The newsletter of
The Acoustical Society of America

ECHOES

Volume 10, Number 3
Fall 2000

The Incredible Shrinking Microphone

by Jennifer Ouellette

(reprinted, with editing, from *The Industrial Physicist*, **5**(4), pp. 7–9, August 1999)

Researchers and electronic companies are abuzz about a new generation of tiny microphones carved into silicon integrated circuits (ICs), often combined with electronic circuitry components. Generally referred to as silicon microphones, the devices are expected to find initial application in high-end markets such as hearing aids, underwater mine detection, and medical ultrasound. However, some researchers envision the devices one day supplanting conventional small microphones, such as those found in cellular phones.

Silicon microphones are among a broad range of devices known as micro-electromechanical systems (MEMS), an emerging field in which various sensors and mechanical devices are constructed on a single wafer using processes developed for making ICs. According to Marc Fischer of Darmstadt University of Technology in Germany, the chief advantage of micromachining silicon microphones is cost. Several sensors can be processed on a chip simultaneously and can be integrated with passive and active electronic devices.

Micromachining makes it possible to precisely control layer thickness and lateral dimensions in the submicrometer range, yielding high precision and reproducibility. "By using silicon micromachining, one is able to design new types of sensors using the special mechanical and electrical properties of silicon," Fischer says.

Most handheld consumer products requiring microphones—such as cellular phones and portable tape recorders—use the electret-condenser microphone invented at Bell Laboratories in the 1960s. These microphones are preferred for their acoustical properties and low price, usually less than $1. In these devices, a vibrating membrane picks up the sound wave, and electronic circuitry converts the vibration into an electrical signal.

Micromachining

The earliest silicon-microphone designs sought to match the advantages of conventional electret microphones by using two chips. One chip serves as the membrane and the other as the electrode or backplate, which together form a capacitor. As the membrane vibrates in response to sound, the capacitance changes, creating an electrical signal in a circuit connected to the device. Two-chip capacitive silicon microphones have good acoustical properties, but new manufacturing techniques now enable the creation of the entire device on a single chip. Single-chip designs are favored because they do not require bonding two chips together. However, the production process is more complex and expensive than that for two-chip silicon microphones.

There are also piezoresistive and piezoelectric silicon microphones. The piezoresistive versions are one-chip devices that use materials as membranes whose electrical resistivity changes with the mechanical stress, caused by the deflection of sound waves. Piezoelectric microphones have a similar design and operation, but their materials generate electrical potential differences at the surface instead of changing resistivity. More radical designs include the two-chip optical microphone, which modulates light, and the field-effect transistor (FET) microphone, in which the vibration of the membrane produces a varying electric field that modulates the amount of current flowing through the FET.

Optical microphones are ideal for applications in which strong external electric or magnetic fields could cause interference, according to Gerhard Sessler, head of the electroacoustics research group at Darmstadt. Sessler, one of the pioneers of silicon-microphone technology, co-invented the electret-condenser microphone with James West while at Bell Labs.

At Lucent Technologies' Bell Laboratories, a team led by Peter Gammel, head of wireless components research, has constructed a pyramid-shaped silicon microphone that measures 300 μm on a side and about 300 μm high. Lucent's is the first silicon microphone whose parts were built entirely with surface micromachining techniques, in which thin films are deposited on a silicon surface and then etched. The prototype was then assembled by hand under a microscope by folding several pieces on the surface to create a three-dimensional structure, much like micrometer-scale origami (illustrated in the background figure).

"We wanted to have something where the micromachined device is not merely a stand-alone component, but can be in-

continued on page 3

To the Editor

Fellows and the Foundation

In late 1998, due largely to the efforts of Bill Cavanaugh and Dick Lyon, the Acoustical Society formed the College of Fellows to encourage and help coordinate meaningful activities for ASA Fellows regardless of whether they happen to hold formal Societal positions. For example, the College has already offered assistance to local ASA semiannual meeting organizing committees to help secure outstanding guest speakers for the Fellows Luncheon. Consideration of special events in conjunction with the Acoustical Society's 75th Anniversary are underway. Also, to help ensure the long-term viability and vigor of the Society, the Acoustical Society Foundation (ASF) launched the "College of Fellows Campaign" last year to encourage Fellows to make significant contributions to the Foundation in its initial efforts to bolster and grow the Acoustical Society Endowment.

