PART 5

# THE DIGITAL DOMAIN

## & THE LAST MAMMOTH


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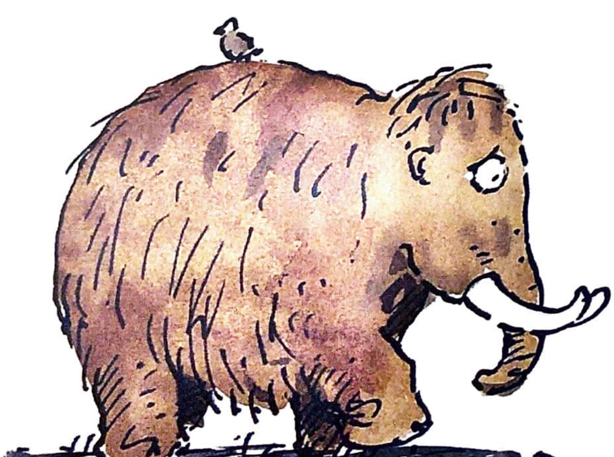
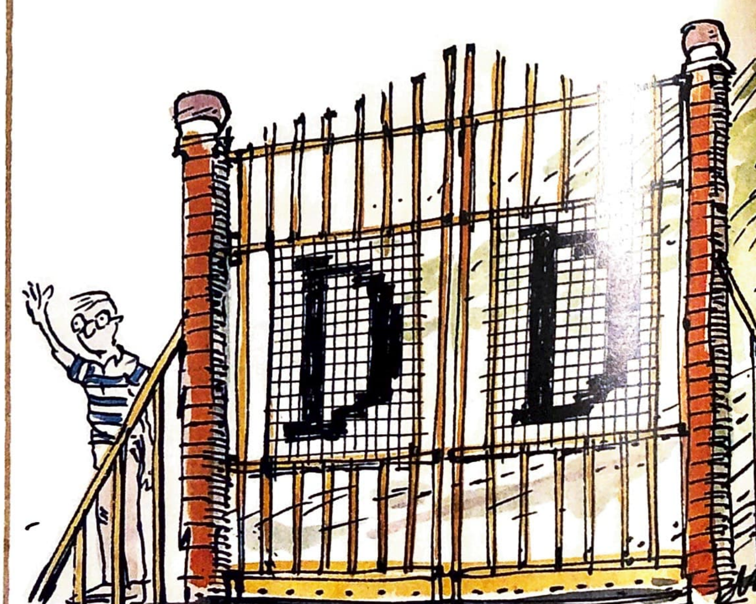


