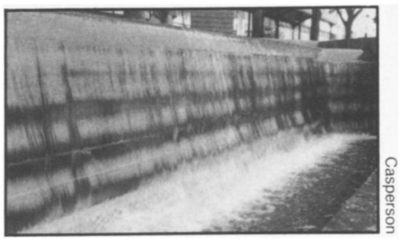
Physical Science

Why fountains thunder and dunes boom



Fluttering fountain in New Zealand.

Inanimate structures sometimes utter surprising sounds. Consider, for example, waterfall fountains. The smooth, falling walls of water can suddenly begin to flutter, emitting a loud roar that sounds like a helicopter taking off. Occasional thunder-like noise from dam spillways has rattled windows a half mile away. Then, too, some sand dunes quiver and hum, while others shake and boom.

These noises have caught the ear of several researchers, who discussed their findings this month at the annual meeting of the Acoustical Society of America, held in Houston.

Lee W. Casperson, an electrical engineer at Portland (Ore.) State University, studied two fountains in Dunedin, New Zealand, and developed a mathematical model describing smooth waterfalls. The model shows that the farther the water falls and the thinner the curtain of water, the more likely it is that the fountain or spillway will generate sound. Also, an enclosed chamber behind the waterfall increases the likelihood that the air behind will build up enough pressure to make the water oscillate, Casperson says. He believes his results can help designers make either loud or quiet fountains.

To quench his curiosity about why sand dunes rumble and boom, David R. Criswell climbed Sand Mountain, a dune just east of Fallon, Nev. A physicist from the University of Houston, Criswell studied the mechanics of how moving sand creates seismic and sound energy. He discovered he could make the dune sound like a bass violin by walking along the crest or sticking a shovel into the sand. "You can also feel it in your finger," he told SCIENCE NEWS.

Then he and four colleagues sat shoulder-to-shoulder on the crest and started inching down on their butts. "A very large sound started welling up from the center of the dune and lasted almost a minute," he recalls. The texture and shape of the sand grains may determine whether a dune booms, Criswell says, adding that high humidity seems to silence a dune.

Fish should avoid rock concerts

Like teenagers who listen to too much rock music and years later find their hearing impaired, fish can suffer damage from sounds people think harmless.

Mardi C. Hastings, a mechanical engineer at Ohio State University in Columbus, reached that conclusion after blasting three kinds of freshwater fish with loud underwater noises. Acoustics are used increasingly for underwater tests and surveys, she notes.

Although not all of the 70 oscars, grommies and goldfish showed obvious physical or behavioral effects, the noise did destroy some of the hair cells in their inner ears, Hastings reported at the Acoustical Society of America meeting.

For her studies, she placed the fish in small tanks and exposed them to frequencies ranging from 150 to 500 hertz (middle C on a piano is 256 hertz) at varying decibel levels for an average of two hours. She observed their behavior and examined them afterward for external and internal damage. Hastings and her colleagues also looked at the fishes' hearing apparatus with scanning electron microscopes.

Some fish died after exposure to the loudest sounds; others lost their sense of equilibrium, swam backwards or tilted, and acted fatigued. But "there's damage that can occur even when there are no [obvious] physical effects," Hastings adds.

Technology

Janet Raloff reports from Chicago at the Council for the Advancement of Science Writing's annual research briefing

Microstimulators serve as digital nerves

Cardiac pacemakers rank among the best-known electrical stimulators. They regularly fire a small electrical impulse into the heart through implanted electrodes to keep the old ticker pumping faithfully. Three labs are now collaborating on a family of related electronic devices to reawaken and command nerve-deadened tissue – from paralyzed arms to bladders.

"Our new device is as sophisticated as the pulse generators in pacemakers," says Philip R. Troyk of the first working prototype, unveiled last month for the National Institutes of Health, the project's major sponsor. The main difference? This one is only slightly larger than a grain of rice.

"If this were bigger, there'd be nothing special about it," notes Troyk, of the Illinois Institute of Technology in Chicago. Neurologists wanted a small implant they could insert into muscle to fire off electrical messages as needed to specifically targeted tissues. Together with researchers at the Alfred E. Mann Foundation for Scientific Research in Sylmar, Calif., and Queen's University in Kingston, Ontario, Troyk's team developed hermetically sealed glass bottles capped on each end by an electrode. Just 1 centimeter long and 2 millimeters in diameter, the implants are designed for insertion with a large-gauge hypodermic injector.

Microstimulator and rice.

A tiny capacitor inside each microstimulator stores up the electrical energy delivered by an external, battery-driven power source. The stimulator discharges into adjacent tissue whenever it receives a radioed command to do so. A custom-built computer chip inside the implant helps the stimulator decode the commands, which tell the stimulator when to pulse, for how long and what amplitude of current to deliver.

If adorned with external sensors, microstimulators might not only listen and fire out commands but also talk back – perhaps offering highly localized assays of a person's blood pressure, joint angle or tissue oxygenation, says Troyk.

The prototype has yet to undergo testing in animals or humans, but Troyk says trials may begin as early as next year.

Desalinization, the microbial way

Respiration – the final step in the process by which cells break down their food sources – releases high-energy electrons. In most cells, it also initiates the pumping of protons across a cell membrane. But Dale A. Webster, a microbiologist at the Illinois Institute of Technology, noticed that an unusual bacterium instead pumps sodium ions across its outer cell membrane during respiration. And that gave him the idea of embedding the agent responsible for the pumping in a synthetic membrane separating two tanks of seawater. An electrical current passing into the membrane should drive most of the sodium ions from one tank into the other – desalinating the water in the first tank.

Webster recently identified the bacterium's sodium pump as a protein pigment known as cytochrome-*o*. He says it appears that the electrons released during respiration energize the pigment, catalyzing its sodium-pumping activity. Because a commercial system would probably require the development of a simpler, functionally equivalent variation of cytochrome-*o*, Webster is trying to tease out precisely how the original functions. His calculations indicate that "if you can get about one electron to transfer one sodium from one side [of the membrane] to the other, that's cheaper than any other desalination process" – perhaps by a factor of 10 to 100, he says.