In many regards, the College of Fellows capital campaign, now in its second of three years, has been very successful. Over 100 Fellows have participated and increased the size of the endowment by about $35,000, which is 8% of the approximately $450,000 received by the Foundation to date. Endowment increases at this point in the formative years of the Foundation will yield major additions to the principal in years to come. The commitment of the Fellows who have contributed so far via the College of Fellows Campaign has been inspirational, with the average annual contribution exceeding $250. For the Fellows Campaign, in terms of total dollars, Fellows of the Speech TC are significantly ahead of those of other TCs, leading the next closest TCs, Noise and Psychological & Physiological, by over a factor of two. Dollar amounts contributed by Fellows of Structural, Underwater, Architectural, Engineering and Physical TCs have also been noteworthy. Outside the US, Japan leads the way in contributions, with other contributions from France and Israel. Sincere thanks to all Fellows who have contributed so far, and a concerted invitation to those who haven't, to join the Campaign. For more information on ways to share in the Foundation's goals and mechanisms for making donations that allow you to give while receiving, please contact Dr. Bob Frisina at 716-275-8130 or asf@q.ent.rochester.edu.

Thank you,
Bob Frisina, ASF General Secretary

ECHOES

Newsletter of the Acoustical Society of America
Provided as a benefit of membership to ASA members

The Acoustical Society of America was organized in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.

Echoes Editor ..... Thomas Rossing
ASA Editor-in Chief ..... Allan Pierce
Editorial Advisors ..... Elaine Moran, Charles Schmid
Desktop Design ..... Lisa Rutley, AIP
Printing ..... American Litho. Tech.

Phone inquiries: 516-576-2360. Contributions should be sent to Thomas Rossing, Physics Dept., Northern Illinois University, Dekalb, IL 60115 <Rossing@physics.niu.edu>

From the Editor

At the risk of sounding repetitious, I want to remind *Echoes* readers, who are also *Echoes* reporters, that we need regular input from you. Probably because summer months are the traditional vacation season, very few news items came in for this issue. Furthermore, a couple of articles that I had counted on failed to materialize, so the lead story this time is an article on silicon microphones which appeared in *The Industrial Physicist* in 1999. The author and editor have kindly given us permission to reprint this article.

We are always looking for news about acoustics and about ASA members. We appreciate good photos. Letters to the Editor are always welcome, and seldom are they edited.

A letter in *Echoes* is a way to share your opinions with 10,000 intelligent people!

We Hear That . . .

- The American Academy of Arts and Sciences has awarded the first Scholar-Patriot Distinguished Service award to **Leo L. Beranek**. The award was given to honor "his contributions to science, his role in founding Bolt, Beranek and Newman and other engineering and media companies, and his service on behalf of the community and the Nation." The Academy also dedicated the Leo L. Beranek Library to honor Dr. Beranek's achievements and his support of the Academy. The Academy was founded in 1870 by a small group of scholar-patriots led by John Adams.
- **Ronald Roy** (Boston University) is the lead acoustics principal investigator in an NSF Engineering Center being established at Northeastern University in partnership with Boston University, Rensselaer Polytechnic Institute, and the University of Puerto Rico. A Center for Subsurface Sensing and Imaging Systems will be established to do interdisciplinary engineering research. Other ASA members involved in the Center are Robin Cleveland and Paul Barbone, the two most recent ASA Lindsay Award winners and both faculty members at Boston University.

Clemson University awarded Professor Emeritus **M. David Egan** an honorary Doctor of Laws degree, recognizing his dedication, expertise, and professionalism in the areas of architectural acoustics, lighting, fire and life safety, and low-energy design. He is a Fellow of ASA and served as vice president of the National Council of Acoustical Consultants.

Society Pages

Avril Brenig to Retire

Katherine S. Harris, ASA President

Avril Brenig, ASA's Standards Manager, will be retiring from her position after over 30 years with the Acoustical Society of America. During that time our acoustical standards program, under Avril's competent stewardship, has grown from just a few standards and a relatively small number of members working on them, to about 120 acoustical standards and a program involving more than 600 experts.

Avril will be receiving the ASA's Distinguished Service Citation on December 6th at our upcoming meeting at Newport Beach "for helping to build the Society's leading position in acoustical standardization." You will be able to read more about her accomplishments in the encomium contained in the Newport Beach meeting program which will be mailed to all members in November.

We will miss Avril, and I know you will join me in expressing appreciation for her many years of devoted work to provide the Society with a strong national and international standards program. We are now proceeding with the difficult job of finding Avril's replacement so that the Acoustical Society will be able to continue the fine program she began for acoustical standards.

First ASA Career Workshop a Success

A workshop to help those interested in improving their skills in finding a career in acoustics was offered at the Atlanta ASA meeting in June. Stephen Brieger, a human resources specialist, discussed techniques for writing resumes and attending interviews, among other things. Although there were a few criticisms voiced, nearly all the respondents to the evaluation questionnaire "strongly agreed" that the workshop is important and should be continued at future meetings. Most of the 30 attendees were students who are not presently employed and are seeking jobs in acoustics.