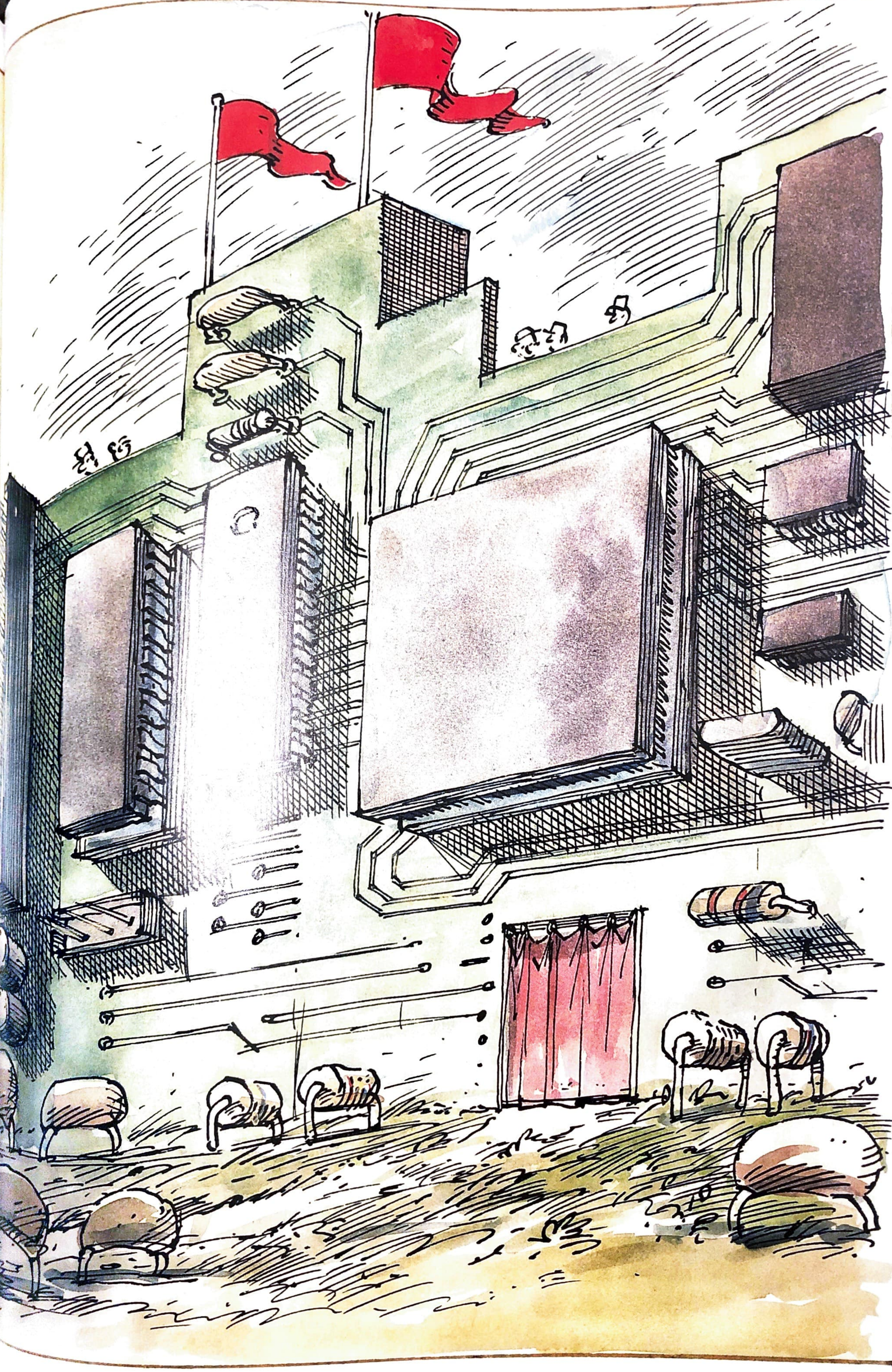
# THE LAST MAMMOTH

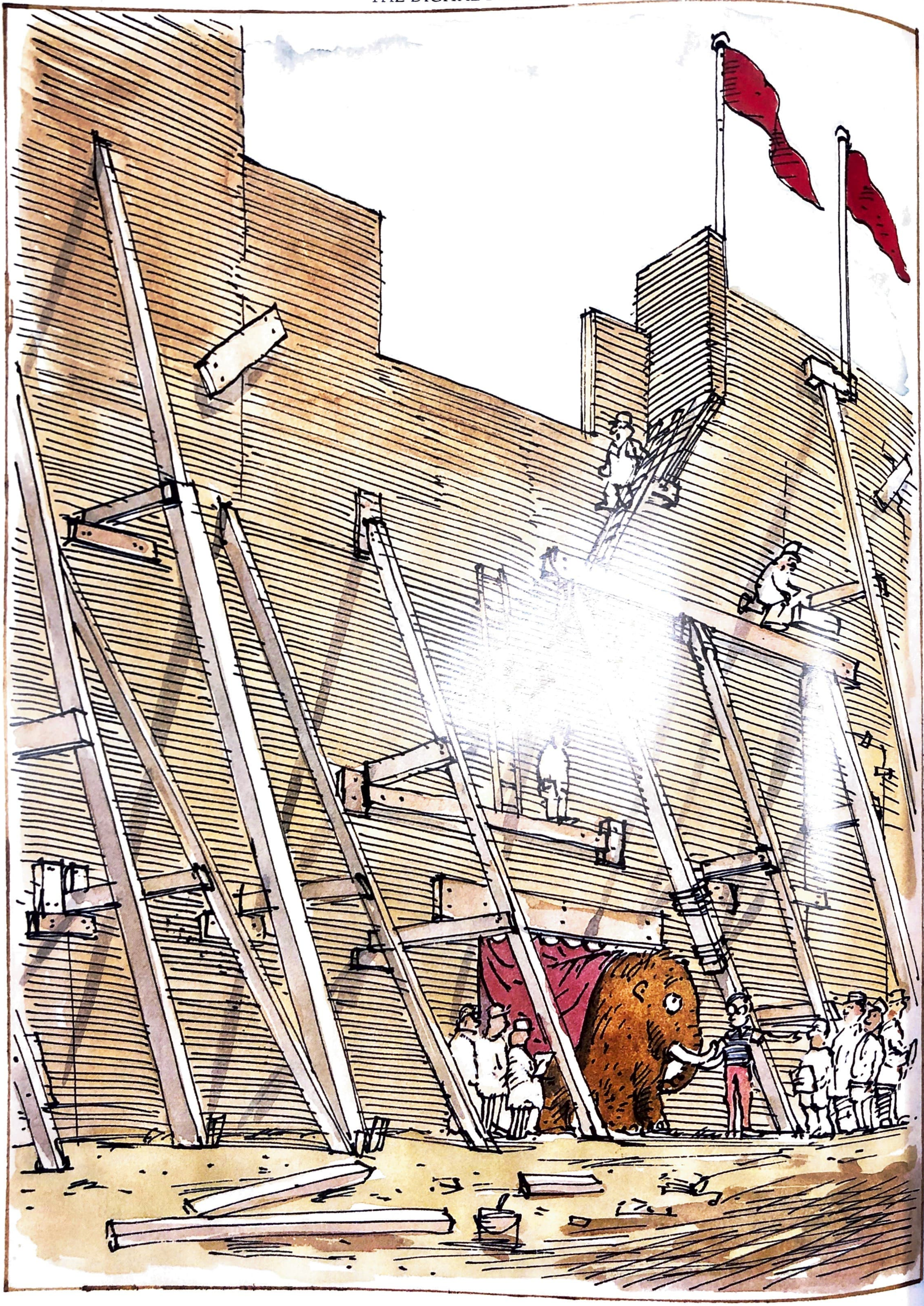
## *CHAPTER ONE*

*Mammoth stood in the stream stuffing clumps of swamp grass into his mouth. As the tender juices trickled down his throat, he contemplated the pros and cons of the solitary life. On the one hand, he didn't have to share the dwindling harvest with any other mammoths—because there were no other mammoths. But, on the other hand, he was terribly lonely. He wondered how he had come to be the last mammoth and where the rest of his proud species had gone. A large oil slick floated by. He marveled at its iridescence before ambling off in search of more food.*

*The trail of dwindling swamp grass led to an imposing wall and an entrance presided over by a character who introduced himself as Bill. Bill announced that this was his "digital domain" and that it was full of wonderful and amazing things, all of which were intended to improve the quality of life but none of which had been fully tested. While Bill spoke with enthusiasm about the future, Mammoth could only dwell on the past. Lonely thoughts filled his tiny brain, releasing a single tear that inadvertently saturated Bill's tennis shoes. Recognizing the mammoth's distress, Bill suggested they work together. He and his digital staff needed someone (or some thing) to process. And the mammoth was obviously desperate for companionship. So it came to pass that Mammoth, who generally distrusted high walls, warily entered Bill's gates.*





