Physical Sciences

Ivars Peterson reports on a meeting of the Acoustical Society of America, held in Cleveland

A sound way to generate electricity

Converting heat energy into electricity is nothing new. That's what happens in a coal-fired power plant, for instance. But transforming heat energy first into sound energy and then into electrical power is somewhat unconventional. This latter process is the basis for a liquid-metal acoustic heat engine now being developed at the Los Alamos (N.M.) National Laboratory (LANL).

Although the acoustic engine isn't as efficient as other heat engines, such as steam turbines, it has the advantage of having no moving mechanical parts and hence a high reliability, says LANL's Greg Swift. Such engines could be used to provide electrical power for satellites and other applications where reliability is extremely important.

The prototype liquid-metal acoustic heat engine consists of a 1-meter-long metal tube, closed at both ends and filled with liquid sodium. A stack of thin parallel plates, made from molybdenum, sits inside the cylinder. Two sets of tiny tubes carry fluids that keep one end of the plates at 125°C and the other at 700°C.

"Sound is generated by the temperature difference across that stack," says Swift, who with Al Migliori designed the engine. "It appears spontaneously," he says. "The liquid sodium starts to sing." In other words, the liquid begins to oscillate. These oscillations in the presence of a magnetic field at the tube's midpoint allow an electrical current to be generated.

So far, in two separate projects, the researchers have confirmed that they can, indeed, produce sound from heat and that their magnetohydrodynamics generator does convert acoustic waves into electrical energy. Eventually, the two steps will be combined into a single working generator. "Nothing we have learned has discouraged us yet," says Swift.

The sodium engine is just one extension of earlier work on acoustic heat engines (SN:12/4/82,p.358). Tom Hofler, a graduate student from the University of California at San Diego and now working at LANL, is developing a loudspeaker-driven refrigerator. In this case, electrical energy is converted into acoustic waves (as in a loudspeaker) and these sound waves produce a cooling effect.

Signs of clapping

Clapping is a common human activity that has been studied very little, says speech researcher Bruno H. Repp of Haskins Laboratories in New Haven, Conn. "I'm interested in the information that is conveyed by the sound of claps—about what the hands are doing when you clap."

In his first, informal survey, Repp recorded the sounds of 10 male and 10 female subjects clapping individually at their most comfortable rates. He also observed their hand motions. Clearly visible in the acoustic spectra, he says, was the difference between the "low, dark" sound of palm striking palm and the "brighter, higher" sound of fingers against palm.

Repp also found that in this laboratory setting, people tended to have characteristic clapping sounds. A computer, for example, was successful 90 percent of the time in identifying an individual's claps just by finding a match in a set of previously recorded average sound spectra stored in the computer. "This suggests that there's a lot of systematic variability among individuals and relatively little within each individual," says Repp.

Human listeners, however, were not very good at identifying individuals by the way they clapped. In fact, Repp discovered in his experiment that although the average sound spectra for males and for females were practically identical, people tended to assume, wrongly, that females clap more quickly than males. "How general a result that is remains to be seen," says Repp.

Probing the depth of burns

Doctors have very few tools to help them determine how deeply a burn has penetrated the skin and how much viable skin remains underneath. These factors strongly influence how a burn injury should be treated. Now an ultrasonic probe for measuring burn depth, under development for nearly a decade (SN:10/8/83,p.230), is ready for clinical testing on human patients.

The current instrument, developed by John H. Cantrell and William T. Yost of the NASA-Langley Research Center in Hampton, Va., has a resolution of 0.03 millimeter in skin tissue. "That's almost an order of magnitude better than we had before," says Cantrell. For pigskin, the system has been able to measure burn depth that agrees to within 5 percent of values obtained independently. "Such accuracy is well within surgical requirements," the researchers say.

Keeping the ultrasonic noise down

Robots that use ultrasonic sensors to measure distances are beginning to appear in factories. However, many manufacturing processes are noisy, and some may generate sounds, inaudible to human ears, that could mask or interfere with such sensors. To study this noise, acoustics researchers Lee N. Bolen and Henry E. Bass of the University of Mississippi in University used a special microphone to measure ultrasonic noise levels at several General Motors Corp. facilities.

The researchers observed that there was little correlation between the sources of ultrasonic sound and the sources of audible sound. "The places that were extremely noisy for a person often had absolutely no ultrasonic sound," says Bolen. "On the other hand, there were lots of places that didn't sound noisy but where the aerodynamic noise, mainly from nozzles, went on well past 200 kilohertz."

The most significant ultrasonic noise source was a laser process used to etch numbers on plastic tags. The stretching and relaxing of metal in a tube-bending operation also generated ultrasonic spikes at frequencies up to 1 megahertz.

"For almost all the other systems that we observed," says Bolen, "the noise fell off very nicely." High-velocity fluid and air sprays, for instance, were the most common sources of ultrasonic sound, but this faded away at frequencies beyond 200 kilohertz. Robot sensors operating at higher frequencies would not be greatly affected.

Noisy bubble clouds

The ocean is a noisy place. One of the chief contributors to the underwater cacophony is the oscillation of bubbles, especially in the top few yards of the ocean's surface. These bubbles, generated by breaking waves, raindrop splashes (SN: 1/4/86, p. 4), living organisms or organic decay, are often easily set into motion. The oscillating bubbles, like tiny balloons, rhythmically expand and contract, generating acoustic waves that can travel thousands of miles before fading away.

Mechanical engineer Andrea Prosperetti of Johns Hopkins University in Baltimore has been studying theoretically how different types of bubble oscillations may contribute to underwater noise at various frequencies. He suggests that at low frequencies — up to tens of hertz — bubbles may be driven into oscillation by turbulence in the water. At frequencies from 1 to several kilohertz, bubbles oscillate freely at a natural frequency dependent on the bubble size.

However, noise in the range of hundreds of hertz may be the result of large clusters of bubbles pulsating together, says Prosperetti. In a sense, each bubble "knows" what its neighbors are doing. Such bubble clouds, probably created by breaking waves, would collectively oscillate at a lower frequency than that of individual bubbles oscillating freely.