(Microphone..., continued from page 1)

tegrated with the silicon," says Gammel. "It then becomes part of the overall silicon integrated-circuit industry and can follow the same performance trends."

Once silicon microphones become as ubiquitous on chips as transistors, he adds, it will be possible to create large arrays for use in hands-free microphones in automobiles and in speaker phones for full-duplex conference calls. The arrays would not only detect the speaker's voice, but signal processing capabilities could cancel out extraneous noise and interference and make it possible to distinguish one speaker from another. The arrays would also make good candidates for advanced directional microphones.

Several research groups based in Germany are developing commercially viable silicon microphones. Robert Bosch GmbH in Stuttgart has collaborated with Microtronic, a Danish firm, to create silicon wafers studded with condenser microphones. Only 2 mm^2 in area, the device's charged membrane (400 nm thick) is capable of converting sound vibrations into electrical signals as well as conventional microphones do.

Sennheiser Electronics (Wedemark, Germany), Europe's leading manufacturer of commercial microphones, has a two-pronged R&D effort. The first is a collaboration with the University of Twente in The Netherlands to develop a radical new silicon-microphone design that requires no outer membrane.

Instead, it employs a transducer to sense the particle flow in an acoustic wave. Called a "microflown," the device was originally invented by Hans-Elias de Bree, then a Twente graduate student. He has since founded Microflown Technologies, which is participating in the Sennheiser–Twente collaboration. Microflown performance characteristics are now close to those of condenser microphones used in telephone receivers, and they have the added advantage of eliminating background noise.

The second effort, headed by Wolfgang Niehoff, is the development of an optical microphone in which sound is recorded by measuring changes in the intensity of a light beam inside the device. An advantage of this design is that the microphone head and photodetector can be placed several hundred meters apart, making it an ideal choice for use in strong magnetic fields or in difficult-to-reach places.

Sessler and his Darmstadt research group are experimenting with several designs, including optical and FET devices. Optical silicon microphones are particularly promising as a solution to the short-lifetime problems of small, humidity-sensitive microphones, such as those used in theaters.

Young Cho of the National Aeronautics and Space Administration has built an optical prototype in which red laser light passes through an optical fiber, bounces off a silicon nitride membrane, and travels back through the fiber. Variations in light intensity generated by the membrane vibrations are converted into an electrical signal. According to Cho, the device is 1,000 times more sensitive than previous fiber-optical pressure sensors and commercial reference microphones.

Challenges ahead

Gammel cites manufacturing, reliability, and packaging problems as the primary challenges to commercializing silicon microphones. "Many people look at these small structures and they appear to be very fragile," he says. However, he argues that the MEMS-based sensors used for air-bag deployment offer evidence that this notion is largely a misperception. Packaging is a central issue in adapting silicon microphones to cellular phones. Unlike air-bag sensors, which are in a hermetically sealed package, cellular phones require the microphone to be coupled to the outside world-usually via a rubber structure—yet still protected from damage.

Nevertheless, "for me, there is no doubt that there will be silicon microphones with good acoustical properties [commercially available] in the near future." Adds Sessler, "In a few years, as these devices are used in more and more applications, prices will come down and they will conquer some of the microphone market, now estimated to be close to 1 million units per year."

Thermoacoustics Demonstration

Build an "Acoustic Laser"

by Steven L. Garrett and Reh-lin Chen
Graduate Program in Acoustics, Penn State University

Introduction

Optics and acoustics are the two fields of classical phenomenology that developed in tandem since the birth of Newtonian physics. The activity in physical optics, optical spectroscopy, and optical devices, as measured by research activity and manpower, diverged dramatically from the corresponding levels in acoustics with the invention of the laser over forty years ago. Fiber-optic communications, bar-code scanners, compact discs, and laser surgery were not anticipated applications for the laser in the 1960s. The increased efforts directed to fundamental research into resonant optical systems related to lasers and to atomic and molecular spectroscopy led to the evolution of those and other technologies that are transforming the global economy today.

Since the time of Pythagoras (570-497 BCE), acousticians have been able to produce coherent sources of acoustic radiation with calculable frequencies, but an important aspect of lasers is their ability to produce high power coherent radiation from a time-independent energy input. In this article, we will describe a very simple thermoacoustic demonstration device that can be made in less than one hour from a test tube, some nichrome heater wire, and a small piece of porous ceramic. This device will produce an uncomfortably loud tone from the heat produced when the heating element is attached to a single 6-volt lantern battery. This version of an "acoustic laser" was first demonstrated in the "Take Five" session, and at the Fellows' Luncheon, during the most recent meeting of the Acoustical Society in Atlanta.