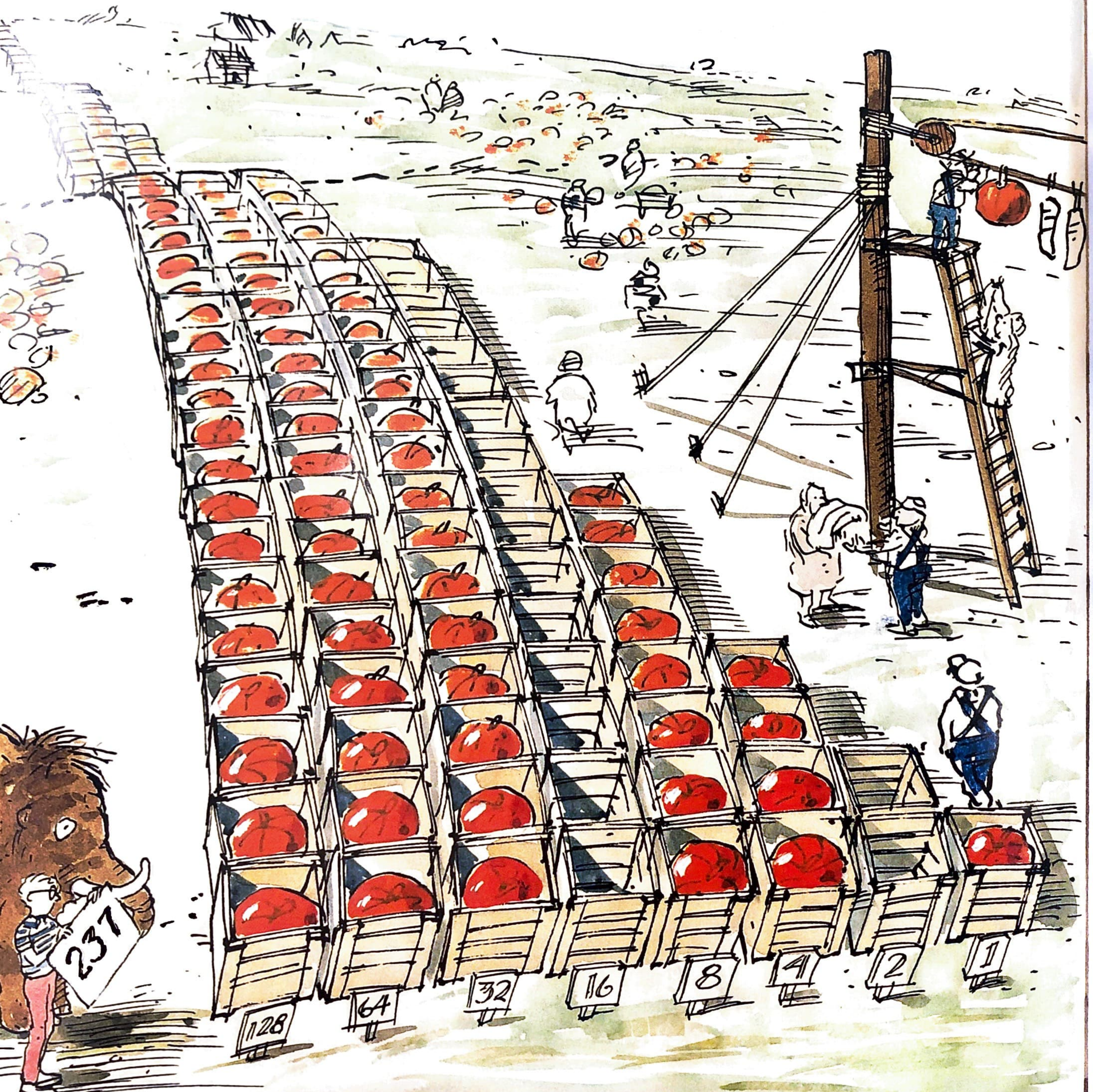


He was immediately surrounded by enthusiastic white-coated workers who began recording every aspect of his considerable being. This was not exactly the kind of companionship he'd been hoping for. One group measured him from top to bottom while another tackled him head to tail. A third group was assigned to gauge his considerable weight. Even those things that could not be so easily measured, such as voice and smell, were meticulously noted.

Within hours, everything about the last mammoth had been reduced to numbers, which Bill copied on large white cards. He informed Mammoth that although they were very good numbers indeed, they weren't actually the right kind of numbers for the digital domain. If they were going to be useful in helping find true companionship, these numbers would first have to be changed.

