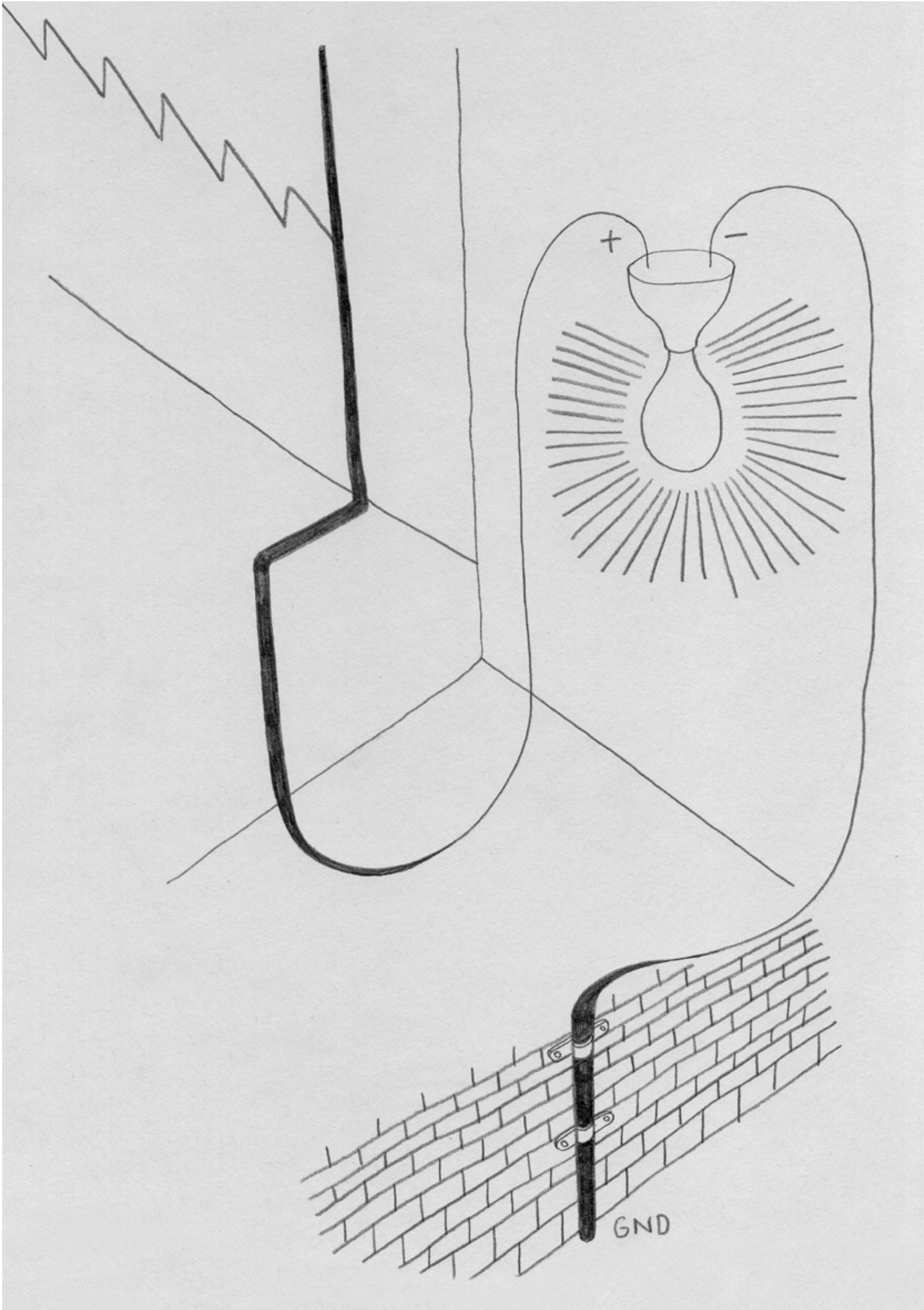

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Cover image: *From Bolt to Bulb*, 2014, pencil on paper, 29.5 × 21 cm

A drawing by the author for an installation in which the striking of a lightning rod attached to the roof of a building powers a 100W light bulb for three continual months

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Every summer at the end of the Christmas holiday, my family and I would embark on a long hike with the goal of reaching the top of Mt. Kosciuszko, the tallest mountain in Australia. Even in ideal conditions, we inevitably failed to summit — the walk is quite far — but in 1990, despite our less than perfect track record and an ominous weather report, we determined to attempt the journey once again. The icy hail blowing like frozen peas against our faces seemed like a fair warning, yet we pressed onward, up the slope along a rusty, metal-treaded path. When my father finally signaled for us to retreat, I was walking a few paces behind him and my brothers, along with my mother and my two sisters. I ran to catch up, turning my head back towards my sisters and mother just in time to see them silhouetted by a violent flash of light. I regained consciousness some minutes later, terrified and confused to find myself in the arms of a stranger, surrounded by a gathering crowd. Through a fence of legs, I caught half glimpses of my sister, struggling in agony as still other strangers held her down. Her clothes were burned to tatters. Being exposed on the mountain combined with the metal path attracted the lightning towards her.

