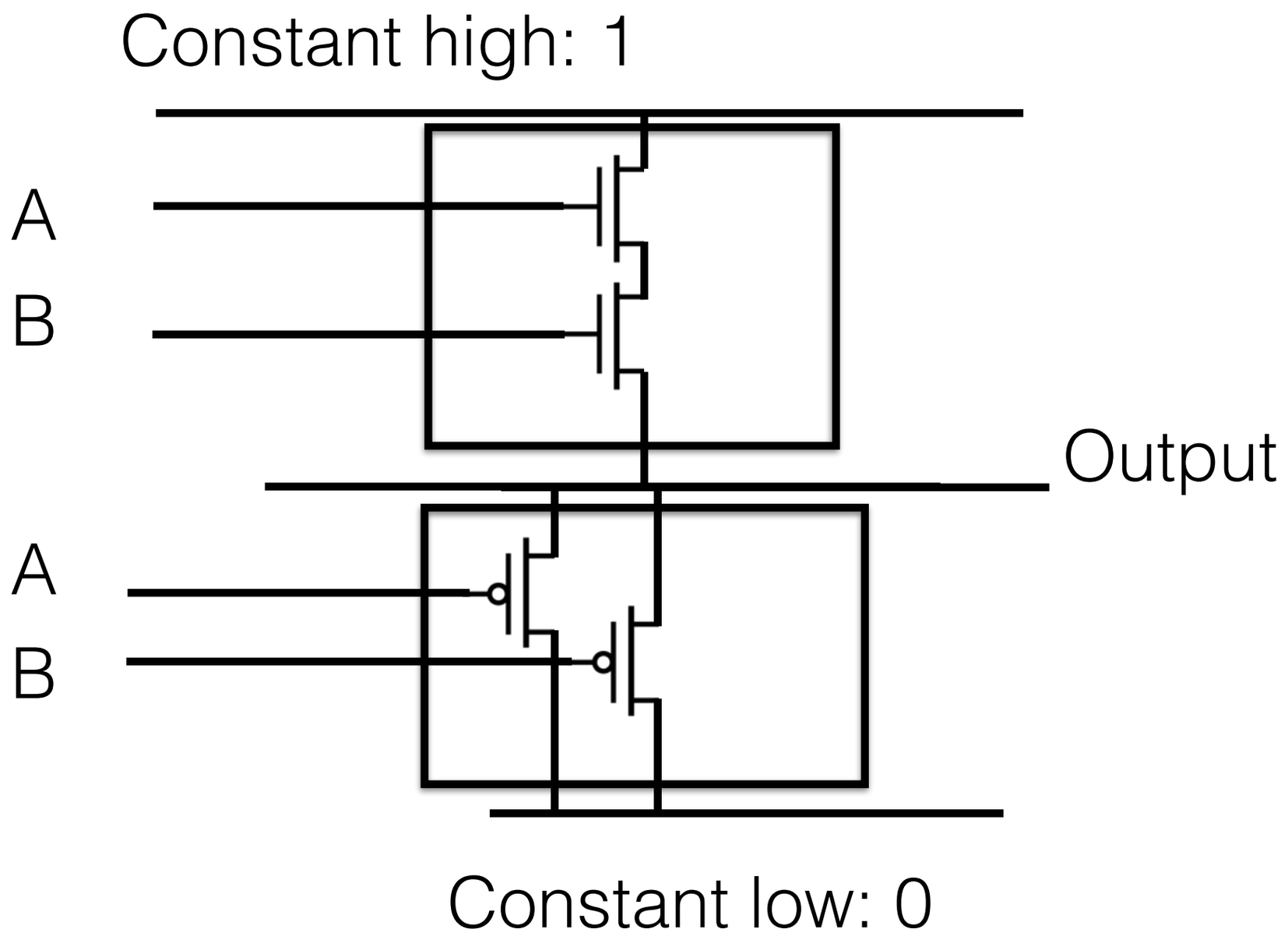


Put together



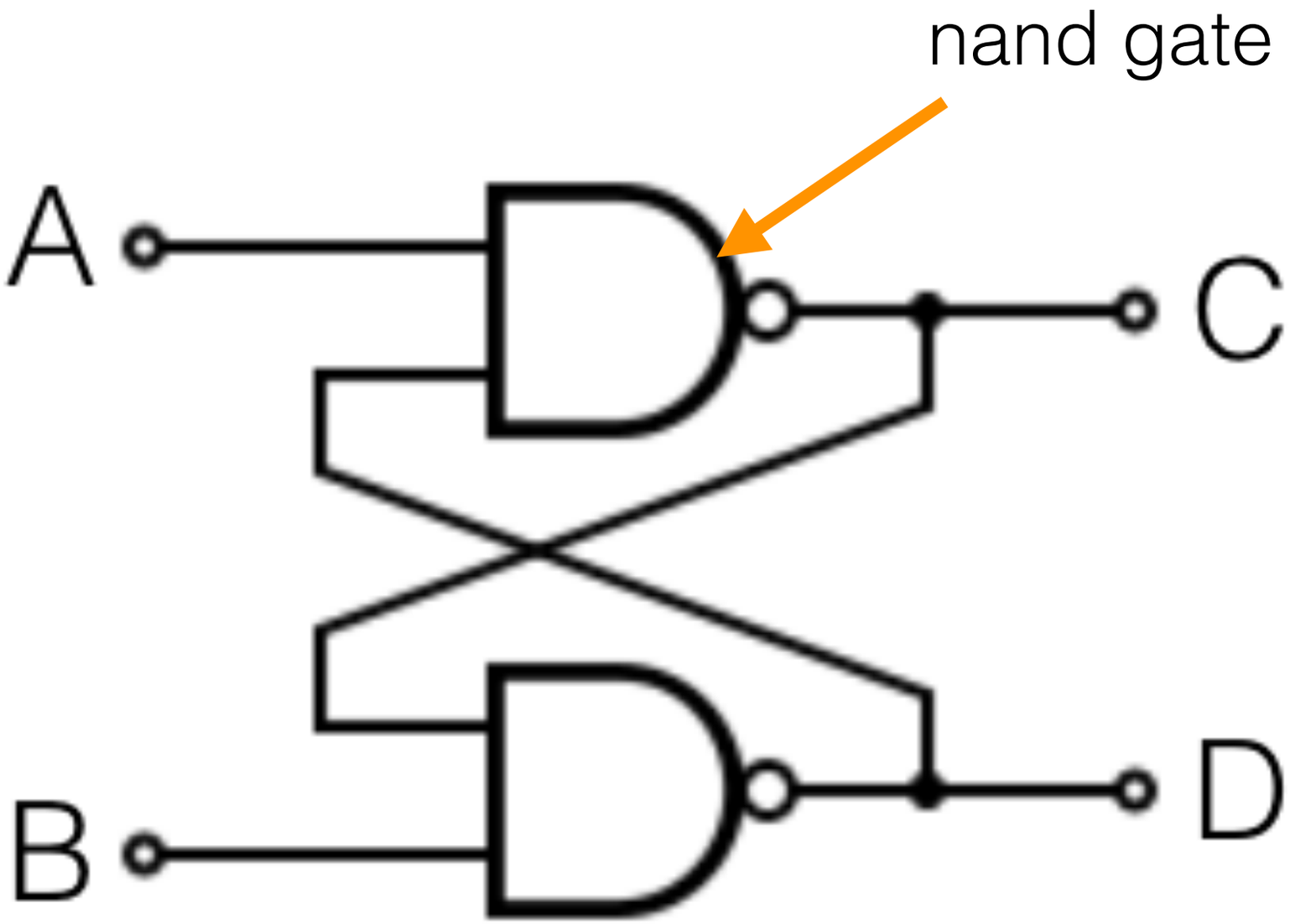


Completed and gate



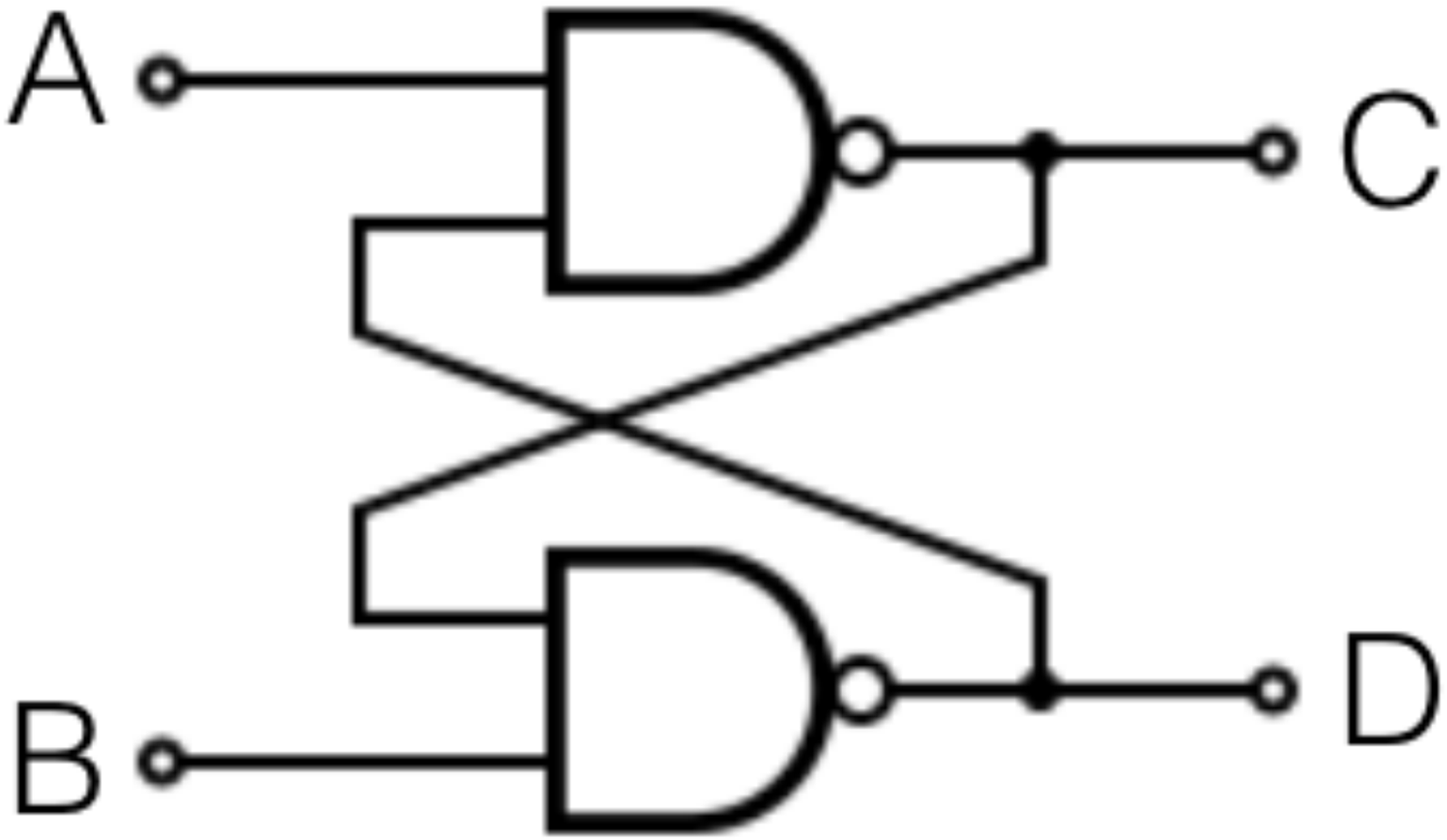
4. Flip flops and memory

Flip flop



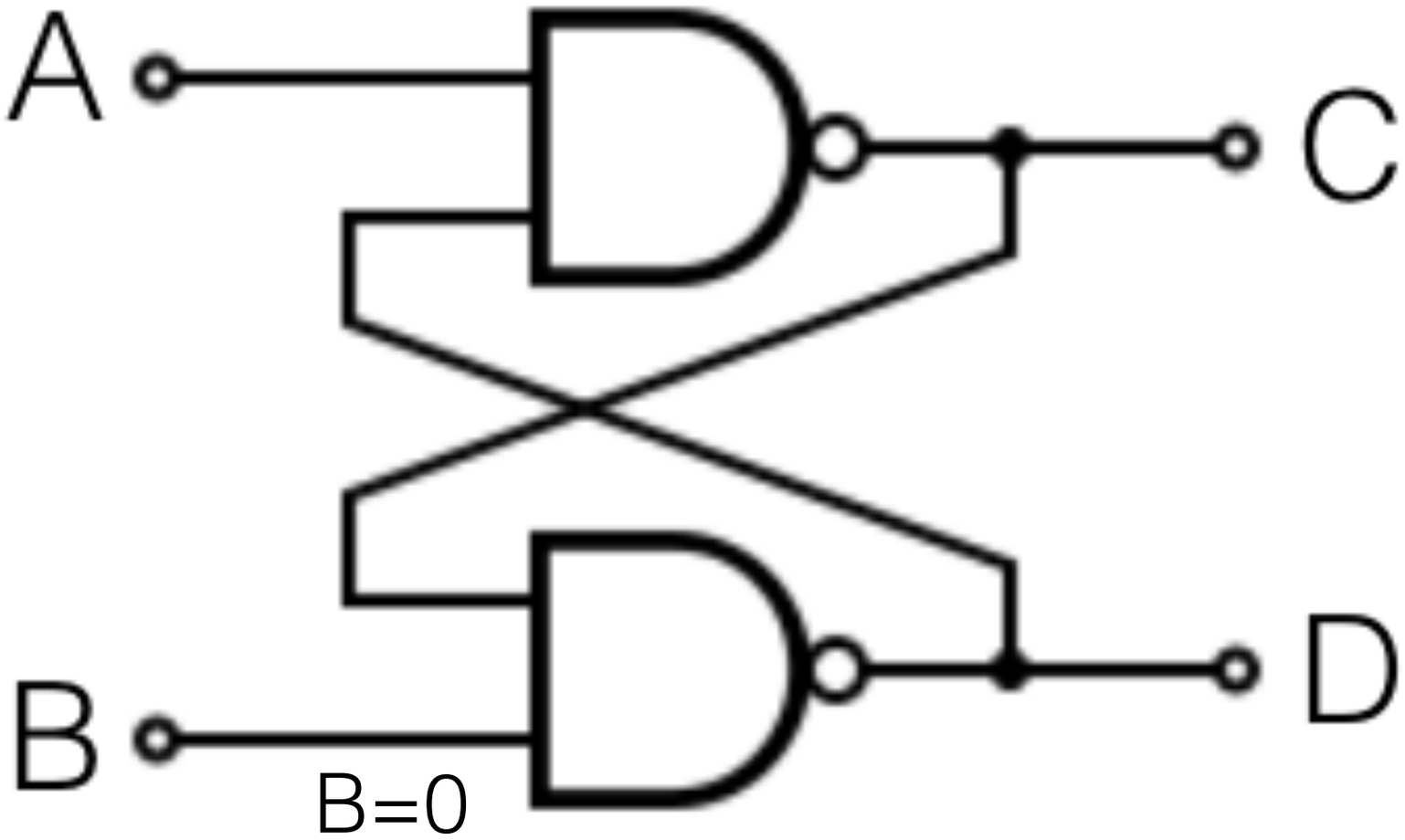
