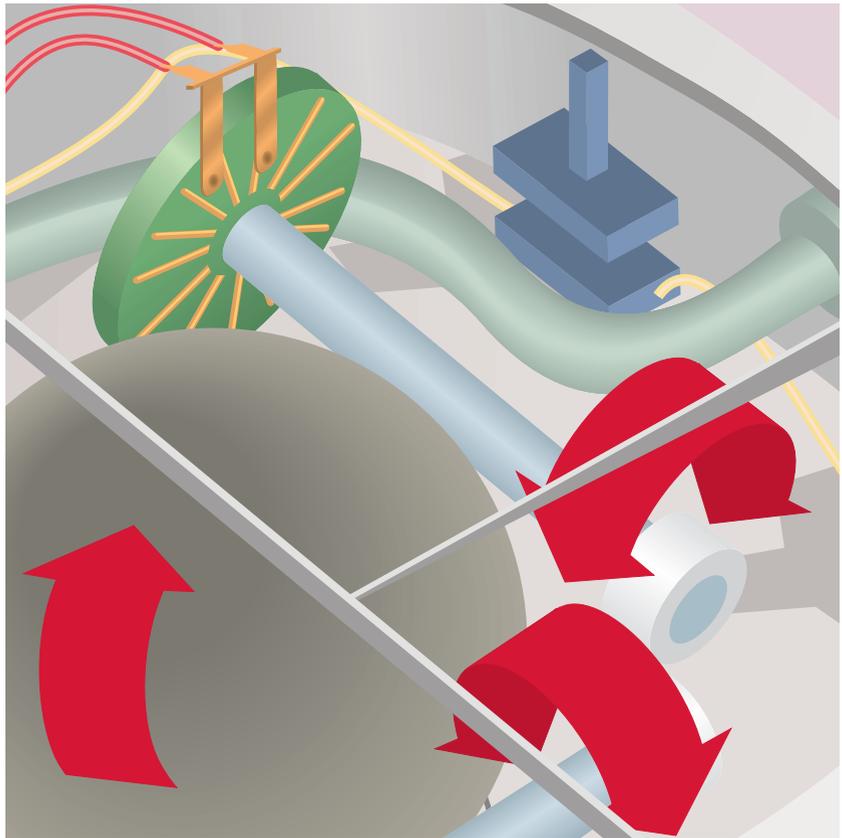


CHAPTER

# 25

# How Pointing Devices Work



**THERE** is nothing natural or intuitive about a keyboard. No child is born knowing how to type, and even when the skill is learned, there's little sense to it—no one can give a sensible explanation of why the alphanumeric keys are arranged the way they are.

For many, the keyboard is actually a barrier to learning how to use a computer. Even for the experienced typist, there's nothing instinctive in pressing F5 to print a file. Engineers—not one of them touch typists, I'll bet—at Xerox Corporation's Palo Alto Research Center (PARC) developed a concept first explored by Douglas C. Engelbert of the Stanford Research Center. The concept was a *pointing device*, something a computer user could move by hand, causing a corresponding movement onscreen. Because of its size and tail-like cable, the device was named for the mouse. Apple Computer made the mouse a standard feature of its Macintosh computers, and Windows has made a mouse standard equipment on PCs, as well.

The mouse is not the only pointing device that's been invented. The joystick used with games essentially accomplishes the same task, but doesn't feel quite right in all situations. *Digitizing tablets* are popular with artists and engineers who must translate precise movements of a pen into lines on the screen. Touch screens, using your finger or a special light pen to control the software, are too tiring to use for any length of time. The most successful of pointing innovations have been “eraserhead” pointing devices, so called because they look like a pencil's eraser stuck between the G and H key; the touch pad, which is a digitizing table without the precision; and trackballs. All three are popular on laptops, used where there's no space for a conventional mouse.

The mouse and its cousins can never replace the keyboard, but they can supplement the keys by doing tasks such as moving and pointing to onscreen objects, tasks for which the cursor keys are ill-suited. We're just reaching the point where we control our PCs simply by speaking to them.

Mice are still an integral part of our systems. The mechanical mouse is the most popular pointing device for graphic interfaces represented by Windows and the Macintosh OS. You control your PC by pointing to images instead of typing commands. Here's how the mouse translates the movements of your hand into the actions onscreen.

