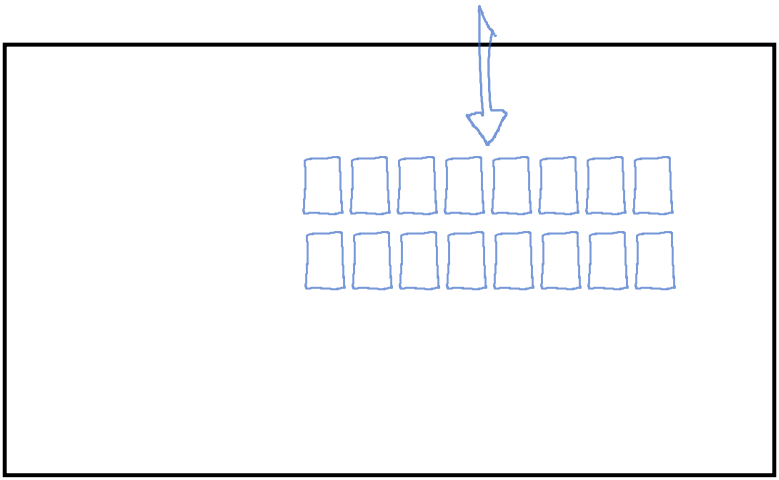
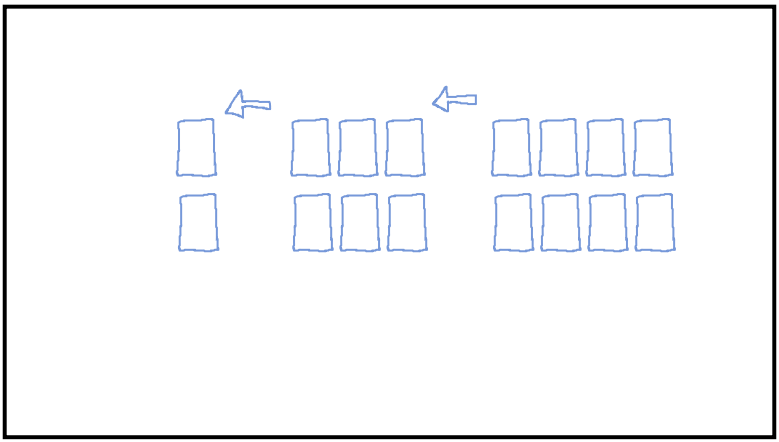
1



Two rows of eight boxes drop down from above.

VO: Say you want to add two 8-bit binary numbers.

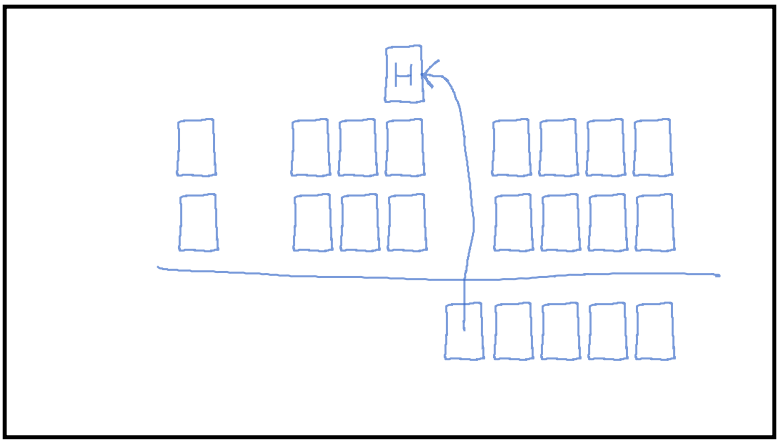
2



The columns separate.

VO: We first separate the digits into the lower 4 bits, the next 3 bits, and the high bit.