Flip flop

If either A or B is 0 then there is only one stable configuration



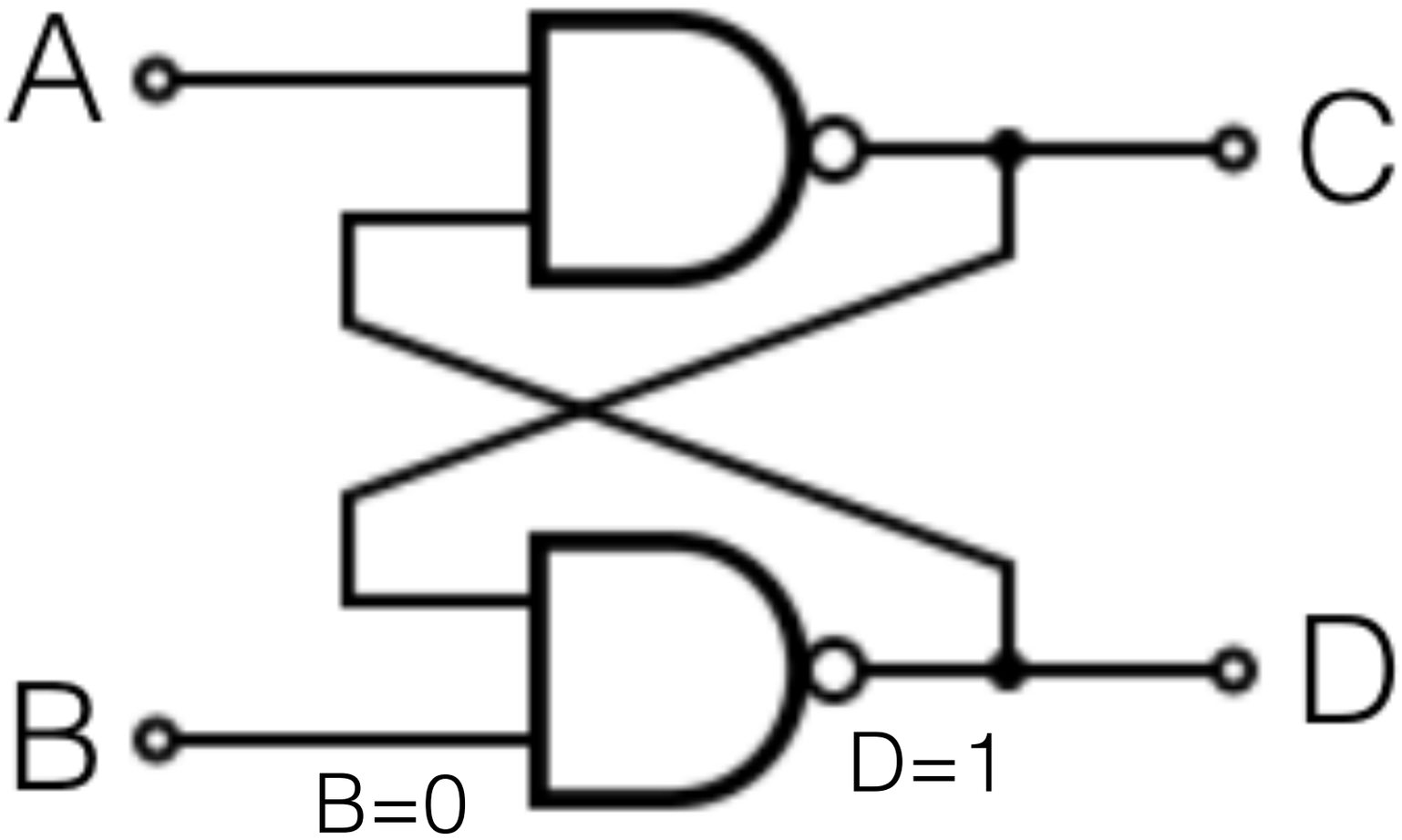
Flip flop

If either A or B is 0 then there is only one stable configuration, eg B=0, A=1



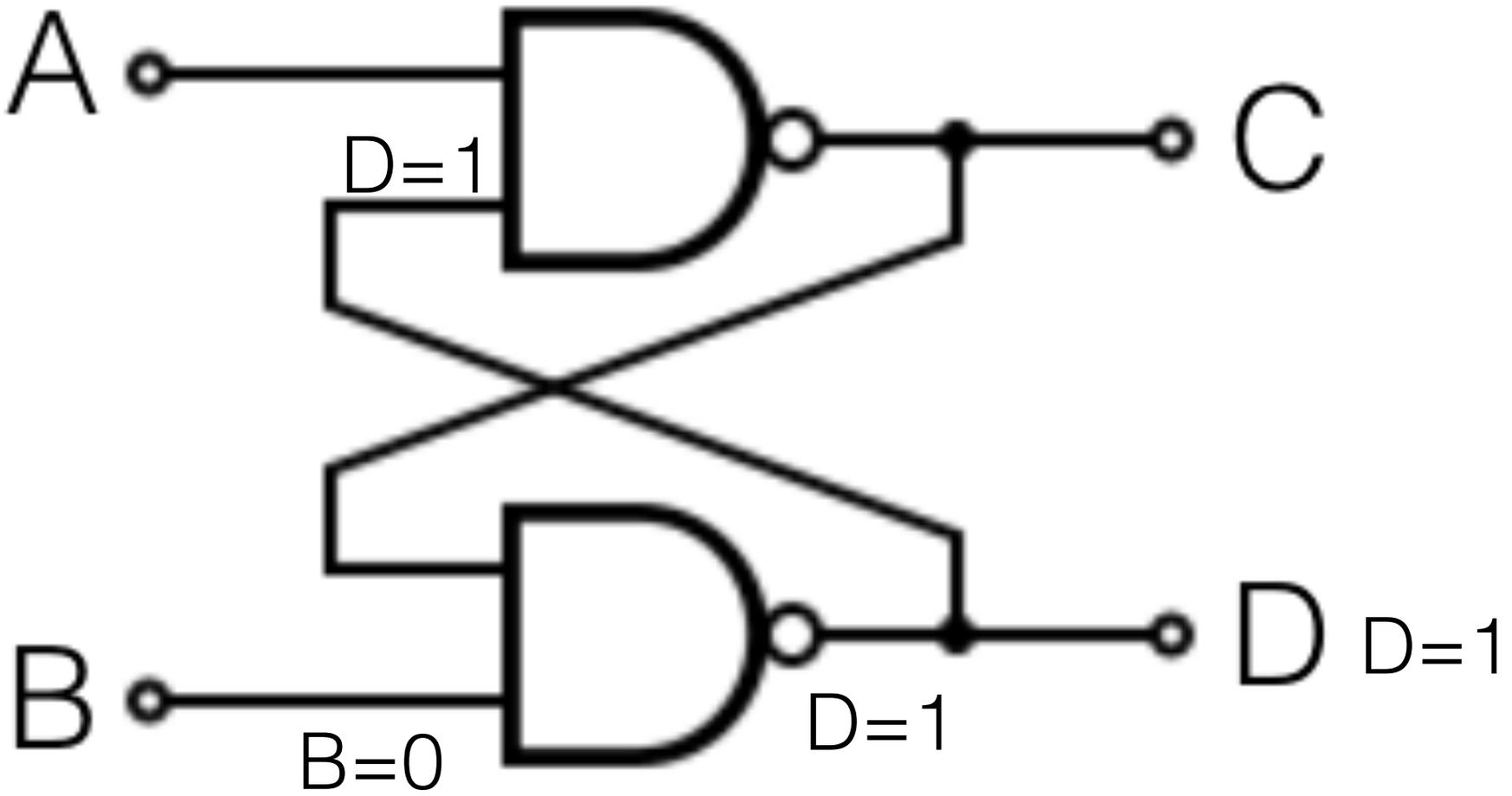