If you were touched by lightning and lived to talk about it, you could show off your Lichtenberg Figure, a spray of branching, rose-quartz-colored burn marks named after German scientist Georg Christof Lichtenberg. A typical figure forms a tree that extends from a thick central trunk, zigzagging in every direction as each branch withers to nothing. The marks arise when capillaries burst following a strike. They appear remarkably lightning-like. It's as though the electrical shock of the strike reveals the corresponding circuitry hidden deep within the body, leaving behind something of a tattoo, or, considering that the marks fade after a few days, more of an electrical hickey. An image of a figure found on the Internet shows what appears to be a bad case of sunburn. Sampling the mark with the Photoshop eye-dropper tool returns the color code "EB4747".

In German, Lichtenberg translates to "lit mountain" — a rather unbelievable coincidence. Lichtenberg, an experimental physicist before the letter, has become famous for his extensive collection of notebooks containing personal philosophy, scientific theories, and aphorisms. In 1777, he built a large static electrical generator two meters in diameter. He then directed the high voltage shock which discharged onto a dielectric surface, likely a kind of silicone or resin, and applied dust to fix the image created by the transfer — a process not unlike making a photocopy. In fact, xerography, invented by Chester Carlson in 1938, was based on Lichtenberg's process of static dry transfer. Lichtenberg was also a promoter of Benjamin Franklin's lightning rod experiment, and was sufficiently impressed by it to import the idea to his home in Göttingen. However, the experiment was first recorded in France during the spring of 1752 by Thomas-Francois d'Alibard. To test Franklin's theory that thunderclouds are electrified, d'Alibard stood on a platform inside a sentry box insulated from the ground while holding a nine-meter iron rod. Franklin's instructions noted that "if the electrical stand be kept clean and dry, a man standing on it [the platform] when such clouds are passing low might be electrified and afford sparks, the rod drawing fire to him from the cloud." Sparks were indeed observed to jump from d'Alibard's iron rod during the thunderstorm, proving that thunderclouds contain electrical charge. Soon after, the experiment was successfully repeated in France, in England, and in Belgium, before Franklin fully appreciated the danger — if the rod were directly struck by lightning, the experimenter would almost certainly die. In July 1753, Dr. G.W. Richman, a Swedish physicist working in Russia, held up an experimental rod and was killed by a direct lightning strike. Franklin subsequently re-designed the test as the iconic kite experiment we know today. Meanwhile, the name Lichtenberg lives on as the title of a round impact crater on the moon, itself composed of silicon and dust.

EB4747, the particular red sampled from the image of the lightning strike victim, is one red among many millions of reds, and only one of a hundred million colors a screen can display, but it is not the entire picture. The image is made from thousands of different color pixels, each with its own corresponding number. 6A4242, for example, is a kind of swampy maroon, while BE9FA4 could qualify for the equally murky designation of beige. Type in EB4748 to see the color closest to EB4747, a red virtually indiscernible from its neighbor. Though the codes seem random, they derive from a common source: *hexadecimal* notation.

When we count, we typically use a *decimal* or "base ten" system. The individual numerals making up "478" for example, fit into a series of columns, each ten times larger than the one preceding, working from right to left. If we split the whole number into columns such as 4|7|8, 8 sits in the ones column, 7 in the tens column, and 4 in the hundreds column: four hundreds, seven tens, and eight ones. Hexadecimal is "base 16," which means each column is multiplied by 16, so that starting on the furthest right is the ones column, then the sixteens column, then the two-hundred-and-fifty-sixes (16×16) column, the four-thousand-and-ninety-sixes (16×256) column, and so on. To mark its 16 discrete values, hexadecimal notation uses the numerals 0–9 followed by the letters A, B, C, D, E, and F to represent numbers 10–15. By this logic, the digits "478" in decimal converted to hexadecimal is expressed as 1DE: $(1 \times 256) + (D \times 16) + (E \times 1) = 478$.