Glassblowers have known for centuries that a heated vessel would occasionally produce a loud, pure acoustic tone[1], but it was only recently recognized that the process could be reversed and sound could be used to produce useful cooling[2,3]. No one could have predicted the resulting new resonant acoustical devices that have emerged during the past five years which employ these two thermoacoustic effects: A thermoacoustic refrigerator was used to cool radar electronics on a US Navy warship[4]. A resonant acoustic-Stirling engine converted heat to mechanical work at efficiencies greater than current gasoline-powered internal combustion engines[5,6]. A thermoacoustic engine, powered by natural gas, has driven a refrigeration system that liquefies natural gas in commercially significant quantities without the need for any moving parts[7].

The "Acoustic Laser"

As shown in the upper part of Figure 1, a laser requires three components: a resonant cavity, a medium disposed within the cavity that can be maintained in a non-equilibrium state, and a power source which can pump energy into that medium to maintain the required non-equilibrium energy distribution. The medium must be able to deposit energy into an optical standing wave with the proper phase to add energy coherently to the wave. In the optical laser, a quantum mechanical process known as "stimulated emission of radiation" produces the proper phasing. Useful optical energy is extracted from the resonant cavity by radiation through a partially silvered mirror at one end.

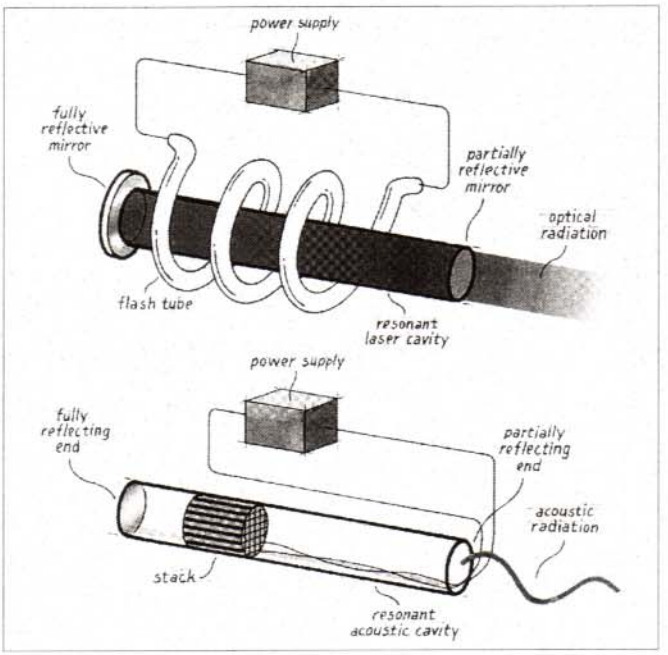


Figure 1. Thermoacoustic engines are similar to optical lasers in that both types of apparatus amplify standing waves set up within resonant cavities. In a ruby laser (top)*, for example, energy is added by means of a flash tube that creates a "population inversion" of electronic energy levels. In the thermoacoustic analogue* (bottom)*, energy is injected into the cavity using heat that creates a non-equilibrium temperature distribution in the stack. [Figure reproduced with permission from* American Scientist Magazine.*]*

The analogous "acoustic laser," shown in the lower portion of Figure 1, contains the same three components as its optical counterpart. In our demonstration device, a quarter-wavelength acoustic resonator is provided by a Pyrex test tube. The acoustical impedance discontinuity between the inside of the tube and the surrounding free-space acts as the "partially-silvered mirror." Inside the test tube we place a porous ceramic material that is manufactured for use in automotive catalytic converters[8]. The end of the ceramic that faces the closed end of the tube has a serpentine electrical heating element wound between the pores. In the left-hand section of Figure 2, the shallow channels that accept the nichrome heater wire are visible through the test tube. The passage of electrical current through the heater wire produces a non-equilibrium temperature distribution (thermal gradient) along the ceramic in the axial direction. Since the other end of the ceramic faces the open end of the tube, acoustic streaming is sufficient to keep that end cool without having to use an additional heat exchanger.