Flip flop

If either input to a nand gate is 0 then its output is 1



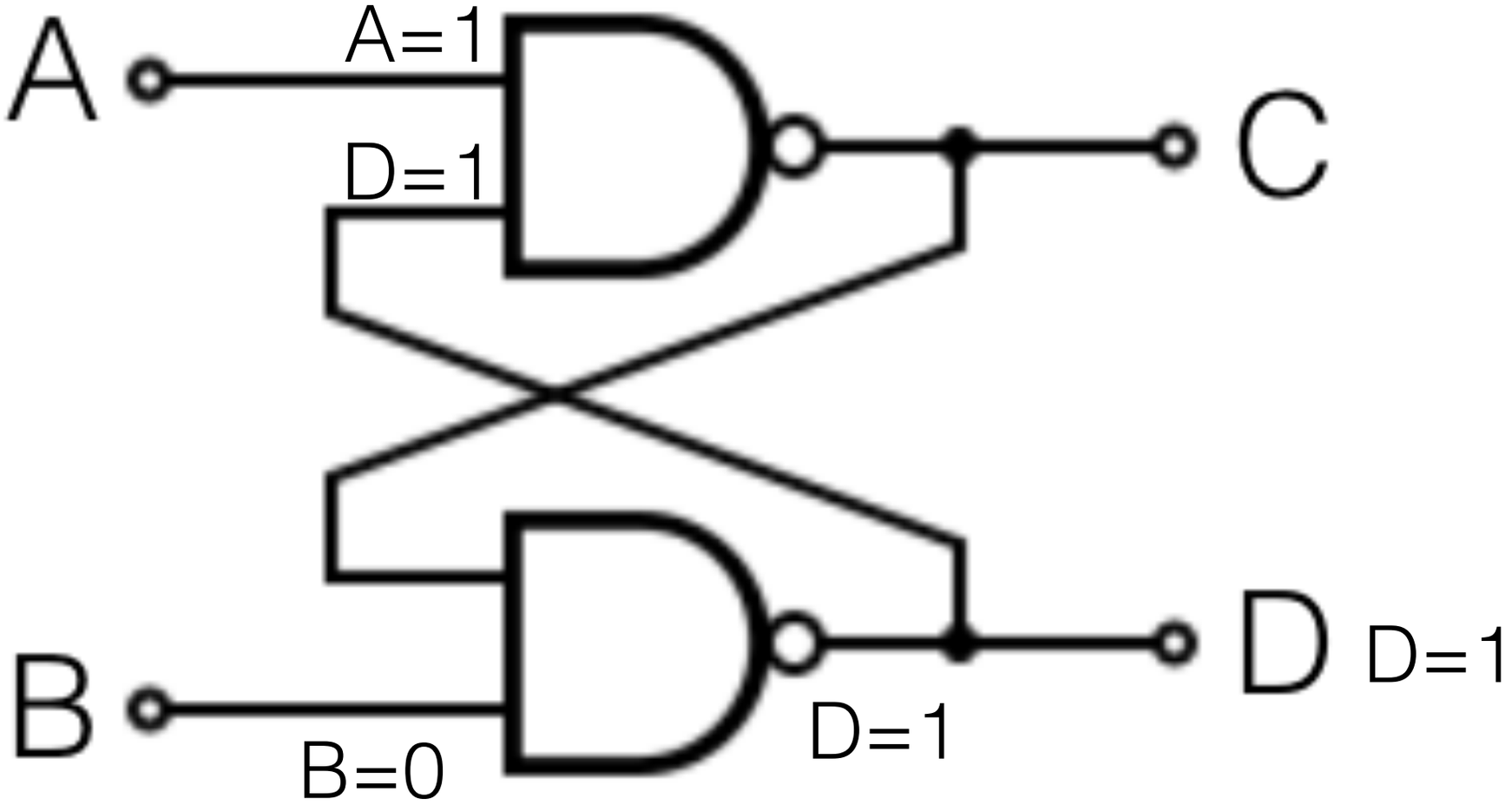
Flip flop

The potential flows through the wires



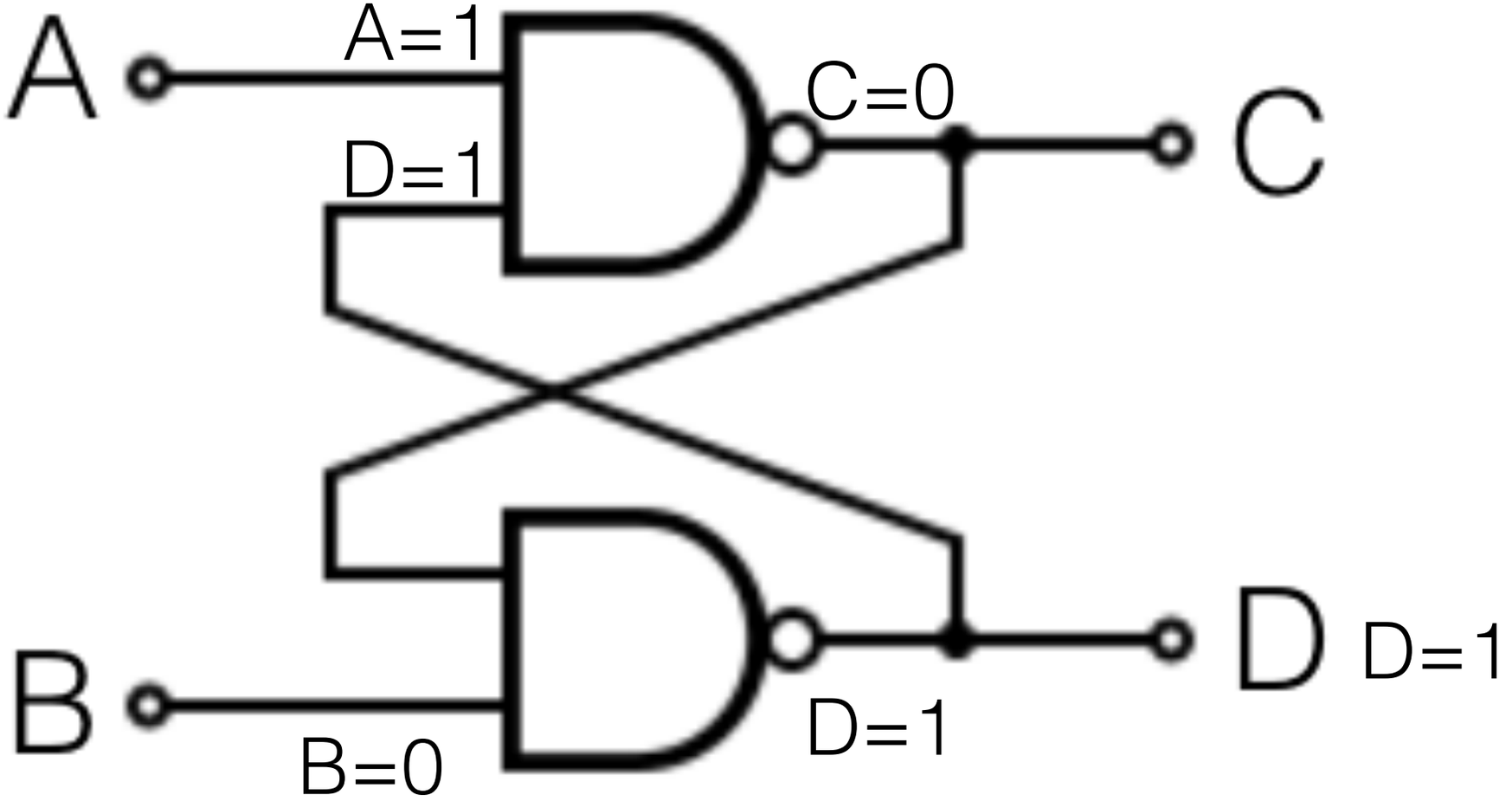
Flip flop

We said A was 1