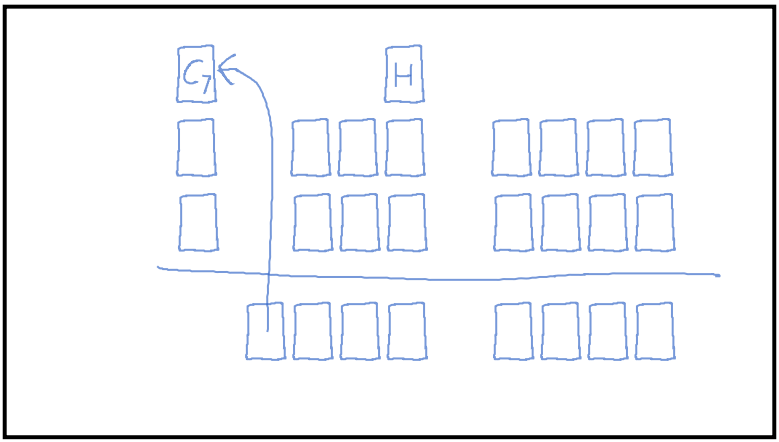
3



The line appears, then the five boxes under that appear. Then the fifth box on the left moves up, and an "H" appears inside.

VO: We add the bottom 4 bits, making a 5-bit sum. The fifth bit is the carry into position 4. This is the half-carry bit, and gets stored in the H flag.

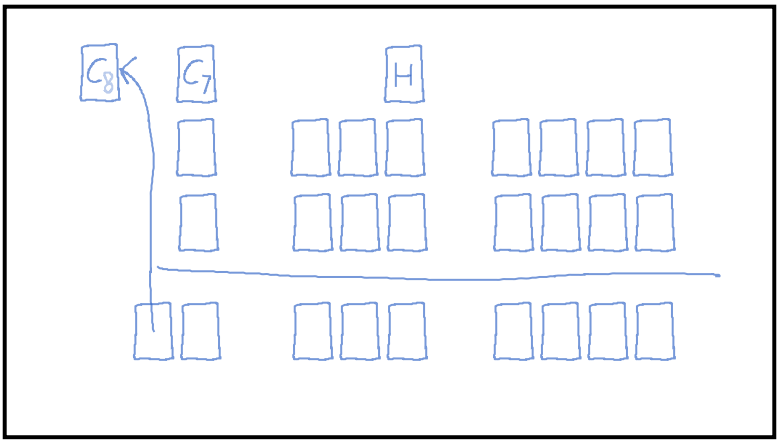
4



Four boxes under the line appear. Then the 4th box on the left moves up, and a "C" with subscript "7" appears inside.

VO: We then add the next 3 bits with the half-carry, making a 4-bit sum. The 4th bit is the carry into position 7.

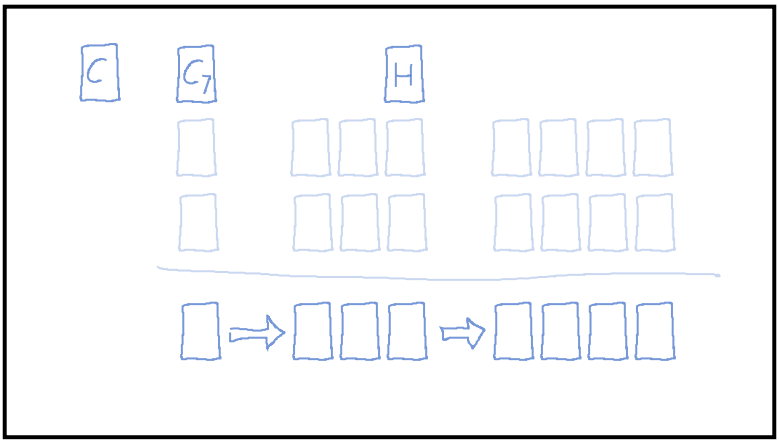
5



Two boxes under the line appear. Then the left box moves up, and a "C" with subscript "8" appears inside. Then the "8" fades away, leaving only the "C".