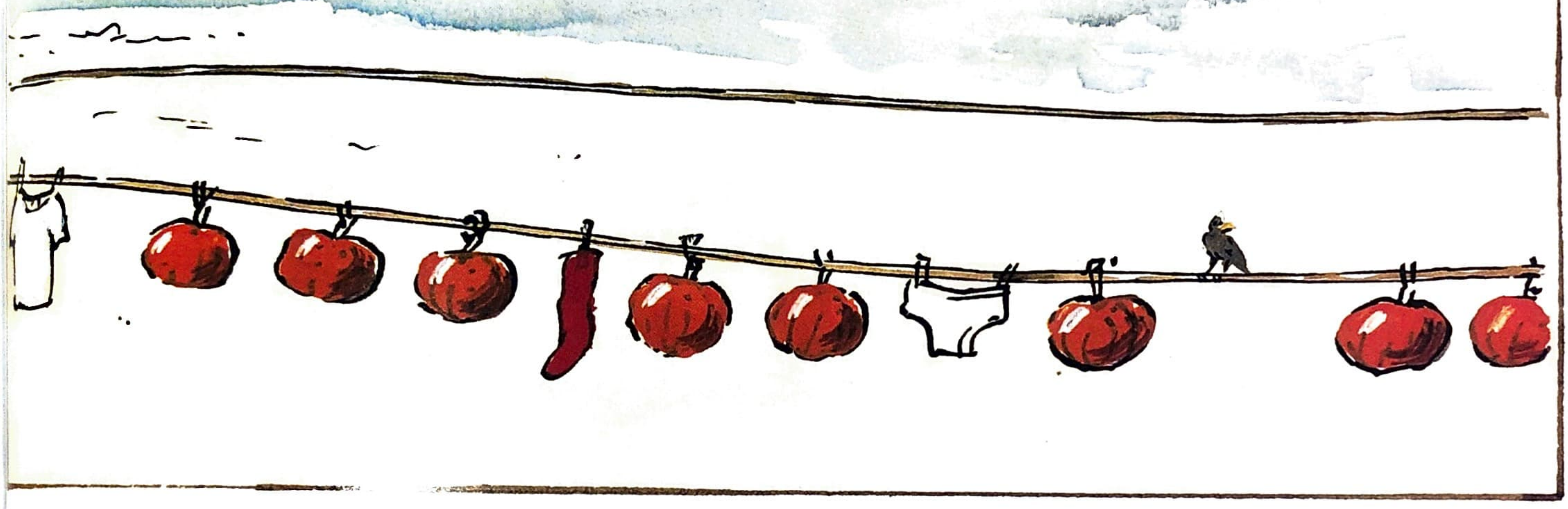
*Along one side of an enormous pumpkin patch, eight rows of crates had been laid out. Each row was half as long as the one that preceded it. The first and longest row contained one hundred and twenty-eight crates, the second contained sixty-four, and so on. When Bill held up the card inscribed with the number 237 (the mammoth's height in centimeters), a team of farm hands quickly harvested exactly 237 pumpkins.*

*Then, moving row by row from longest to shortest, they placed one of these pumpkins in each crate. If they couldn't fill an entire row completely, they simply skipped it. As soon as all the pumpkins had been appropriately crated, Bill drew Mammoth's attention to the pattern of pumpkins along the bottom of all eight rows.*



*He explained that in the language of the digital domain, the relatively simple number 237 was now "pumpkin, pumpkin, pumpkin, no-pumpkin, pumpkin, pumpkin, no-pumpkin, pumpkin." "That's progress," he added proudly. Mammoth was having a little trouble with this concept but really shook his head when Bill suggested that "pumpkin" and "no-pumpkin" were equally important. To Mammoth this was like saying swamp grass and no swamp grass were equally filling.*

*Bill supervised as the pumpkins from the first crate of each row were hung on a long clothesline. Special care was taken to keep them in exactly the same order. For each "no-pumpkin," a space was left. However, since this happened to be a Tuesday, these spaces were filled with single pieces of wet laundry. When pumpkin, pumpkin, pumpkin, sock, pumpkin, pumpkin, underpants, pumpkin had been secured to the line, the whole thing began to move slowly out of view. "Come on, Mammoth," shouted Bill. "We've got work to do."*



# MAKING BITS

The mammoth found the digital domain unfamiliar and confusing. While we are familiar with the computers and other devices the digital domain makes possible, the way these things work is bewildering to many of us. The thing that all digital devices share is that they work with numbers. The mammoth finds its dimensions, image, and sound changed into numbers as it goes digital. Similarly, all digital machines begin a task by converting things like these into numbers. Instead of the decimal form that uses the ten digits 0 to 9, numbers in the digital domain are binary numbers, which use only two digits, 0 and 1, and which are much more convenient for machines. These digits are called bits—short for "binary digits."