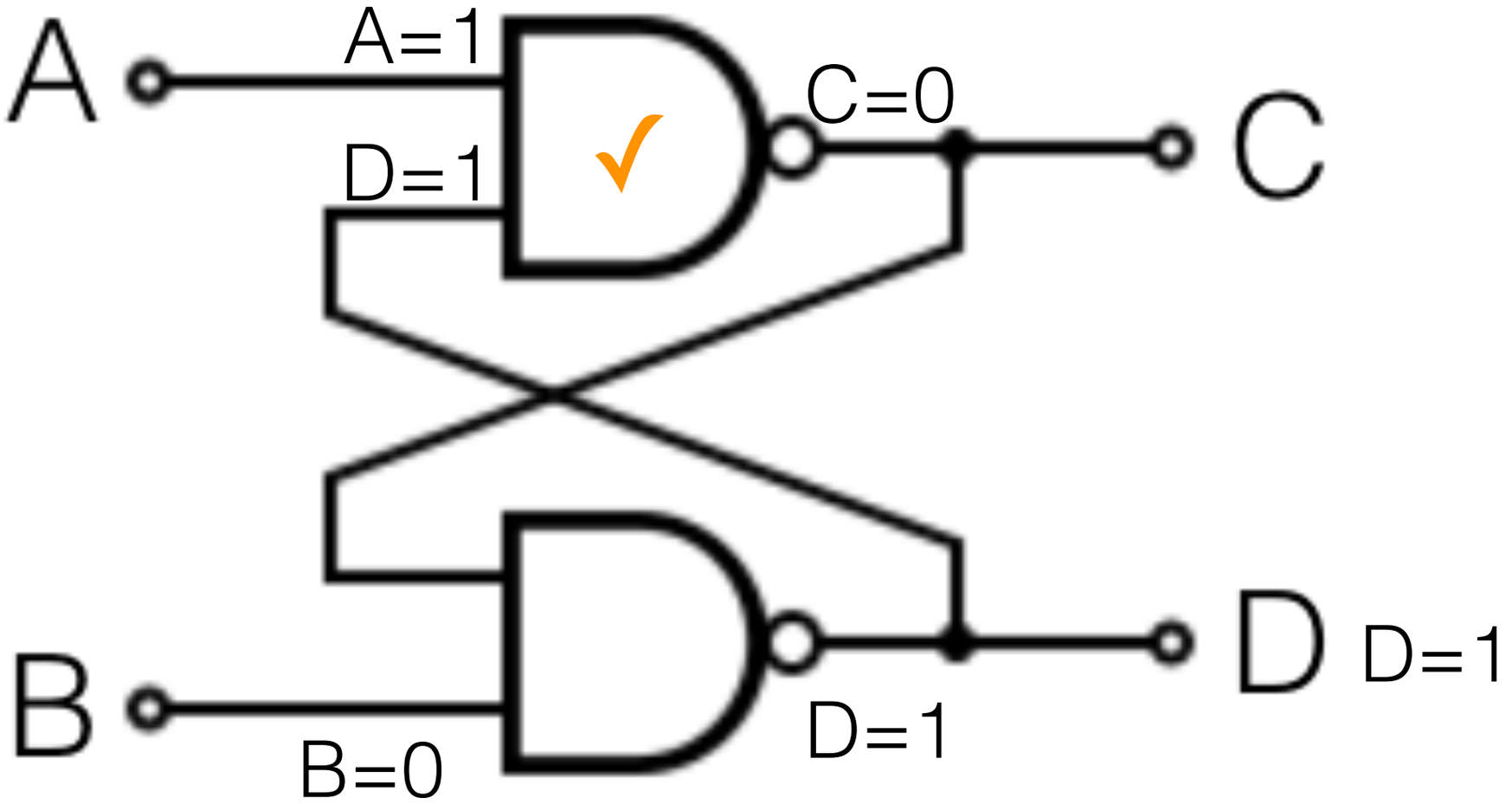
Flip flop

Output of top nand gate is 0



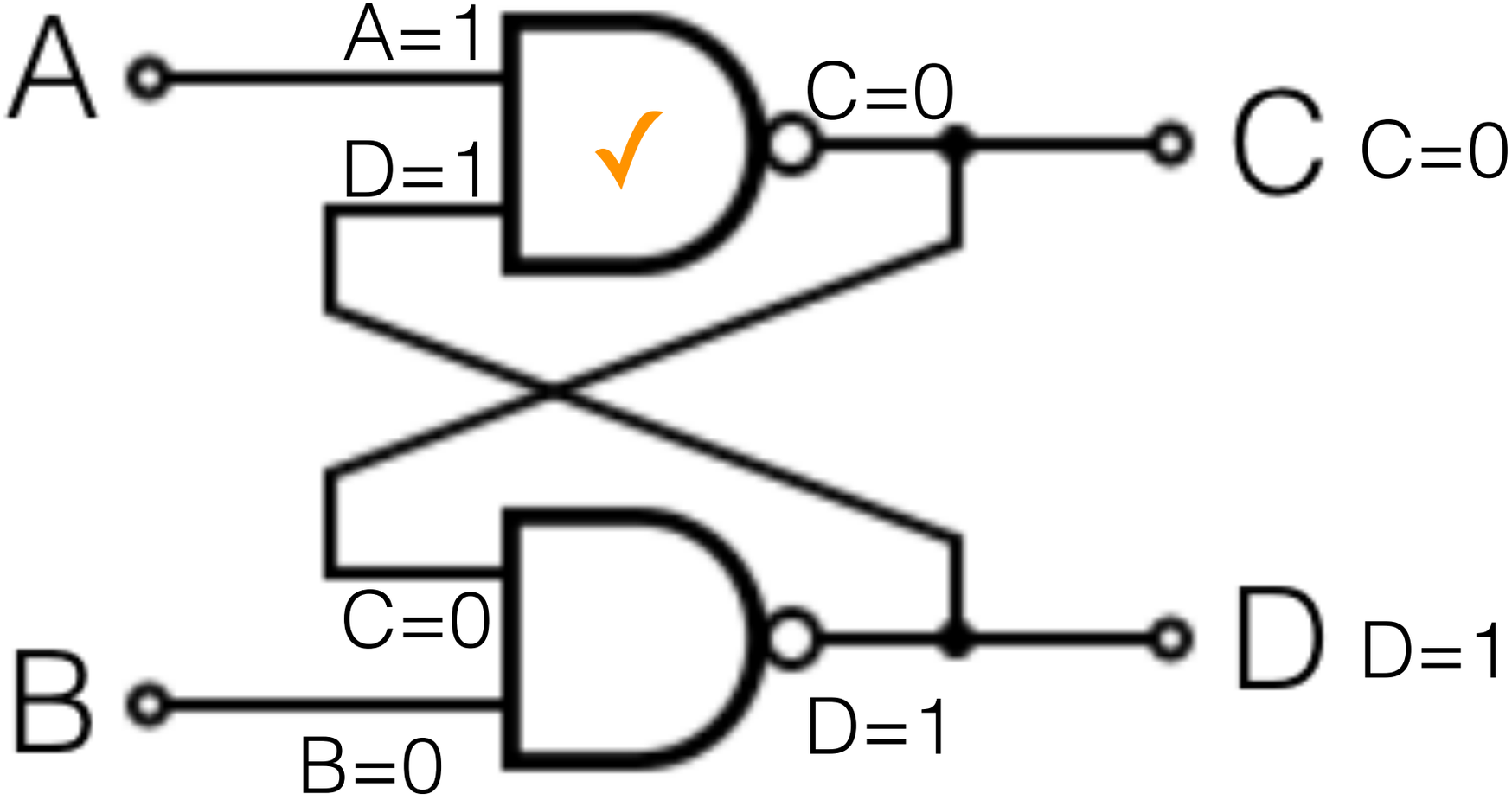
Flip flop

We can see all the wires into and out of the top nand gate and it is OK: inputs both 1, output 0