VO: Next we add the high bits with the position 7 carry, making a 2-bit sum. The 2nd bit is the carry into position 8. This is the carry out, and becomes the carry flag.

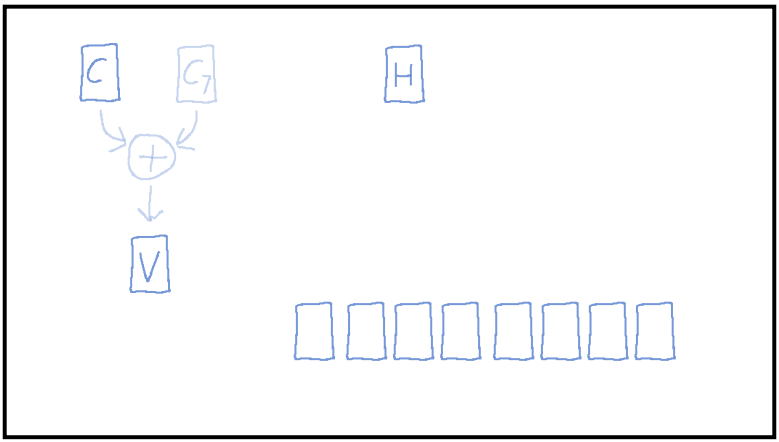
6



The original two rows fade away along with the line. The boxes on the bottom become a group of 8.

VO:

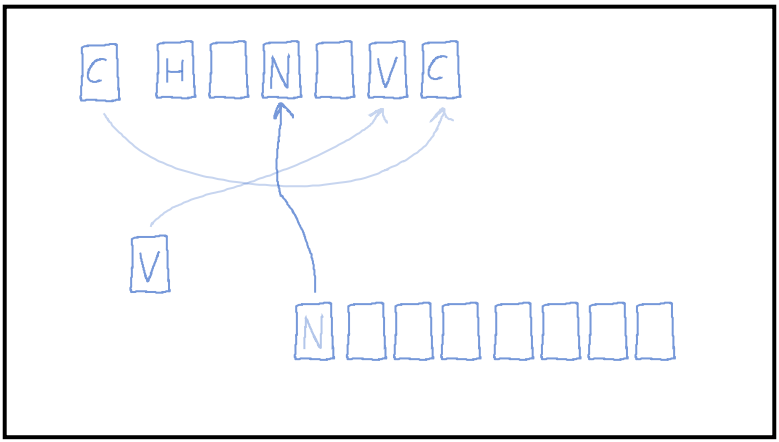
7



A circle with a plus inside appears, two arrows lead from C and C7 to the circle. An arrow comes out of the circle, and a box with "V" inside appears.

VO: The carry-out and the position 7 carry are exclusive-orred together, and this is stored as the V, or overflow, flag.

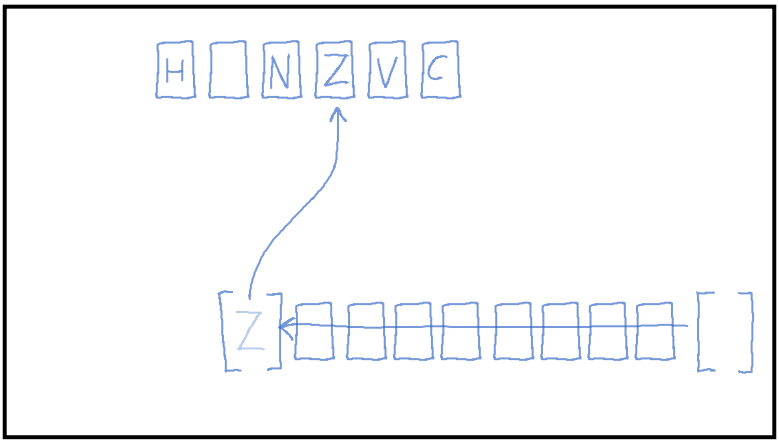
8



The H box moves to the left. Three blank boxes appear to its right. The V box moves to the right of those boxes, and the C box moves to the right of the V box. An "N" appears in the leftmost box of the bottom group, and duplicates itself. The duplicate moves to take its place in the middle blank box. The original "N" fades away.