Like the laser, a "natural process" provides the proper phasing for the injection of thermal energy into the standing sound wave. In the thermoacoustic case, the acoustic motion of the individual gas parcels that oscillate within the ceramic medium, known as a "stack" amongst thermoacousticians because of its similarity to a stack of plates, is sufficient to pump energy into the standing wave. When the gas moves toward the

Figure 2. A simple thermoacoustic engine can be constructed from common components (left). *A small test tube, a heater wire, and a plug of porous ceramic (material used in automotive catalytic converters) properly arranged can produce about a watt of radiated acoustic power. If one end of the ceramic plug is placed at the focus of a parabolic mirror* (right), *solar energy, too, can power this demonstration engine. [Photo courtesy of Reh-lin Chen.]*

closed (hotter) end of the tube, the gas is compressed into a portion of the stack that is hotter than the location that the same gas parcel came from during the previous half-cycle of its motion. The gas absorbs heat from the stack when it is compressed and its pressure rises further due to the thermal expansion of the gas parcel. This pushes the gas parcel back away from the closed end of the tube a little harder.

Similarly, as the gas parcel moves toward a position in the stack closer to the open (cooler) end, it expands more that it would have. The temperature of the stack is lower than it was at its previous position a half-cycle before so some heat leaves the gas and enters the stack. This pressure reduction due to thermal expansion sucks the gas parcel outward (toward the open) a little farther.

The net effect of this combination of the gas motion and the heat transfer between the gas and the stack is that the stack does work on the gas by increasing its pressure when the gas is compressed and reducing its pressure when it is expanded. For a sufficiently large temperature gradient in the stack[3], the energy added to the sound wave overcomes the thermoviscous losses in the stack and the resonator, causing an exponential growth of the sound amplitude within the tube. More detailed explanations of this amplification process are available elsewhere[3] as well as computer animations of the process that are available on the Thermoacoustics Home Page[9].

Since the stack provides acoustic gain, any fluctuation in the gas motion will be amplified and will initiate growth of the acoustically resonant oscillations. The acoustic amplitude saturates when the energy provided by the stack is equal to the sum of the energy losses due to radiation out of the tube and the thermoviscous dissipation within the tube and stack. For the demonstration device shown in Figure 2, the radiated acoustic power is about one watt for an electrical input power of fewer than 20 watts.

As shown in the right-hand portion of Figure 2, the acoustic laser can be powered directly by concentrated solar radiation. The first such solar-powered thermoacoustic engine was described by us at the joint meeting of the Acoustical Society of America and the 16th International Congress on Acoustics in Seattle[10].

Build Your Own!

The device shown on the left-hand side of Figure 2 is very easy to fabricate. My fourteen-year-old daughter, Wendy Garrett, built and tested twenty-two of the devices in less than ten hours. The total value of the parts for each demonstration device is less than a dollar. Unfortunately, the manufacturer of the ceramic material used for the stack, requires a $150 minimum purchase (which is enough material for more than 500 demos!). To make this demonstration device widely available, the Graduate Program in Acoustics will provide complete kits for a USD$10/kit donation to cover the cost of packaging and postage. (Send payment by check made out to Penn State University to: Acoustic Laser Kit, Graduate Program in Acoustics, P. O. Box 30, State College, PA 16804-0030). These kits include four feet of magnet wire, one foot of the 26 gauge Ni-Cr heater wire, a Pyrex test tube, three chunks of the ceramic, step-by-step instructions, and suggestions for various experiments. The ceramic chunks can easily be shaped into a cylinder that will slide into the test tube using only an old hacksaw blade and sandpaper (not provided in the kit).

Portions of this article appeared in a paper by S. L. Garrett and S. Backhaus, entitled "The Power of Sound," *Am. Sci.* **88**, 516-525 (2000). Those portions are reproduced here with the permission of *American Scientist Magazine*.

References

1. Sondhauss, C. (1850) "Uber dei Schallschwingungen der Luft in erhitzten Glasröhren und in gedeckten Pfeifen von ungleicher Weite," Ann. Phys. (Leipzig) **79**, 1.
2. Wheatley, J. C., Swift, G. W. and Migliori, A. (1983) "Acoustical heat pumping engine," US Pat. No. 4,398, 398.
3. Swift, G. W. (1988) "Thermoacoustic engines," J. Acoust. Soc. Am. **84**(4), 1145–1180.
4. Garrett, S. L. (1997) "High-power thermoacoustic refrigerator," US Pat. No. 5,647,216.
5. Backhaus, S. and Swift, G. W. (1999) "A thermoacoustic-Stirling heat engine," Nature **399**, 335–338; (2000) J. Acoust. Soc. Am. **107**(6), 3148–3166.
6. Garrett, S. L. (1999) "Reinventing the engine," Nature **399**, 303–305.
7. Swift, G. W. (1997) "Thermoacoustic natural gas liquefier," *Proc. DOE Natural Gas Conf.* (Federal Energy Technology Center, Morgantown, West Virginia).
8. Celcor catalytic converter, HP-CB-03-1, 400 cells/in^2, Corning Inc., Corning, NY 14831.
9. Thermoacoustics Home Page: www.lanl.gov/thermoacoustics/.
10. Chen, R-L. and Garrett, S. L. (1998) "Solar/heat driven thermoacoustic engine." in *Proc. 16th Int. Cong. Acoust.*, Vol. 2:813–814, eds. P. K. Kuhl and L. A. Crum (Acoustical Society of America, Melville, NY).