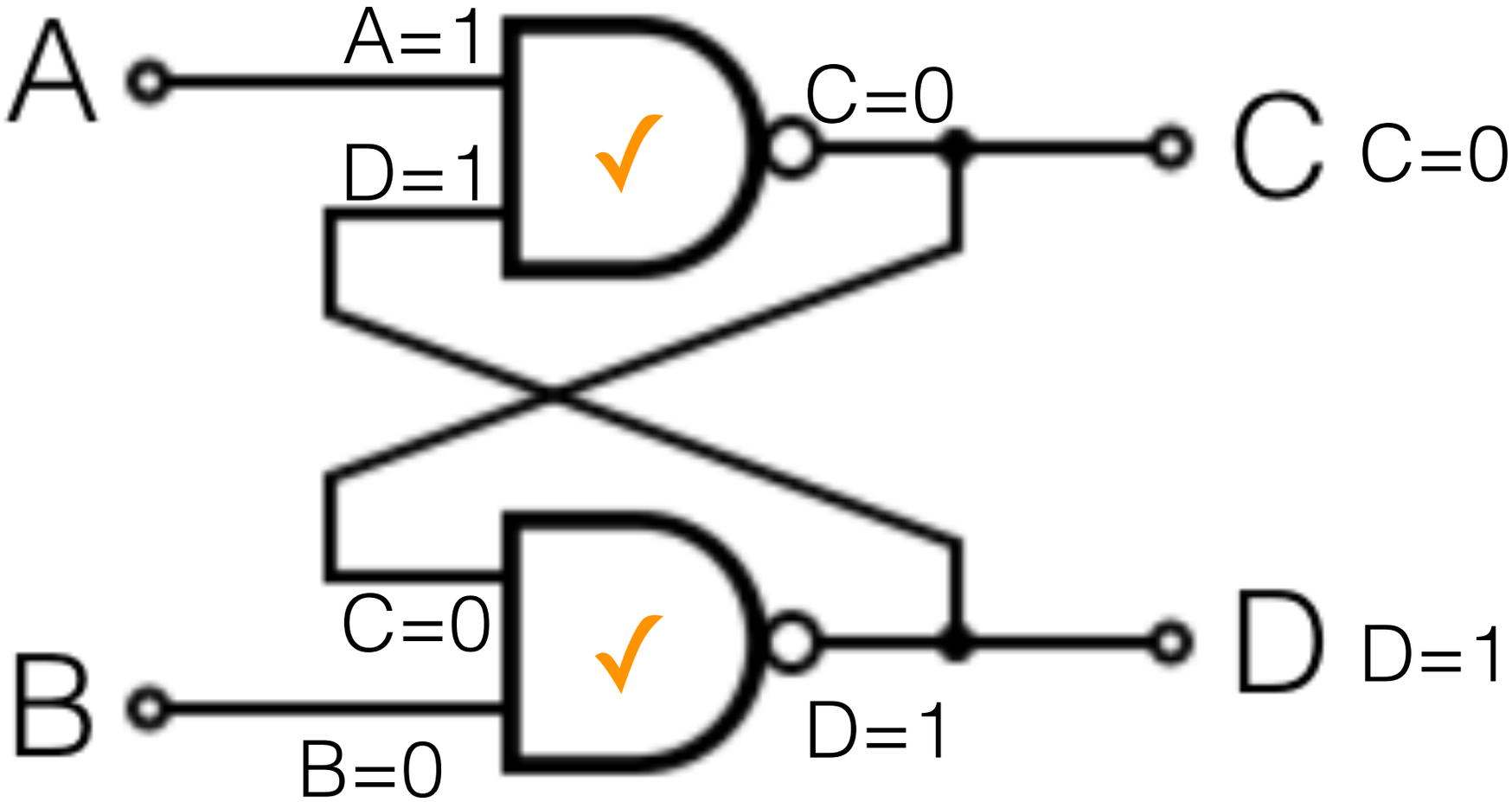
Flip flop

Potential flows through the wires.



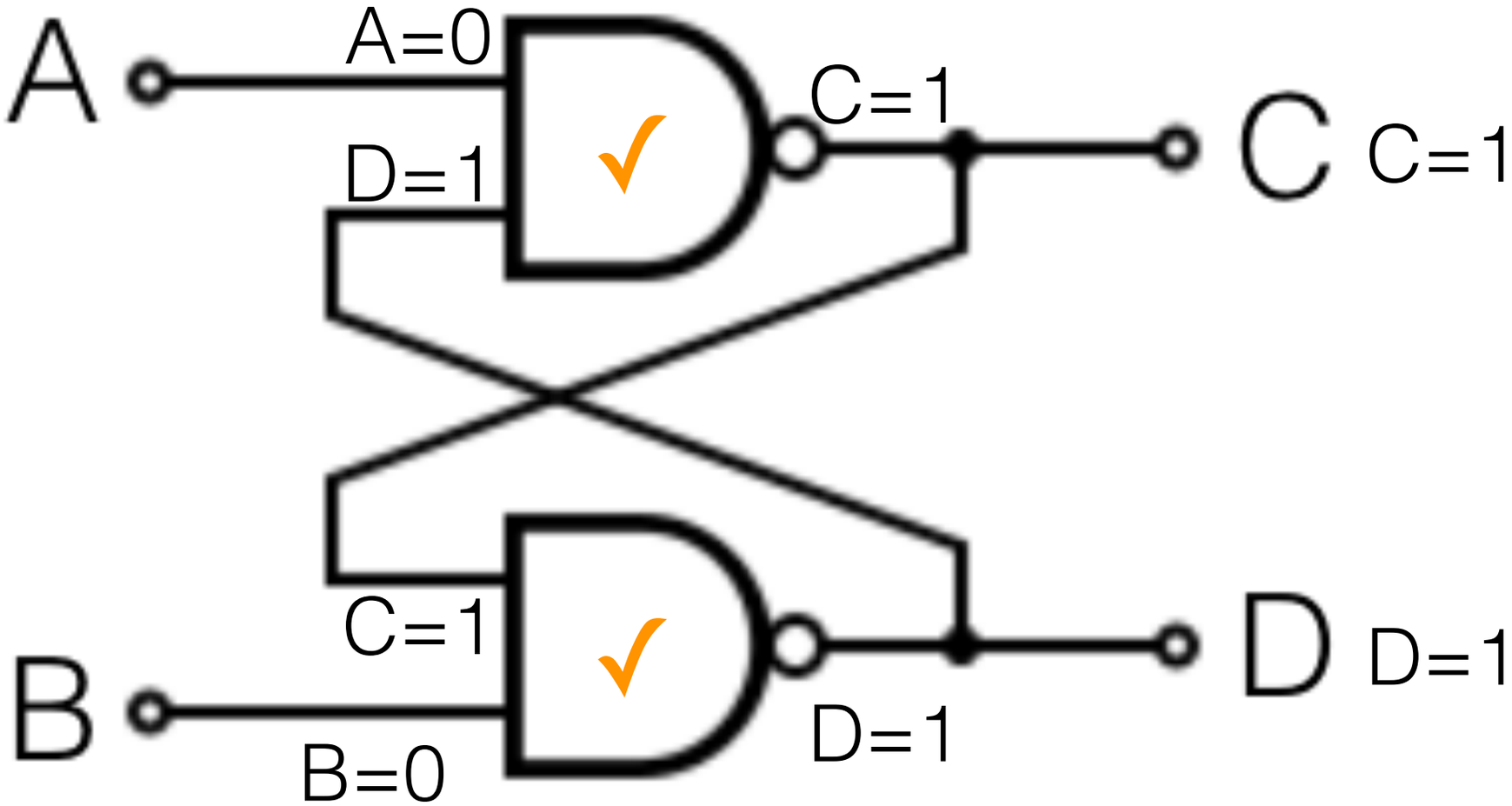
Flip flop

We can see all the wires into and out of the bottom nand gate and it is OK: inputs both 0 output 1