VO: The N, or negative, flag, is simply the high bit of the sum, because in twos-complement arithmetic, negative numbers always have their high bit set.

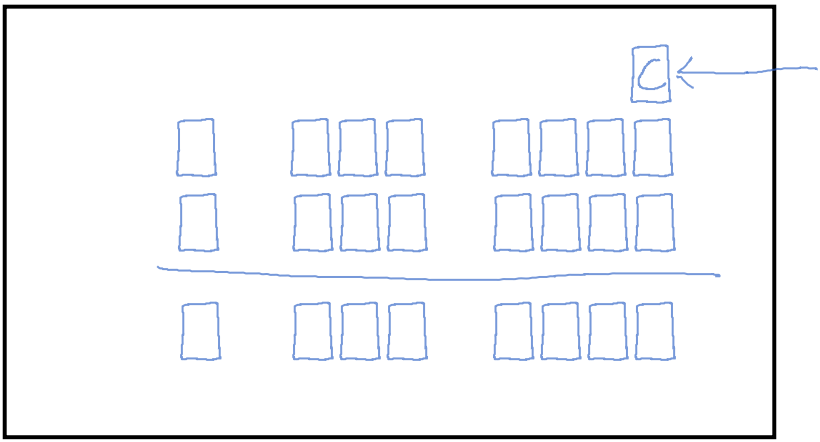
9



A pair of brackets appear on the right, then scans across the group of 8 boxes, stopping to the left. As it passes over each box, the box highlights and then dims. A "Z" fades in inside the brackets once it reaches the left. It duplicates itself, moves to its empty box at the top, then the original fades away.

VO: The Z, or zero, flag, is set if the result is zero.

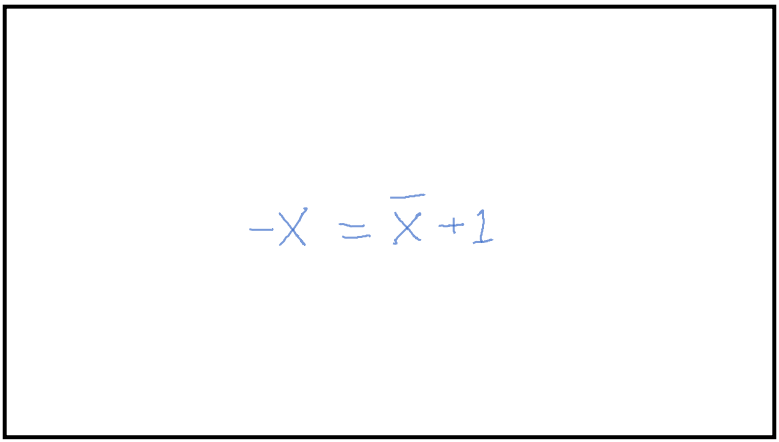
10



Fade out. Fade in. A boxed "C" moves in from the right to stop on top of the rightmost column.

VO: Add-with-carry works the same way, except we use the carry flag as the carry-in bit.

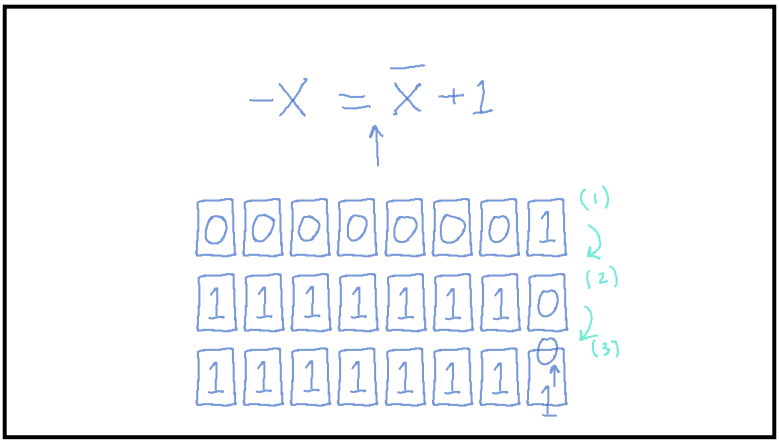
11



Fade out. An "X" appears, then a negative sign. They move to the left, and then the rest of the equation appears.