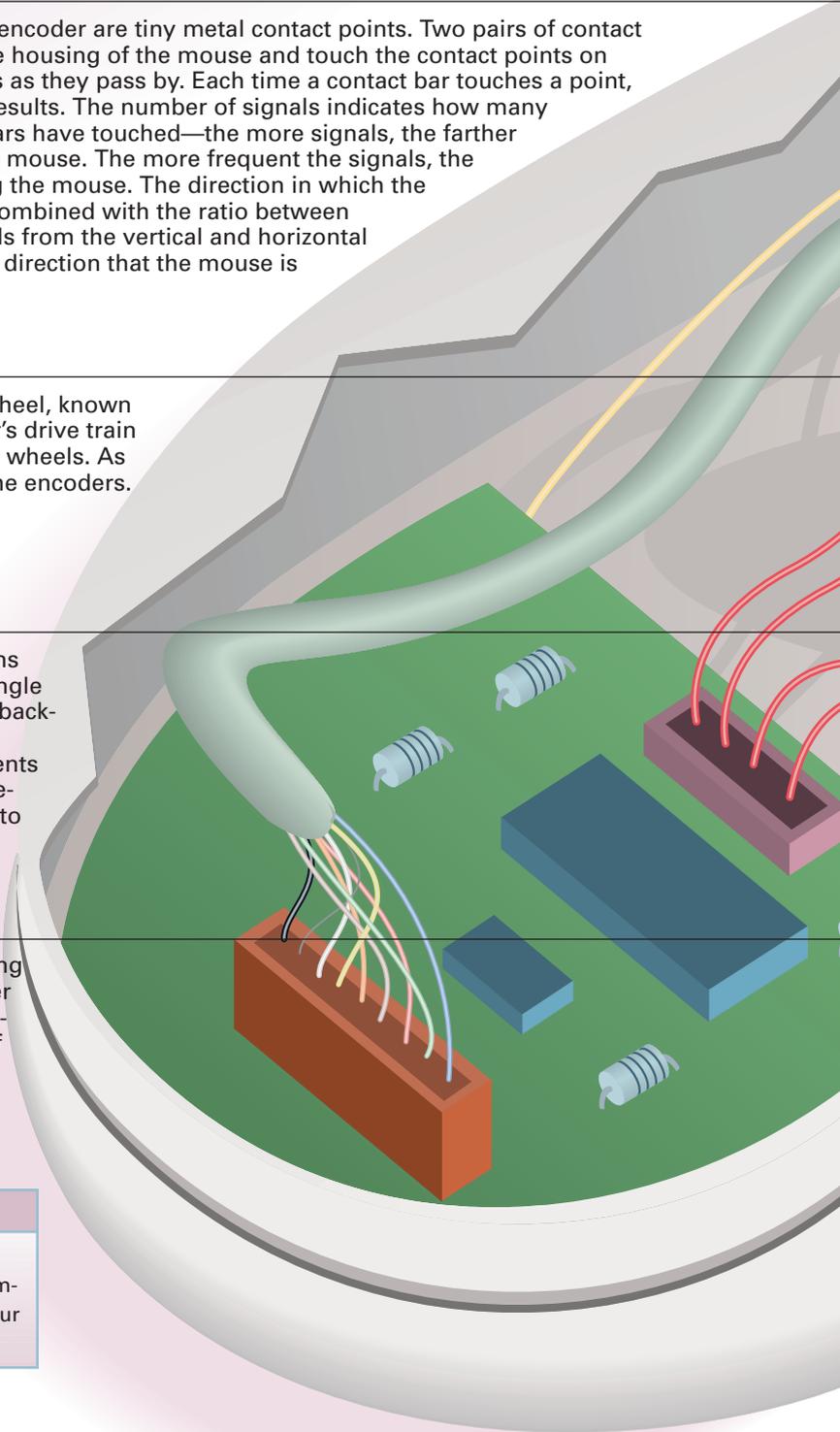
# The Mechanical Mouse

**4** On the rims of each encoder are tiny metal contact points. Two pairs of contact bars extend from the housing of the mouse and touch the contact points on each of the encoders as they pass by. Each time a contact bar touches a point, an electrical signal results. The number of signals indicates how many points the contact bars have touched—the more signals, the farther you have moved the mouse. The more frequent the signals, the faster you're moving the mouse. The direction in which the rollers are turning, combined with the ratio between the number of signals from the vertical and horizontal rollers, indicates the direction that the mouse is moving.

**3** Each roller is attached to a wheel, known as an *encoder*, much as a car's drive train is attached by its axles to the wheels. As the rollers turn, they rotate the encoders.

**2** As the ball rotates, it touches and turns two rollers mounted at a 90-degree angle to each other. One roller responds to back-and-forth movements of the mouse, which correspond to vertical movements onscreen. The other roller senses sideways movements, which correspond to side-to-side movements onscreen.