Flip flop

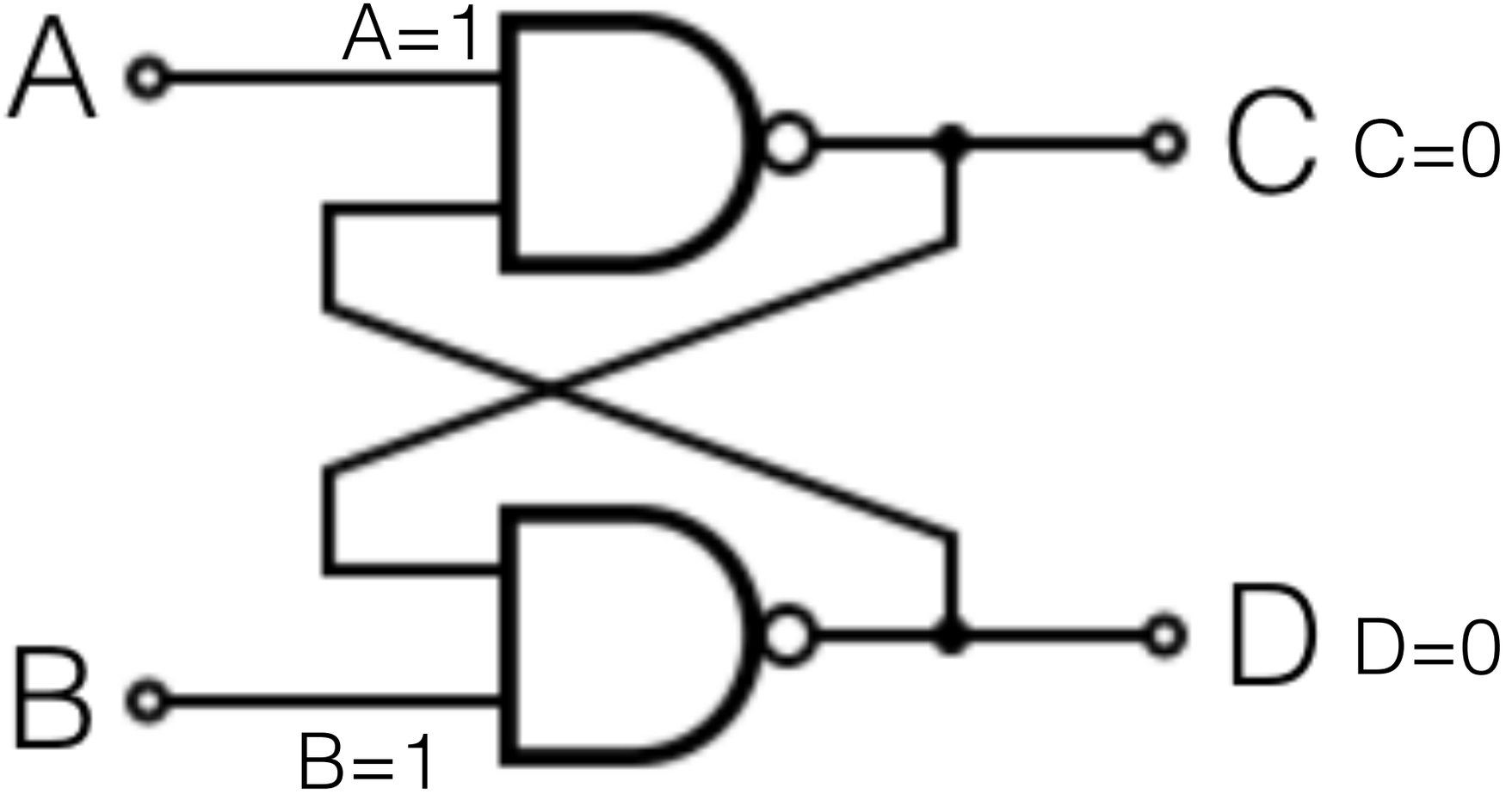
Similar result if A=0, but C is now 1



Flip flop

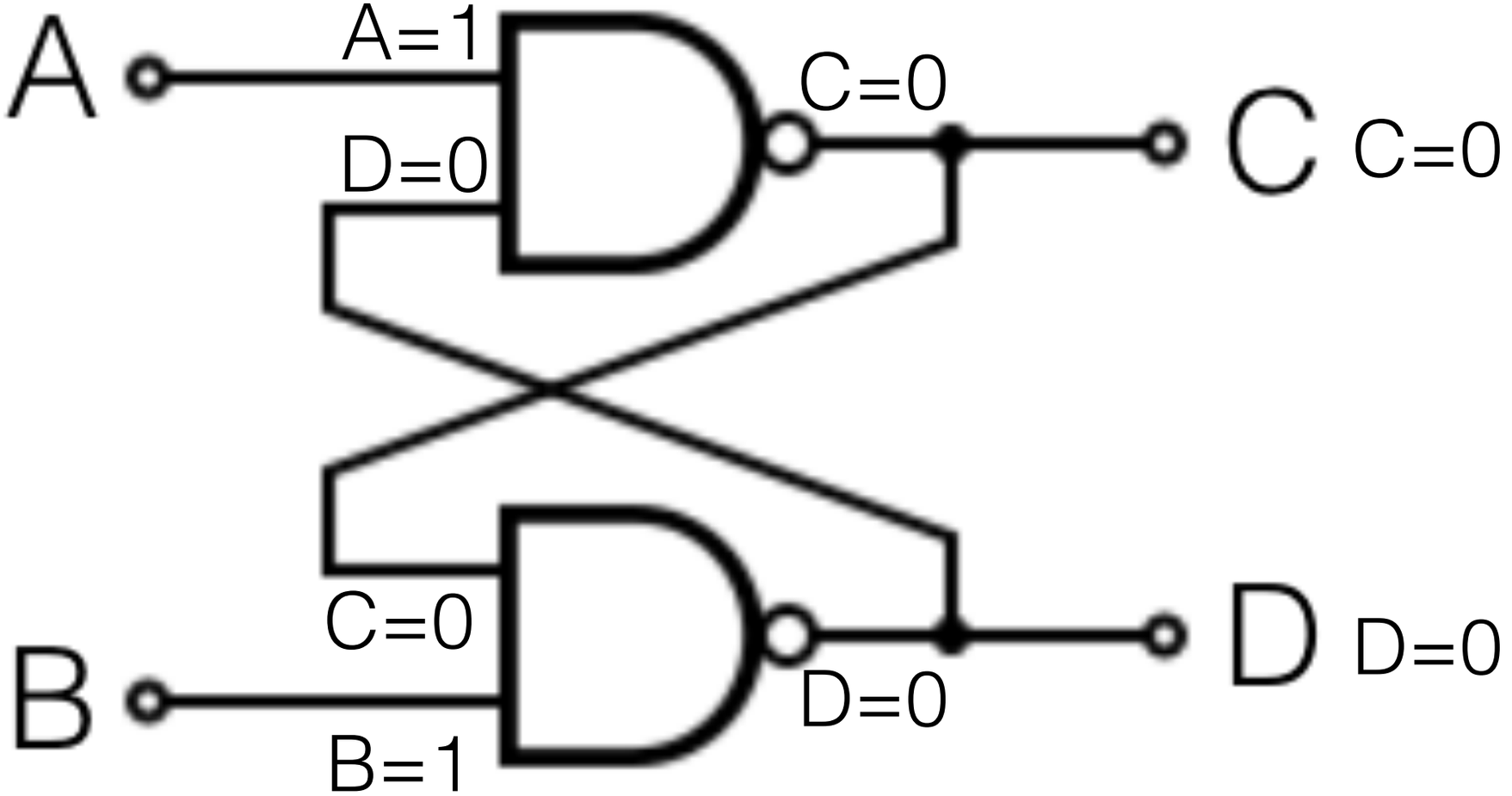
Now try with A=B=1.

There are four possibilities for C and D, try C=D=0



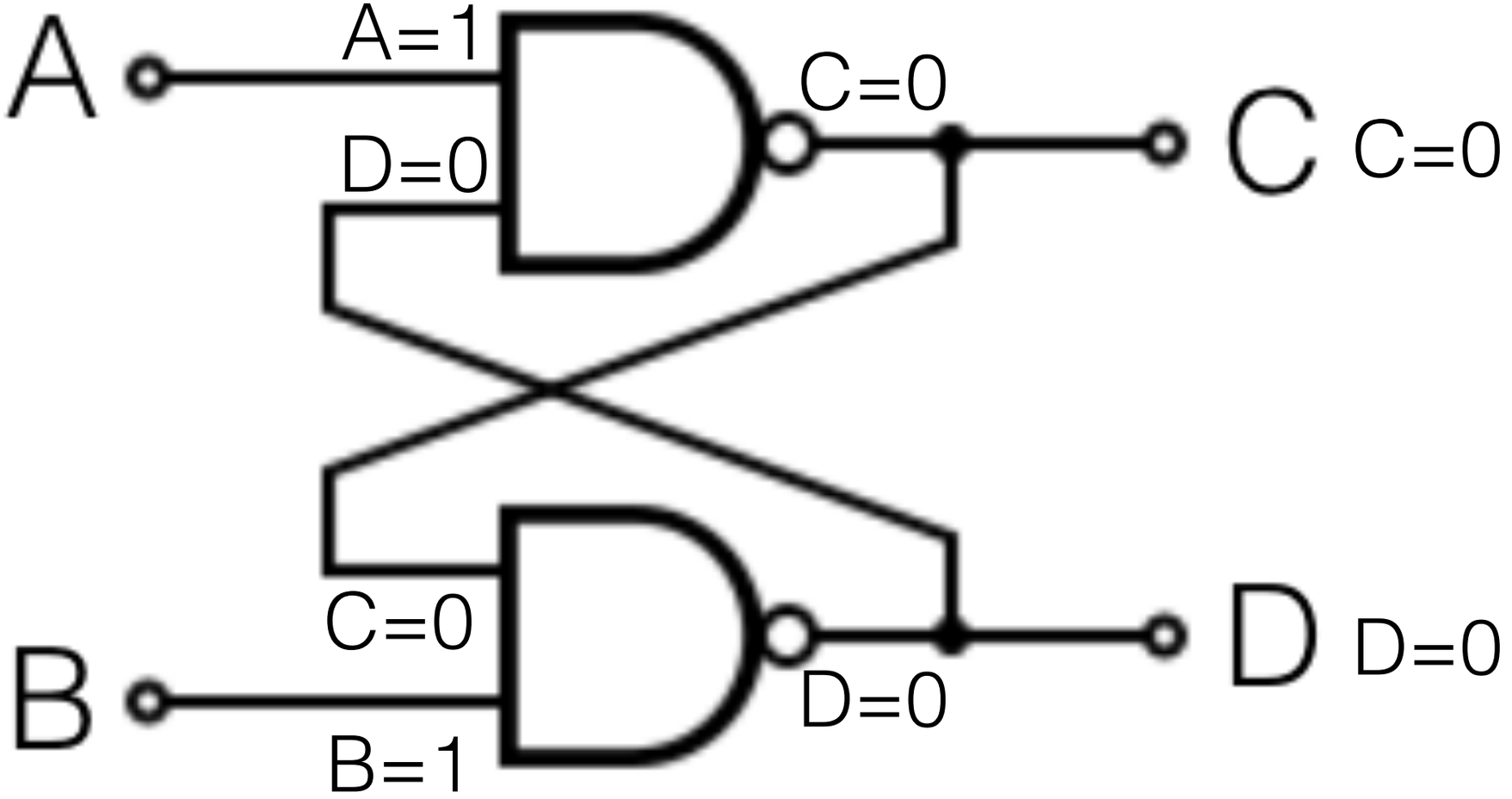
Flip flop

Potential along wires is same at any point.



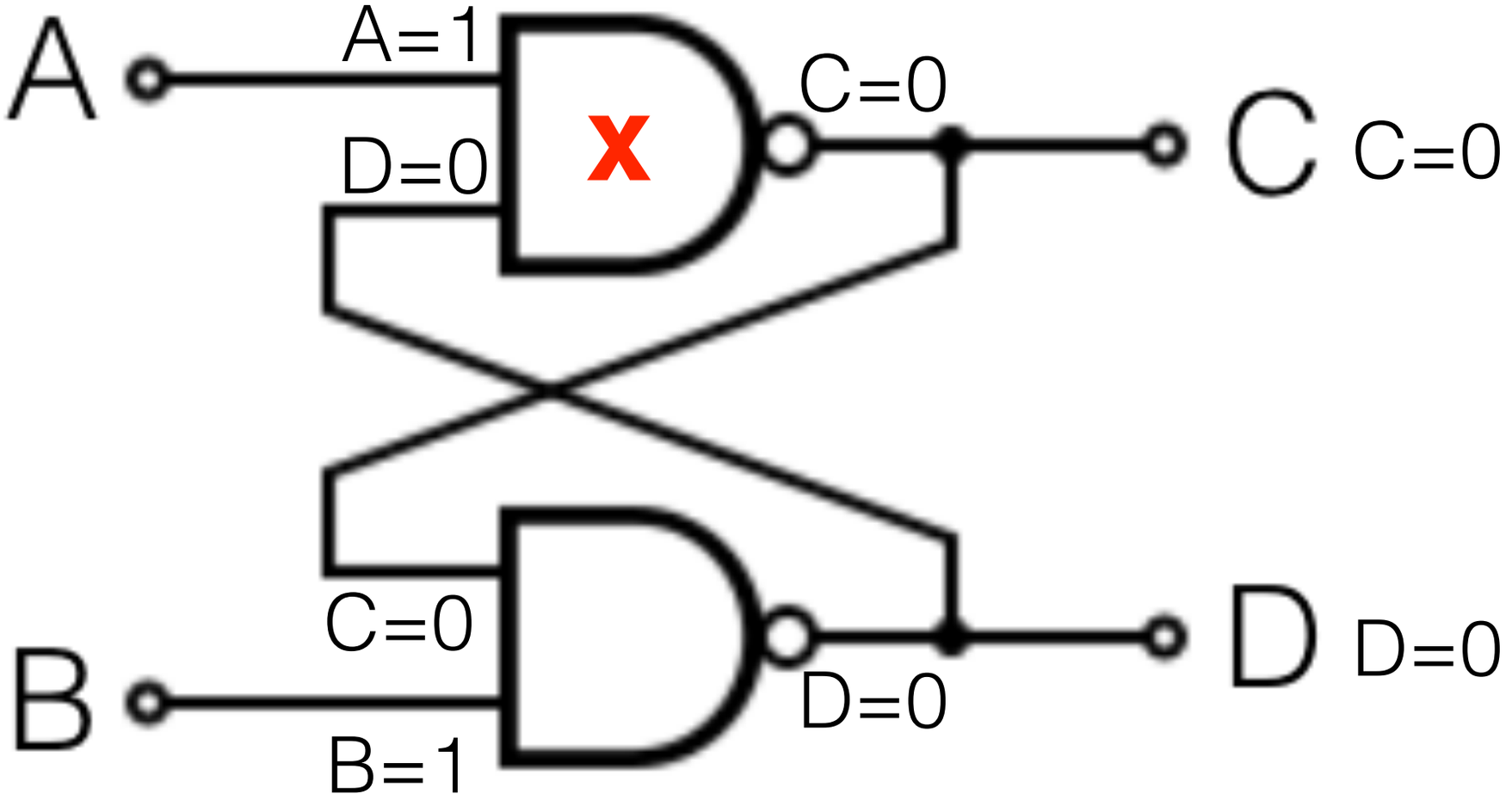
Flip flop

We can see all the wires into and out of the nand gates.