VO: Subtraction is almost the same, with a twist. In twos-complement, the negative of a number is the inverse of that number, plus one.

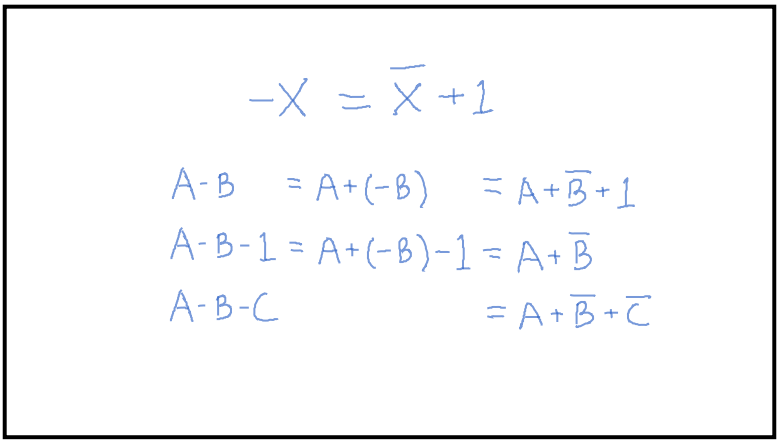
12



The equation moves up to make room for 8 boxes with "00000001" in them. The contents crossfade to "11111110" (i.e. 0 becomes 1, 1 becomes 0). Then the last zero rolls up odometer-like to become a "1", leaving the contents now at "11111111".

VO: For example, "one" would get inverted to 11111110. Then we add one, which makes negative one equal to 11111111 in 8-bit twos-complement.

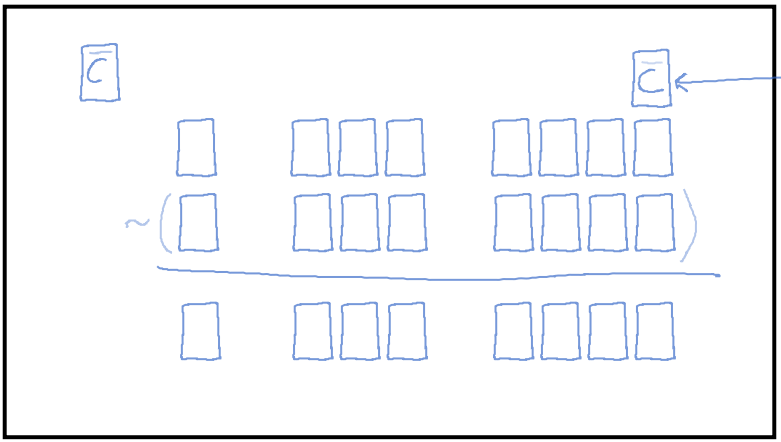
13



Three more equations appear, one by one. Note the alignment of terms.

VO: To compute A minus B, we add A plus negative B, which is A, plus the inverse of B, plus one. Subtract with carry, if carry were one, additionally subtracts one. So we can see that to subtract with carry, we add with carry, except the carry-in to use is the inverse of the carry-in we want.

14



A boxed "C" moves in from the right. Then the "C" gets a line above it fading in. Then the second row gets parentheses fading in around it, with a vertically-centered tilde to its left. Then the "C" in the box on the left gets a line above it fading in.

VO: One final twist. After we invert the carry-in and the addend, the carry-out, after all flags, including overflow, have been calculated, is also inverted.