**1** As you move a mechanical mouse by dragging it across a flat surface, a ball—made of rubber or rubber over steel—protruding from the underside of the mouse turns in the direction of the movement.

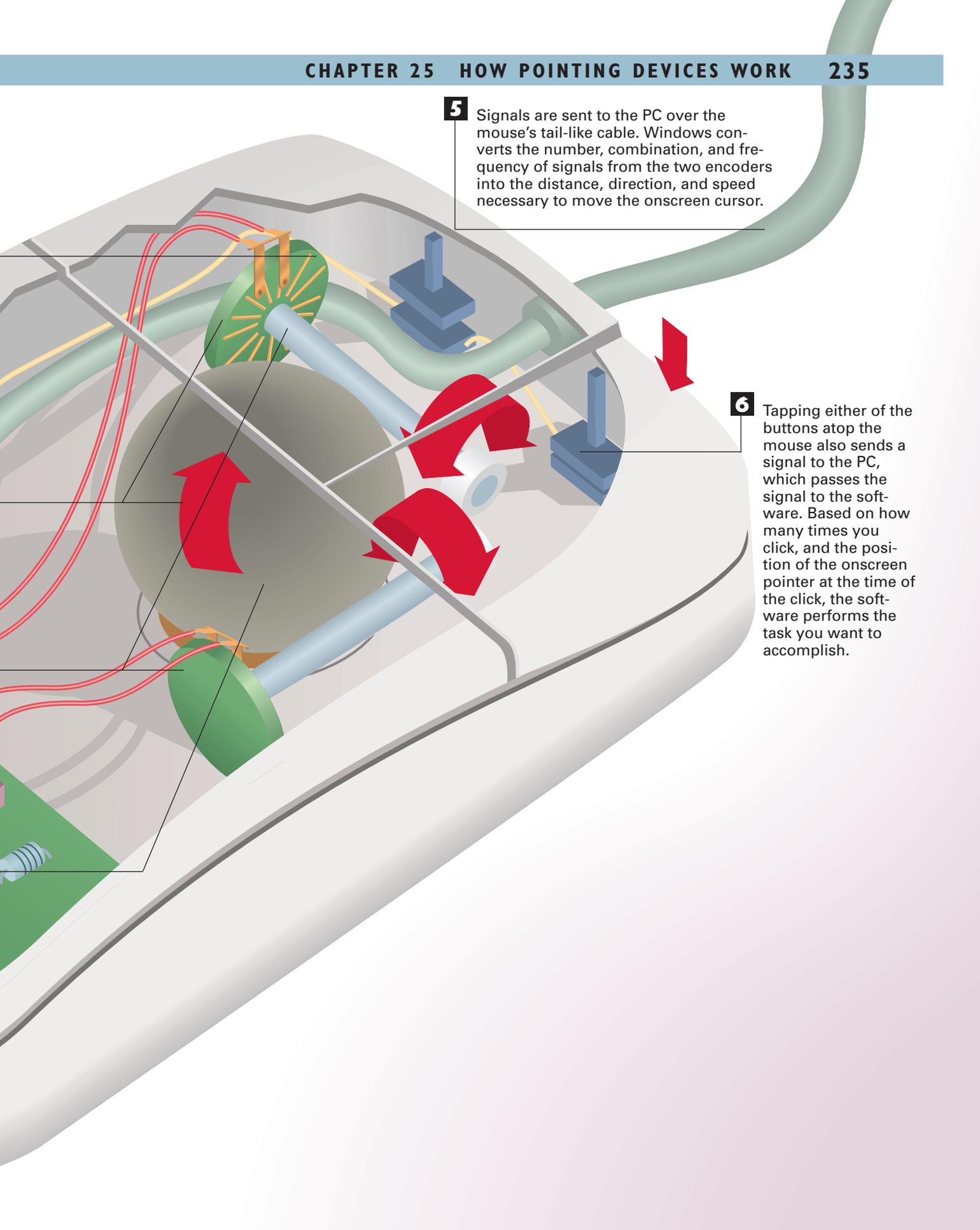


## A Mouse on Its Back

Want to know how a trackball works? Turn these pages upside-down and you'll get some idea. A trackball is simply a mouse mounted so that the ball is rotated with your fingers instead of on the surface of your desk.

**5** Signals are sent to the PC over the mouse's tail-like cable. Windows converts the number, combination, and frequency of signals from the two encoders into the distance, direction, and speed necessary to move the onscreen cursor.