Sound Waves and Ocean Waves

The *smell* of an ocean breeze; the *taste* of gourmet food; the *warmth* of exquisite sunsets; and barefoot *walks* on white sand beaches are what the Newport Beach Conference and Visitors Bureau promises attendees at the 140th meeting of the Acoustical Society of America December 3–8, 2000. This meeting will be a joint meeting with NOISE-CON 2000 at the Newport Beach Marriott Hotel and Tennis Club.

The meeting will feature more than 100 special sessions on a wide variety of topics. The Plenary session will be held on Wednesday afternoon where Society awards will be presented and recognition of Fellows will be announced. Complimentary buffet socials with cash bar will be held on Tuesday and Thursday evenings, and a Fellows' Luncheon will be held on Thursday. Technical tours of the Orange County Performing Arts Center, the John Wayne Airport Access and Noise Office, and the Fiske Museum of Musical Instruments are being arranged.

A Distinguished Lecture on "Ultrasonic Eyeglasses for the Blind" will be presented by Leslie Kay of New Zealand. A Vern O. Knudsen lecture will be presented by Paul Scarbrough of Norwalk, CT.

Named sessions include those honoring Kenneth Stevens and Alvin Liberman. A session on brass instruments will end with a concert by the Americus Brass Band. A session on informal education in acoustics will feature the Mobile Science Museum from California State University in Long Beach.

Exhibit

The joint ASA/NOISE-CON instrument and equipment exposition will open on Sunday evening at 5:30 p.m. The exposition will include computer-based instrumentation, sound measuring equipment of all kinds, signal processing systems, acoustical materials, active noise control systems, and other acoustical exhibits.

Tutorial on Virtual Musical Instruments

A tutorial lecture on Virtual Musical Instruments will be given by Julius O. Smith III of the Center for Computer Research in Music and Acoustics (CCRMA) at Stanford University. The tutorial will cover some of the more effective virtual instrument algorithms and how they can be played and varied in real time. Sound examples will be played. Attendees are urged to preregister by Nov. 6 in order to be assured a set of lecture notes.

Short course on Applied Digital Signal Processing in Acoustics

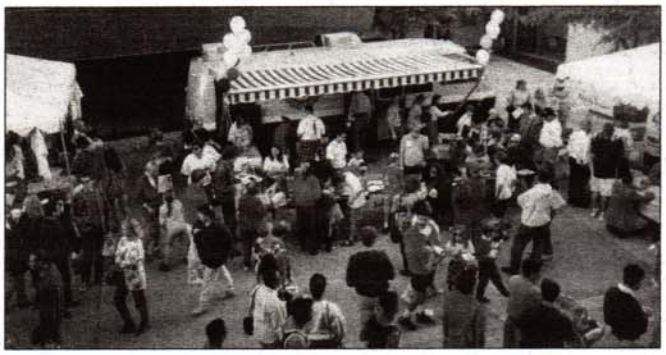
This short course on Friday afternoon and Saturday morning, Dec. 8–9, will develop digital signal processing (DSP) techniques that are applicable to acoustical signal processing problems. The discussions will range from basic DSP techniques such as digital filtering and FFT, to more advanced approaches such as spectral estimation and adaptive processing. Participants will obtain a basic understanding of the approaches and their applicability from the practitioner's perspective, rather than that of a DSP expert. Attendance is limited so register early.

Student Design Competition

The Technical Committees on Engineering Acoustics and Architectural Acoustics, in association with the American Loudspeaker Association, JBL Professional, JBL Consumer, Infinity and Revel, are sponsoring a student loudspeaker design competition. Each entry will consist of a working prototype device and complete schematic design. A "first honors" prize of $1000 and four "commendation" awards of $500 each will be given to the winners.

Gallery of Acoustics

The Interdisciplinary Technical Group on Signal Processing in Acoustics will sponsor the fourth Gallery of Acoustics. The Gallery will consist of posters, videos, and audio clips of images and/or sounds generated by acoustic processes or resulting from signal processing of acoustic data.



The C.S.U.L.B. Mobile Science Museum on display.