The mammoth observes that its height, measured in decimal centimeters as 237, becomes, in the digital domain, a set of eight crates, some containing a pumpkin and others empty. The sequence of full and empty crates is a binary number containing eight digits or bits: 237 is full-full-full-empty-full-full-empty-full. When writing binary numbers, we use the two numerals 1 and 0 to represent bits, 1 meaning full or yes and 0 meaning empty or no, so that the decimal number 237 becomes 11101101.

In the decimal system that we are all familiar with, each place value is ten times the value of the place to its right—a decimal number may be made up of thousands, hundreds, tens, and ones. The decimal number 237 is made up of two 100s, three 10s, and seven 1s. In the binary system, each place value is twice the one to its right—that's why the rows of pumpkin crates can hold 128, 64, 32, 16 pumpkins, and so on. As Mammoth discovered, 237 in binary is 11101101: this tells us that the number is reached by adding one 128, one 64, one 32, one 8, one 4, and one 1.

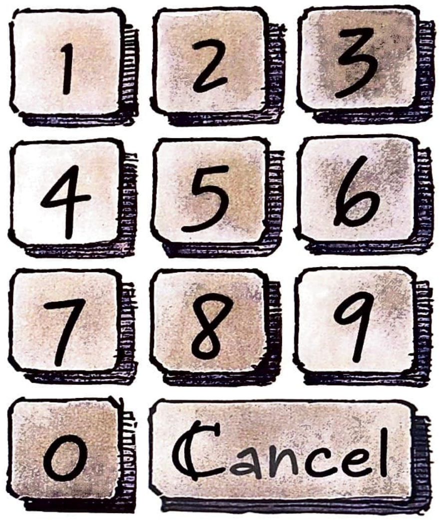
In a digital machine, bits take a form just as physical as pumpkins. They manifest themselves primarily as electric charges in which the electricity is switched either on or off. Here, 237 becomes on-on-on-off-on-on-off-on. Numbers represented by on-off electrical signals and on-off light signals flash to and fro along the pathways of digital machines in huge quantities at great speed. Digital machines can handle vast amounts of numbers arranged in countless ways, allowing them to carry out a huge variety of complex tasks very quickly. Furthermore, bits are rugged: they do not easily degrade as they rush about the digital domain. Being born survivors, bits enable digital machines to work at superior levels of quality and reliability.

# FINGERTIP INPUT

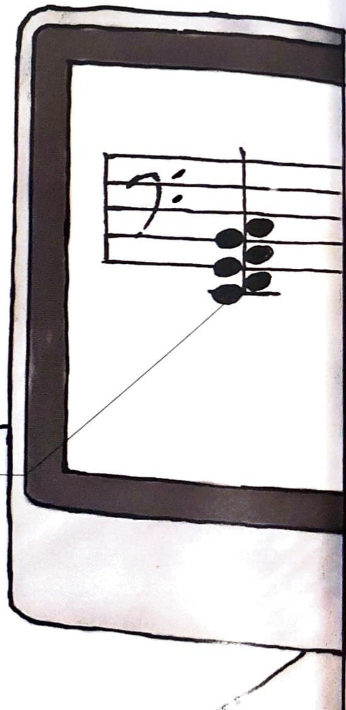
Every digital device, from computers and smartphones to digital cameras and Blu-ray players, needs input in the form of bits (binary digits, 1s and 0s). The input might be a command, to make the device do what we want, or it might be data, such as text for a document or a digitized sound or image (see pp. 324-25). Many devices allow the user to input commands or data by pressing on keys or buttons—on a keypad, computer keyboard, or musical keyboard, for example. Each key on a keypad or keyboard produces a unique group of bits when it is pressed. A specific combination of key presses might represent a code, such as a PIN number (see p. 336) for a cash machine.

## CASH MACHINE AND ELECTRONIC LOCK

Getting cash out of a machine is simply a matter of inserting your card, then typing your PIN number and the amount required on the keypad. You also type in a code number on a similar keyboard to open an electronic lock. Like the number keys on the computer keyboard opposite, the keys act as switches to generate a sequence of on-off electric pulses forming the bits in the numbers. From a cash machine, these bits go to the bank's central computer, which checks the PIN number and debits your account before instructing the machine to pay out. In the lock, the bits go to a chip that checks the number. If it is correct, the chip produces an electric signal that frees the bolt so that the door can be opened.