**6** Tapping either of the buttons atop the mouse also sends a signal to the PC, which passes the signal to the software. Based on how many times you click, and the position of the onscreen pointer at the time of the click, the software performs the task you want to accomplish.

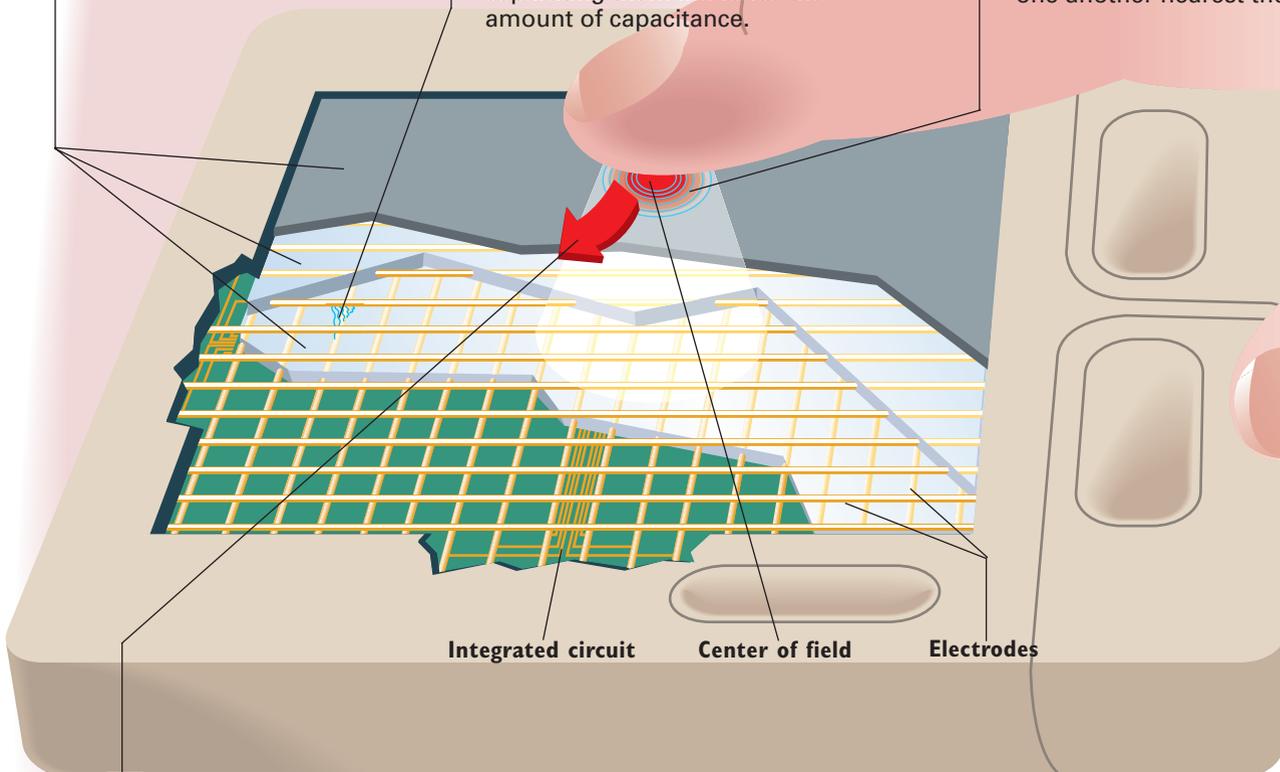


# How a Touchpad Works

**1** Beneath the top rubber layer of a touchpad are two more layers, each of which contains a row of electrodes, one row going horizontally and the other vertically.

**2** The crossing electrodes do not touch, but a positive electrical charge builds up in one set and a negative charge in the other. This creates an *electric field* between the layers. Integrated circuits for the horizontal and vertical electrodes sample the strength of that field's electrical *potential*, or *mutual capacitance*. The size and shape of the electrodes and the non-conductive, *dielectric* material separating them influence the amount of capacitance.

**3** Capacitance is also affected by the surrounding electromagnetic field from other objects, including a finger, which has very different dielectric properties from air. Even if the finger doesn't actually touch the pad, the fingertip's field penetrates the grid of electrodes, changing the capacitances where electrodes cross over and under one another nearest the fingertip.



**4** The capacitances are most affected at the center of the finger. By reading the capacitances of adjoining intersections, the touchpad can identify the finger's center, and feeds that location to Windows to position the onscreen arrow. The capacitances are measured about 100 times a second. Changes in those measurements caused by moving the finger are translated into cursor movement.

# How a Pointing Stick Works