Scanning the Journals

by Thomas D. Rossing

- The outer layer of the cerebral cortex is divided into different areas specialized for detecting and processing sensory signals from the eyes and ears and other senses, a paper in the 18 August issue of *Science* reminds us. Although the different sensory areas meet the special processing needs of each type of sensory signal, they also cooperate with each other by **integrating the sensory stimuli**. In ventriloquism, for example, the apparent direction of sound is attracted toward the displaced location of a simultaneous visual stimulus. Biologically important combinations of sensory stimuli are likely to be endowed with hard-wired neural pathways in the brain.

- In order to attempt an answer to the often-asked question "Is there really a lost secret that sets Stradivarius violins apart from the best instruments made today?" Colin Gough discusses the **physics of violins** in the April issue of *Physics World*. The motion of the bowed string, the behavior of the bridge, and the resonances of the violin body are considered. Readers are reminded that most old Italian violins have been modified, revarnished, and adjusted repeatedly through the years.

- **Humpback whales** change their tune according to the season, and researchers at Rutgers University think they know why, according to the 16 September issue of *New Scientist*. In

Acoustics in the News

Papers given at ASA meetings continue to attract media attention. For example, *Discover* picked up on a paper "Perceptual Assessment of Intoxication Level" by Harry Hollien, et al. at the Atlanta meeting. The authors asked clinicians who treat chemical dependency, along with a group of everyday people, to listen to recordings made by volunteers when they were sober, then mildly intoxicated, legally impaired, and finally, completely smashed. Listeners consistently overestimated the drunkenness of mildly intoxicated subjects. Conversely, they underestimated the alcohol levels of those who were most inebriated.

RN magazine, published by the Medical Economics Company, cited another Atlanta ASA paper "Using ultrasound to assess change in corneal stiffness" by Mardi Hastings. Corneas of six intact donor eye globes from five different species were examined with ultrasound while being excited by audible sound waves. Noninvasive assessment of corneal stiffness has potential application in diagnosing and treating glaucoma. The article in RN suggests that glaucoma patients may someday be able to monitor their own fluid pressure at home and adjust medications accordingly.

Papers in JASA also form the bases for news stories in the media. An example is a news story "Seeing through soil with sound" which appeared as a news brief on the *Scientific American* website. This was based on the paper "Acoustical imaging of objects buried in the soil" by Catherine Frazier, et al. in the July issue of JASA. A source and receiver array are moved together along a linear path to collect data using delay-and-sum beamforming. One goal is to image cultural artifacts in order to assess the historical significance of a potential construction site. Another is to search for land mines.

A news note in the 30 September issue of *New Scientist* is based on a paper "Zones of impact around icebreakers affecting beluga whales in the Beaufort Sea" by Christine Erbe and David Farmer in the September issue of JASA. Two types of noise emitted by an icebreaker are analyzed: bubbler system noise and propeller cavitation noise. Effects on beluga whales are modeled both in a deep-water environment and a nearshore environment. The model estimates that the icebreaker is audible to beluga whales over ranges of 35 to 78 km, and the zone of behavioral disturbance is only slightly smaller. Temporary hearing damage can occur if a beluga stays within 1 to 4 km for at least 20 minutes.

- For years, researchers have known that animals such as dolphins and whales communicate at low frequencies. But according to a story in the *News and Observer* (Raleigh, NC), Liz von Muggenthaler has been recording sounds of tigers, rhinos, and even giraffes that no human can hear. Using audio equipment borrowed from NASA, she began listening to and recording rhinos at the Bronx Zoo in New York, and in 1992 she published a paper pointing out that rhinos made infrasonic sounds. She has been recording animal sounds ever since. She has pursued her research at the North Carolina Zoological Park in Asheboro and paid for her passion with an inheritance, temporary work, bartending and waitressing. She has created the nonprofit Fauna Communications, and studying elephant sounds is a major objective. She will present two papers at the ASA meeting in Newport Beach.
- Jack Randorff and his associates designed an "acoustical umbrella in order to reduce reverberation at the Republican National Convention in Philadelphia's First Union Center, according to a story in the Spring issue of the National Council of Acoustical Consultants (NCAC) Newsletter. The rectangular structure, which hung 60 feet over the speakers' heads, created a "shadow zone" to block reverberating sound waves from reaching the speakers and their microphones. To cut down on low-frequency sounds, they covered unused seats with very thick Mylar and also lined the walls of the mezzanine level with fiberglass and sprayed cellulose material.
- One of the "Ig Nobel" prizes this year, according to an Associated Press story, was awarded to Chris Niswander for creating "PawSense," a program that detects the presence of cats on computer keyboards and emits a sound to send them scurrying. This program prevents cats from wandering across computer keyboards, deleting files and shedding between the keys. The Harvard-based spoof of the real Nobel prizes recognizes achievements that "cannot or should not be reproduced."