Swedish-American civil engineer John William Nystrom called hexadecimal "the tonal system" in his 1862 paper, "Project of a New System of Arithmetic, Weight, Measure and Coins Proposed to be Called the Tonal System, with Sixteen to the Base."

In his tonal proposal, Nystrom developed names for the digits, calling zero "noll" and counting from 1 to 15: an, de, ti, go, su, by, ra, me, ni, ko, hu, vy, la, po, fy, ton—hence the name "tonal." According to this limited lexicon, the hexadecimal translation of 1510,0000 would be "mill-susanton-bong."

Hexadecimal can be used to represent large amounts of *binary* code. In further contrast to hexadecimal and decimal, binary is "base two," therefore each column is two times larger than the one preceding it: ones, then twos, then fours, then eights, then sixteens, and so on. In binary, 0110 is equivalent to 6 in decimal because there is nothing in the ones column, a one in the twos column, a one in the fours column, and nothing in the eights column (i.e. $2 + 4$).

0000 = 0	0100 = 4	1000 = 8	1100 = 12
0001 = 1	0101 = 5	1001 = 9	1101 = 13
0010 = 2	0110 = 6	1010 = 10	1110 = 14
0011 = 3	0111 = 7	1011 = 11	1111 = 15

Binary is the native language for the sequence of on-off switches that constitute computer processing, conventionally written as groups of four

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digits. Often in computer programming, the decimal value 2 (which is otherwise expressed as "10") is expressed as 0010. This typographic convenience hints at something more fundamental: computer memories are organized around powers of 2, and names are given to their logical divisions so that $2^1 = 1$ bit (on, off, 2 possible values); $2^2 = 1$ nibble (4 bits, 8 possible values); $2^3 = 1$ byte (8 bits or 2 nibbles, 16 possible vales). Hexadecimal's base 16 system embeds these exponential relationships and so proves very useful for keeping track of the binary codes that represent all of the data in a computer's memory, as well as the logic that allows the computer to operate on it. Everything in the computer is encoded in binary — movies, music, images, operating systems, applications — according to specific protocol. EB4747 translated to decimal numbers is 15,419,207, an amount comparable to the voltage within the weakest lightning, each value a one or a zero, an on or an off, all electricity. The Lichtenberg image on my screen is nothing more than a string of ones and zeroes — albeit a very long string.

Binary is also used to represent the voltages that flow through computer components, specifically micro-controllers. These parts are designed for calculation, where inside every micro-controller is a series of nanoscopic transistors. The purpose of each transistor is to open or close (like a gate or switch), allowing electrical current to either flow on to the next transistor or component, or, to redirect it to ground. The gates open or close based on the amount of voltage flowing through them. The process is called "digital logic." Digital logic runs at a maximum voltage (usually) of 5 volts. For example, a USB device is powered by a voltage of between zero and five volts. Returning to the gates inside the transistors within micro-controllers, these function as either on or off, and they determine whether to be on or off based on the amount of voltage flowing through them. So, the transistor detects any voltage below 3 volts and directs to an "off" state, 3 volts and above, it switches to an "on" state, thus opening the gate/switch. The rounding up or down of numbers is a way to prevent electrical interference, which has been a problem for other logics — analog, for instance. So, "on" is represented by a binary value of 1, while 0 represents "off." In other words, 3 volts passing through a computer chip will switch "on" a transistor, registering it as a 1 in binary.

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Digital electronics share some of the same qualities as vocal speech. They are both physical phenomena encoded with information. Speech produces a physical product as a stream of vibrating airwaves. The vibrations in the sequence are intercepted by our ears, and our brain then interprets these as language. In a similar way, voltage encodes binary logic, which is interpreted by integrated circuits.

There are many forms of capacitive sensors that use the human body as an input. All rely on two types of capacitive sensing system: *mutual capacitance,* where the object (such as a finger or conductive stylus) alters the mutual coupling between row and column electrodes; and *self- or absolute capacitance,* where the object loads the sensor or increases the parasitic capacitance to ground. What that means is, when I touch my screen to awaken my phone, an imperceptible electrical pulse passes from the glass to my index finger. The phone's energy travels like lightning through my nervous system. For a fraction of time, the device uses my body as a capacitor to store the electricity. It swims against the body's own current and, without becoming lost, surfaces again at the glass while the circuits behind the screen stand by for a response. They measure the decreased current where the touch took place. This information relays to the touch-screen driver software; the phone awakens; the light on the screen glows gently. It's impossible to imagine how quickly this synaptic event happens during every moment we touch to press a button, or to zoom in on an image. We are the instruments of the phone's hardware, applied as the touch-screen combines us with the circuit.