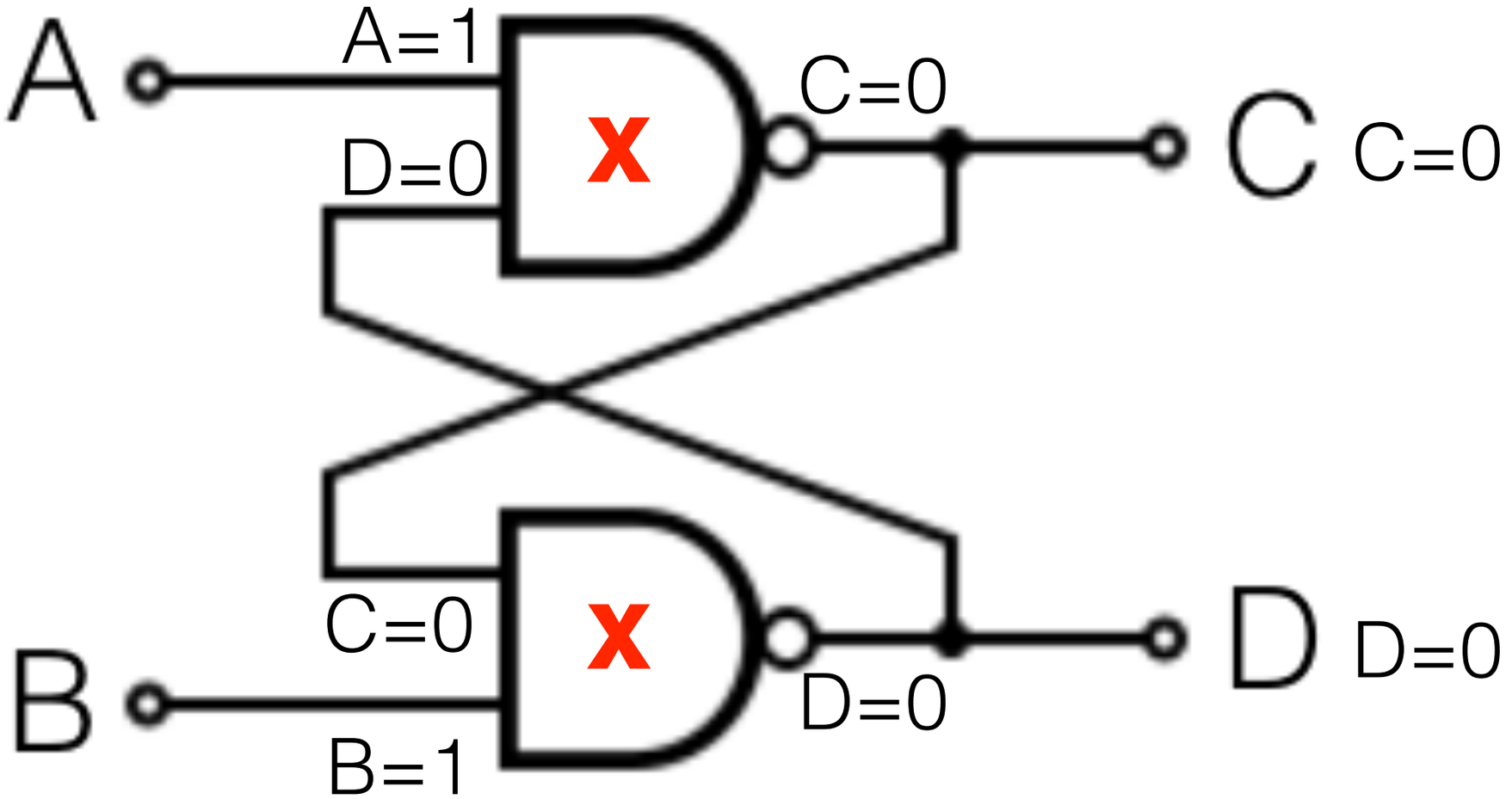
Flip flop

Top nand gate has inputs 1 and 0 output 1
It is not happy.



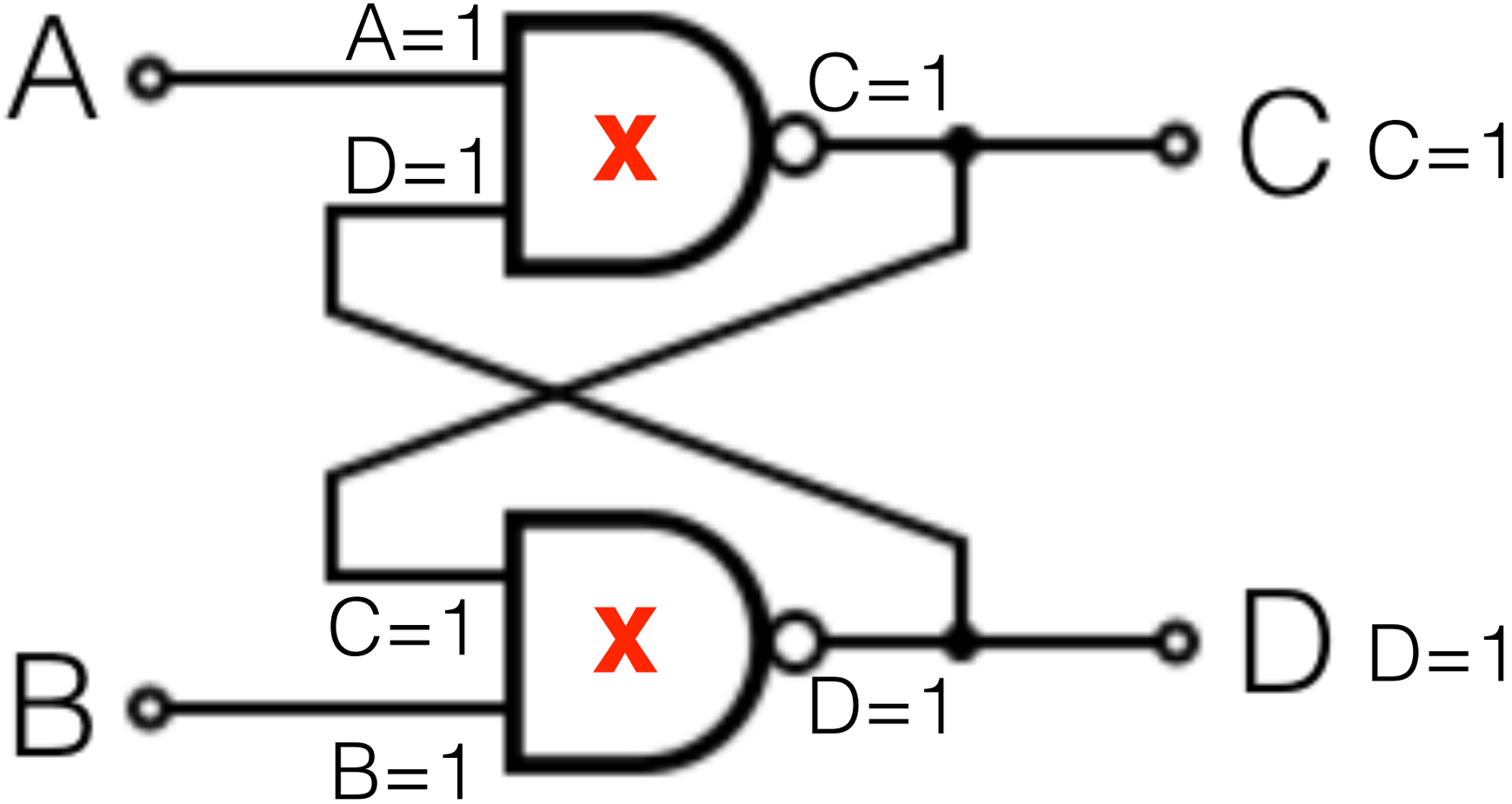
Flip flop

Bottom nand gate has inputs 0 and 1 output 1
It is not happy.