ACOUSTICAL•SOCIETY•OF•AMERICA
SUITE 1NO1
2 HUNTINGTON QUADRANGLE
MELVILLE, NEW YORK 11747-4502

Non-Profit Org.
U.S. POSTAGE
PAID
Hicksville, NY
Permit No. 289

Acoustics in the News

Papers given at ASA meetings continue to attract media attention. For example, *Discover* picked up on a paper "Perceptual Assessment of Intoxication Level" by Harry Hollien, et al. at the Atlanta meeting. The authors asked clinicians who treat chemical dependency, along with a group of everyday people, to listen to recordings made by volunteers when they were sober, then mildly intoxicated, legally impaired, and finally, completely smashed. Listeners consistently overestimated the drunkenness of mildly intoxicated subjects. Conversely, they underestimated the alcohol levels of those who were most inebriated.

RN magazine, published by the Medical Economics Company, cited another Atlanta ASA paper "Using ultrasound to assess change in corneal stiffness" by Mardi Hastings. Corneas of six intact donor eye globes from five different species were examined with ultrasound while being excited by audible sound waves. Noninvasive assessment of corneal stiffness has potential application in diagnosing and treating glaucoma. The article in RN suggests that glaucoma patients may someday be able to monitor their own fluid pressure at home and adjust medications accordingly.

Papers in JASA also form the bases for news stories in the media. An example is a news story "Seeing through soil with sound" which appeared as a news brief on the *Scientific American* website. This was based on the paper "Acoustical imaging of objects buried in the soil" by Catherine Frazier, et al. in the July issue of JASA. A source and receiver array are moved together along a linear path to collect data using delay-and-sum beamforming. One goal is to image cultural artifacts in order to assess the historical significance of a potential construction site. Another is to search for land mines.

A news note in the 30 September issue of *New Scientist* is based on a paper "Zones of impact around icebreakers affecting beluga whales in the Beaufort Sea" by Christine Erbe and David Farmer in the September issue of JASA. Two types of noise emitted by an icebreaker are analyzed: bubbler system noise and propeller cavitation noise. Effects on beluga whales are modeled both in a deep-water environment and a nearshore environment. The model estimates that the icebreaker is audible to beluga whales over ranges of 35 to 78 km, and the zone of behavioral disturbance is only slightly smaller. Temporary hearing damage can occur if a beluga stays within 1 to 4 km for at least 20 minutes.

- For years, researchers have known that animals such as dolphins and whales communicate at low frequencies. But according to a story in the *News and Observer* (Raleigh, NC), Liz von Muggenthaler has been recording sounds of tigers, rhinos, and even giraffes that no human can hear. Using audio equipment borrowed from NASA, she began listening to and recording rhinos at the Bronx Zoo in New York, and in 1992 she published a paper pointing out that rhinos made infrasonic sounds. She has been recording animal sounds ever since. She has pursued her research at the North Carolina Zoological Park in Asheboro and paid for her passion with an inheritance, temporary work, bartending and waitressing. She has created the nonprofit Fauna Communications, and studying elephant sounds is a major objective. She will present two papers at the ASA meeting in Newport Beach.
- Jack Randorff and his associates designed an "acoustical umbrella in order to reduce reverberation at the Republican National Convention in Philadelphia's First Union Center, according to a story in the Spring issue of the National Council of Acoustical Consultants (NCAC) Newsletter. The rectangular structure, which hung 60 feet over the speakers' heads, created a "shadow zone" to block reverberating sound waves from reaching the speakers and their microphones. To cut down on low-frequency sounds, they covered unused seats with very thick Mylar and also lined the walls of the mezzanine level with fiberglass and sprayed cellulose material.
- One of the "Ig Nobel" prizes this year, according to an Associated Press story, was awarded to Chris Niswander for creating "PawSense," a program that detects the presence of cats on computer keyboards and emits a sound to send them scurrying. This program prevents cats from wandering across computer keyboards, deleting files and shedding between the keys. The Harvard-based spoof of the real Nobel prizes recognizes achievements that "cannot or should not be reproduced."

ACOUSTICAL•SOCIETY•OF•AMERICA
SUITE 1NO1
2 HUNTINGTON QUADRANGLE
MELVILLE, NEW YORK 11747-4502

Non-Profit Org.
U.S. POSTAGE
PAID
Hicksville, NY
Permit No. 289