**KEYPAD**
*The CANCEL button enables you to delete any wrong key presses and start again.*

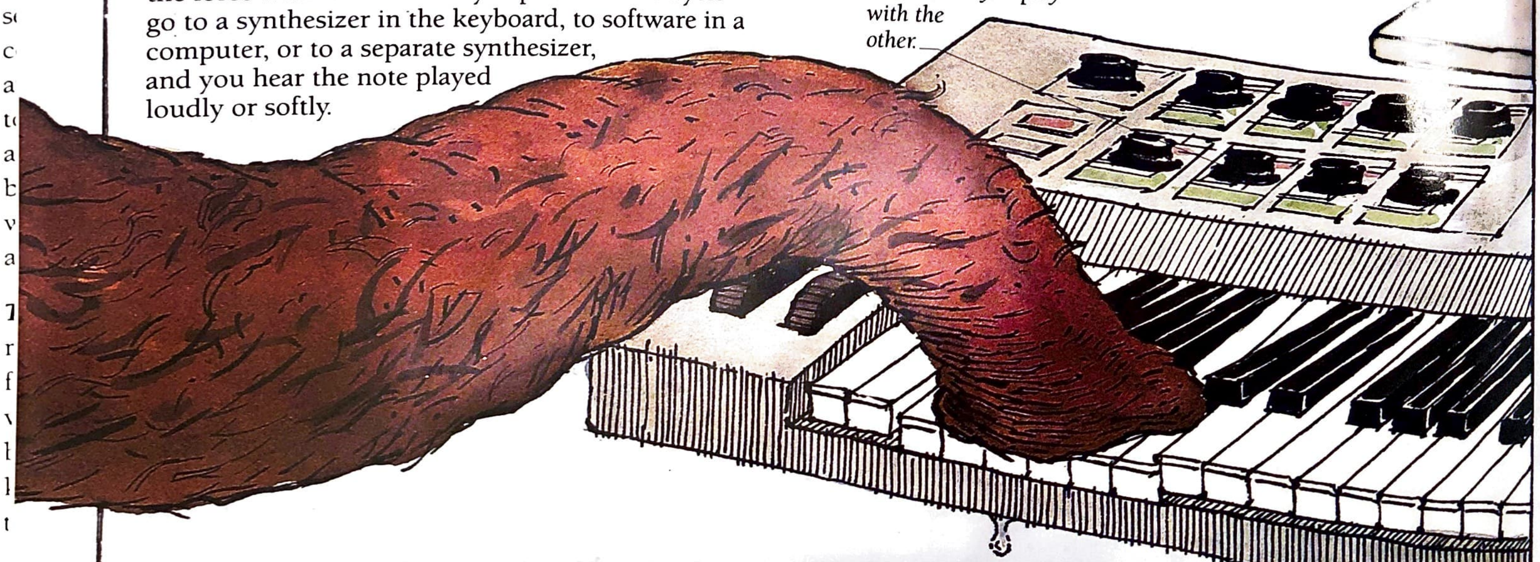


## ELECTRIC KEYBOARD

Electronic music equipment conforms to a standard called MIDI (Musical Instrument Digital Interface). When you play a note on a MIDI keyboard, it sends out a digital code number, made of three bytes (three groups of eight bits). The first byte is a command, such as "turn this note on." The second is the actual note—middle C is 00111100 (decimal 60), for example. The third byte represents the force with which the key is pressed. The bytes go to a synthesizer in the keyboard, to software in a computer, or to a separate synthesizer, and you hear the note played loudly or softly.

**INSTANT MUSICAL SCRIBE**
*The MIDI bits can go to a computer, which displays the music in written form on the screen as you play.*

**CONTROLS**
*You can operate the sound controls with one hand as you play with the other.*



# COMPUTER KEYBOARD

Only about half of the hundred or so keys on a computer keyboard produce characters—letters, numbers, and signs. Pressing the other keys makes the computer take action, and more options become available by pressing two or even three keys at once. This versatility is possible because pressing a key causes the keyboard to generate an electric signal forming a code number that identifies the key. The code number is in the form of bits made up of on-off electric pulses. This digital signal passes to the computer's processor, along a USB cable (see p. 369) or via a wireless connection. The processor interprets the code number or combination of numbers either to display a character or to take action.