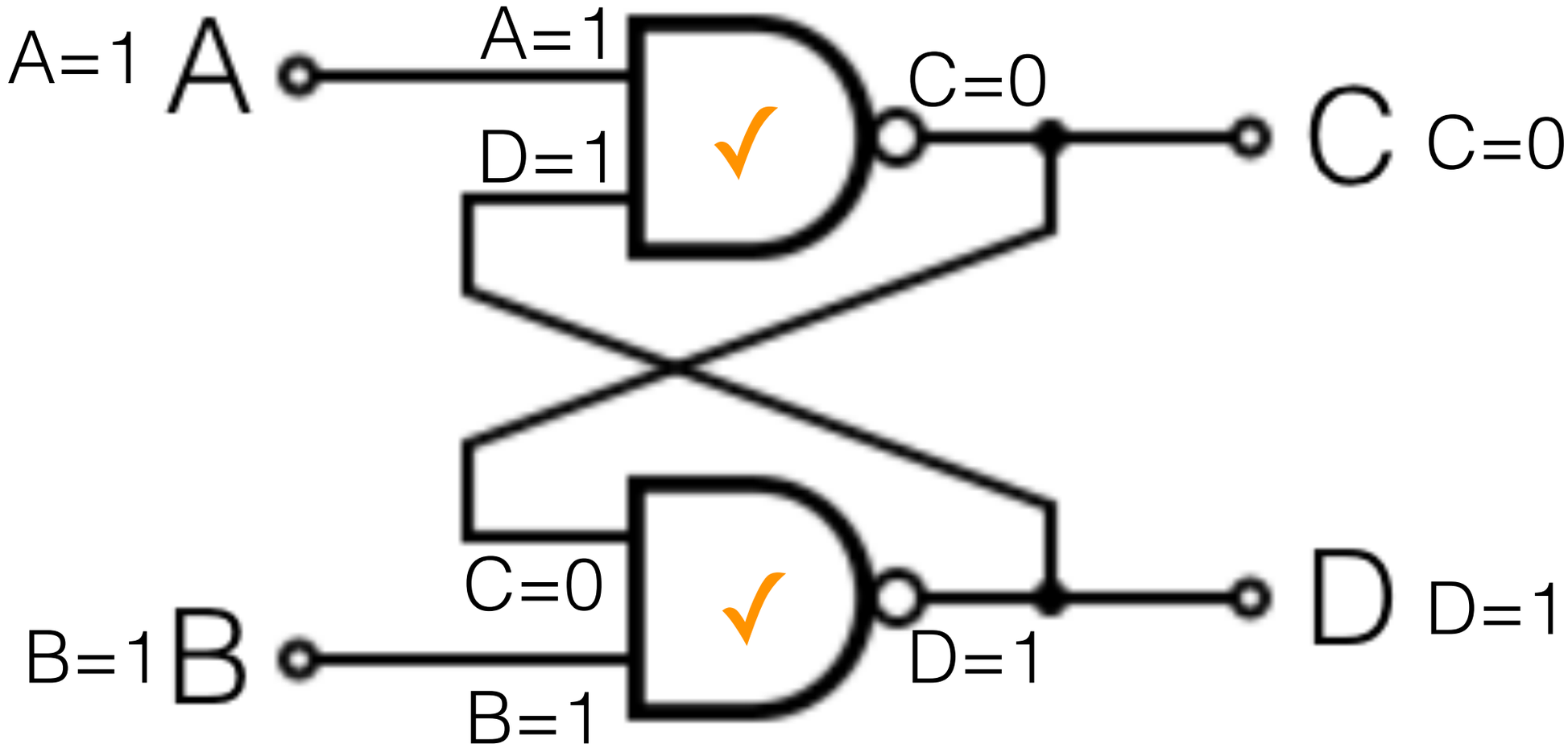
Flip flop

Similarly, if C=D=1, configuration is not stable.



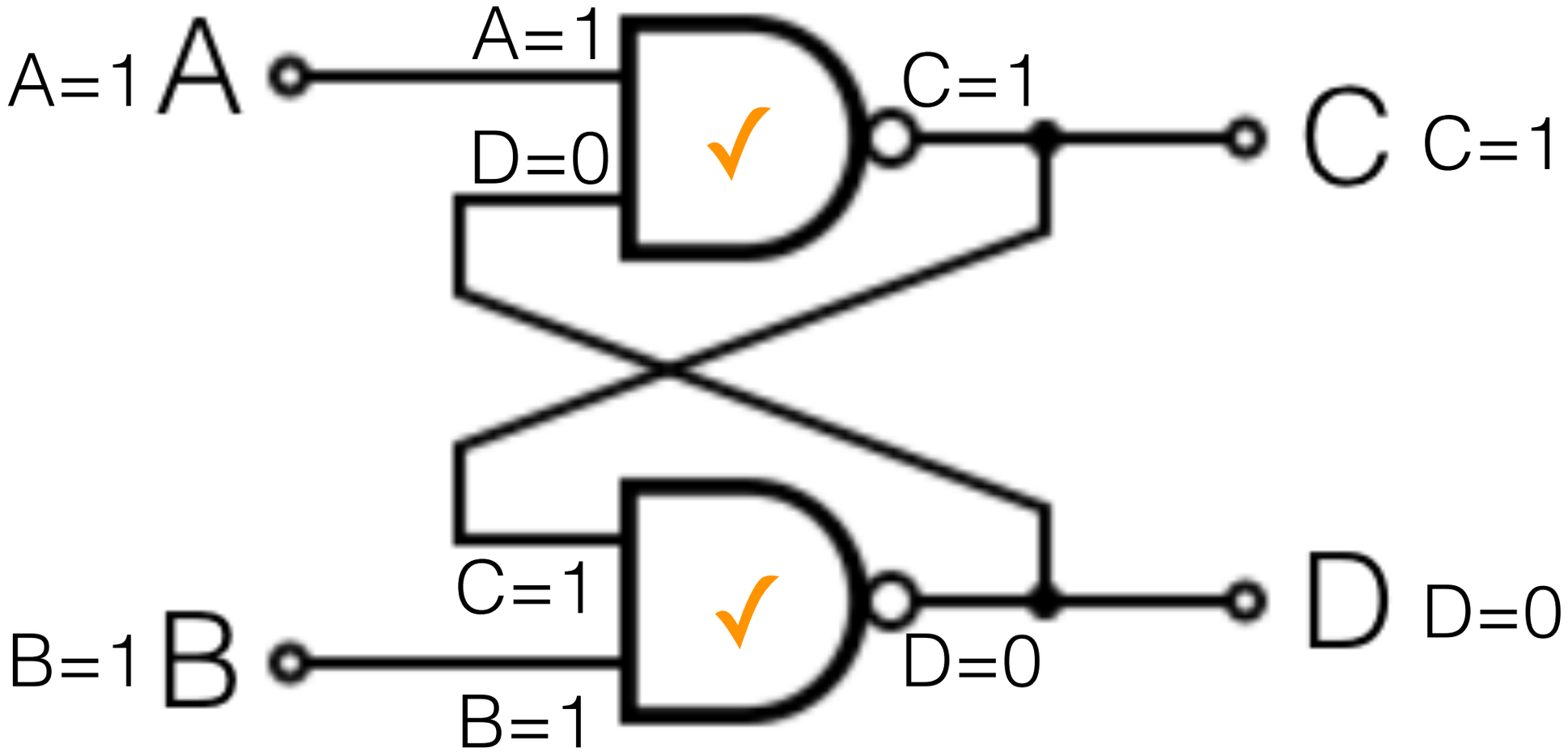
Flip flop

But if C=0 and D=1, configuration is stable.



Flip flop

But if C=0 and D=1, configuration is stable.



Flip Flop's stable configurations

A	B	C	D
0	0	1	1
0	1	1	0
1	0	0	1
1	1	0	1
1	1	1	0

Two possibilities when A=B=1

5. Design a circuit…

5. Design a circuit with two inputs AA and BB, and two outputs A and B that has the following behaviour: when AA = 0 and BB = 1 then A = 1 and B = 0; when AA = 1 and BB = 1 then A = 0 and B = 1; when BB = 0 then A = 1 and B = 1.

AA	BB	A	B
0	0	1	1
0	1	1	0
1	0	1	1
1	1	0	1

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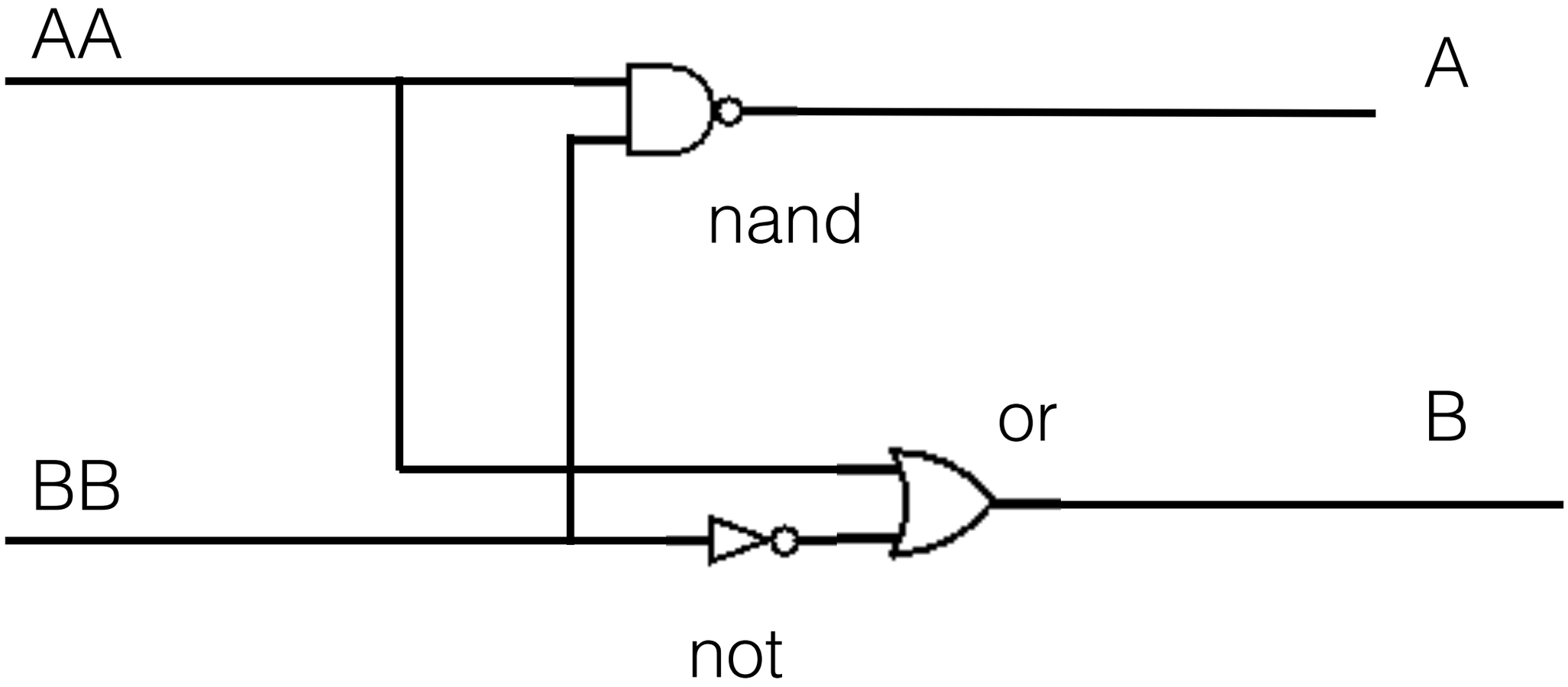
AA	BB	A	B
0	0	1	1
0	1	1	0
1	0	1	1
1	1	0	1

A = AA nand BB

B=AA or (not BB)

One way to build this is using standard gates



A = AA nand BB B=AA or (not BB)

Another way would be using transistors as earlier