Recently, we have been integrated into a hybridized environment by the proliferation of electronic technology without fully realizing it. We are surrounded by atmospheric electricity and radiation invisible to the human eye, but are physically implicated by these electronic technologies in order for them to work. If I send an email of the Lichtenberg image wirelessly, the message would pass through my body as the "swoosh" from the speakers confirms it being sent. As a string of ones and zeros, the physical electricity moves down the line, is interpreted by something, somewhere, then received by my intended recipient as the electricity passes through her body when she touches her screen to open it.

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Steve Mann is a faculty member at the University of Toronto in the Department of Computer and Electrical Engineering. An inventor of digital eyeglasses, he physically embodies the technology he designs:

I wear a computer vision system and carry a letter from my family physician, as well as documentation on this system when I travel. I have worn a computer vision system of some kind for 34 years and am the inventor of the technology. On the evening of July 1st, 2012, my wife and children and I went to McDonald's at 140 Avenue Champs Elysées in Paris, where a McDonald's employee physically assaulted me. He angrily grabbed my eyeglasses, and tried to pull them off my head. I showed him the letter from my doctor and the documentation I had brought with me. He then brought me to two other persons. After all three of them reviewed this material, [he] angrily crumpled and ripped up the letter from my doctor pushed me out the door, onto the street.

Since being thrown out of McDonald's, Mann's blog has been almost singularly focused on the incident. One has a sense that he even welcomes such an incident, which falls into the lap of his cause — *sousveillance* — "community-based recording from first person perspectives." In a recent portrait, Mann wears a pair of glasses with a camera attached, along with a large grayscale LCD screen strapped to his chest. The screen shows a live video feed from the camera. You can watch him watching you.

As a ten-year old, I spent countless hours transcribing pages of code from a floppy wire-bound manual to my computer, reading cautiously, running my fingertip along each line of numbers as though to understand them. In truth, I had little idea what any of it meant. Rather, I was motivated by the vision of creating a near-professional program, or something that would at least resemble the pictures in the book. Copying code was an exact science, considering the computer only allowed users to delete each previous letter o-n-e-a-t-a-t-i-m-e. In retrospect, I sense that underneath my desire to build programs by these painstaking means, was a desire to better understand the underlying processes of the computer. And simply by using a command-line interface, I did gradually develop a sense of the language that makes computers work.

Looking back isn't always a question of nostalgia. Recently, I found myself hunched over my desk, battling a case of planned obsolescence. I urgently needed to record sound from an external source directly to my computer. It should have been a simple task: RCA connection to the input of the mixer, plus audio jack from the mixer to the headphone jack on the laptop, but that wasn't working. I searched online for answers. A troubleshooting page directed me to:

1. Plug the input audio device into the combination audio port using the proper adapter cable.
2. From the Apple menu, choose System Preferences.
3. Choose Sound from the View menu.
4. Click the Input tab.
5. Change the "Use audio for:" menu selection from sound Output to the Sound Input.
6. The device type should change from "Internal Microphone/ Built-in Input" to "Line In/Built-in Input."

I followed the steps sequentially, but stumbled at point 5. "Use audio for" was missing. The option simply wasn't there. I checked the connection, plugged in the cable, and silence. I blew air into the port, wiped the jack connector, checked that all the inputs were indeed inputs, outputs were indeed outputs, checked the power supply, and silence. So, with the feeling of breaking into someone else's home, I resorted to opening the casing to tinker around inside. After unscrewing the bottom panel, I saw no sign of damage, at least from what I could understand. The board was a mindbogglingly dense city of surface-mounted resistors, capacitors, and transistors, almost microscopic in size. I didn't dare touch them for fear of my own parasitic static damaging the parts. The headphone jack seemed fine, so I closed the panel carefully and screwed it tight again.

Cyberneticians use the term "black-box" to describe a piece of machinery or set of commands that is too complex to understand. Bruno Latour writes: "Scientific and technical work is made invisible by its own success [because when] a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become."

I walked outside to call technical support. Tiny droplets of rain collected on the screen of my phone as I dialed the number with my fingertip. Within a few minutes, the trees were swaying. A mother and her two

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girls walked past. Huddled together, sharing one umbrella, they turned the corner just as a flash of light split the sky, followed by a boom of thunder that echoed for some time. At the same moment, the phone in my hand lost its glow as the battery drained. A grey wheel then spun around two times before the screen went black.

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