Trickling sand: How an hourglass ticks

The familiar image of sand gradually trickling from one chamber into the other of an hourglass has long represented the inexorable passage of time. But new experiments reveal that sand in an hourglass doesn't always flow smoothly.

A team of researchers has discovered that under certain conditions, the flow of particles in an hourglass actually stops and starts at regular intervals. In other words, the hourglass "ticks."

Xiao-lun Wu of the University of Pittsburgh, Daniel Bideau of the University of Rennes in France, and their co-workers describe their findings in the Aug. 30 PHYSICAL REVIEW LETTERS.

The researchers performed their experiments using uniform glass beads, ranging from 41 to 160 microns in diameter, in a specially modified hourglass. Its lower chamber has an opening so that beads could flow into a cup resting on a balance, allowing the researchers to record how steadily the mass increases.

The group found that the beads flow continuously only for a certain range of values of the ratio between the bead diameter and the width of the neck linking the hourglass' two chambers. The flow becomes intermittent when the particles are less than one-twelfth or more than one-half the neck's width.

The researchers suggest that a tiny difference in air pressure causes this surprising behavior of small particles. Gravity pulls the beads down, forcing them against each other to form a tenuous network of arch-like structures. As beads pass through the neck of an hourglass, they carry air with them. The air pressure in the upper chamber thus falls slightly below that in the lower chamber. This pressure difference – typically one ten-thousandth of an atmosphere – exerts an upward push that stabilizes the arches in the bead-packing. The flow comes to a halt. It begins again when the difference in air pressure diminishes.

As evidence supporting their explanation, the researchers note that by opening a cap on the upper chamber, they can bring it to the same pressure as the lower chamber. Under these conditions, the flow becomes continuous.

Moreover, the occurrence of intermittent flow appears extremely sensitive to vibrations, temperature changes, and air currents. "Indeed, sealing the lower chamber of the hourglass and simply holding it, thus slightly warming the lower chamber, is enough to stop the flow entirely," the researchers report.

These findings may help elucidate the mechanics of the flow of fine powders, such as cement or certain drugs, where trapped air often plays a significant role.

– I. Peterson

Another cause found for ozone depletion

Last spring, scientists reported that atmospheric ozone, the airborne chemical that shields life on Earth from harmful solar radiation, had reached record low levels above much of the planet during 1992 and early 1993 (SN: 4/24/93, p.260).

Some scientists attribute this unexpected loss to droplets of volcanic sulfuric acid created by the eruption of Mt. Pinatubo in the Philippines in 1991. Adding to this debate, Ralf Toumi and his colleagues, all atmospheric chemists at the University of Cambridge in England, report in the Sept. 2 NATURE another possible mechanism to explain ozone depletion. Chlorine nitrate, a natural atmospheric compound, accounts for a greater proportion of ozone depletion than previously recognized, they maintain.

"Chlorine nitrate is an active agent in ozone depletion, which has not been realized before," Toumi says. Chlorine nitrate forms over the polar regions during winter, then drifts toward the equator, where according to Toumi it destroys ozone slowly over a wide area. "This cycle is slower than the other polar ozone depletion cycles, but its potential influence is far ranging," Tuomi says. Chlorine nitrate could have a great effect in Earth's warmer latitudes, he says, accounting "for a sizable portion of the ozone depletion that has so far not been explained."

Toumi believes current climate-change models should add the chlorine nitrate cycle to assess the compound's long-range impact. Since measured ozone depletion "has been far outstripping the models," he says, "the challenge has been to explain the changes at lower latitudes. This mechanism should account for some – though certainly not all – of the unexplained ozone changes."

– R. Lipkin

Micromarvel: Wires thinned to nanometers

Picture a magnetic carpet, each strand a wire only a few atoms thick.

This image is purely figurative. Yet it conveys a sense of what may soon be possible on a molecular scale with newly developed nanometer-size wires embedded in a thin film – for example, higher-quality audio and video tapes.

Such one-dimensional nanowires can now be made, says T.M. Whitney, a chemist at Johns Hopkins University in Baltimore. "We call them one-dimensional nanowires because they're small wires, only a few tens of nanometers thick, and because they're nearly one-dimensional structures," says Whitney. "They're not quite a string of atoms, but they behave like a string of atoms."

He and his colleagues report their work in the Sept. 3 SCIENCE.

Scientists have long wanted to make semiconductors this size, Whitney says. But making them has proved quite difficult. The Hopkins group set out to create such structures with ordinary metals. They etched long, thin tracks into a polycarbonate membrane, or film. The tracks ranged in width from 30 to 200 nanometers. Using a technique called electrochemical deposition, they placed nickel and cobalt into the narrow tracks, creating tiny metal wires.

"Most scientists make nanometer-size structures by physically putting things together," says Peter C. Searson, a chemist at Hopkins and a coauthor of the report. "But that technique doesn't work well for wires. What's important about our technique, using electrochemical deposition, is that we can make structures that others can't make using physical deposition. So this is a new, easy, and cheap processing technique for making hard-to-build nanometer-size structures."

Whitney/SCIENCE

Micrograph of nickel nanowires.

These nanowires may prove useful for storing information because of their unique magnetic properties. "Their magnetic field is perpendicular to the film in which they're embedded, meaning that the field is much stronger along their length than along their width," Whitney says.

This feature could, potentially, improve magnetic recording materials, such as video or audio tape. To make a better magnetic recording material, Whitney notes, "you want the wires embedded in the film, standing up parallel to each other, perpendicular to the film surface." That way, a recording head, like the ones in a tape recorder or VCR, could glide right over the tops of the nanowires.

The limitation here is the size of the recording head. "No one has made a recording head that small yet," Whitney says.

– R. Lipkin