The newsletter of
The Acoustical Society of America

ECHOES

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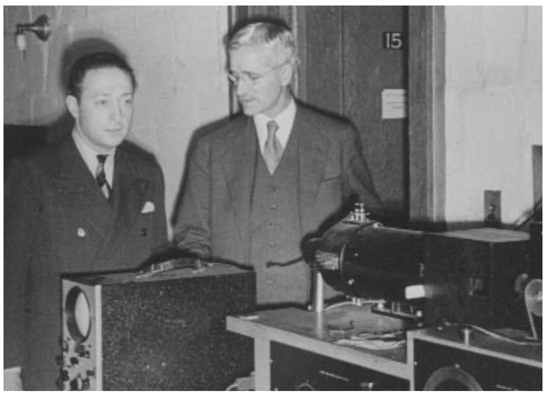
Frederick A. Saunders

Carleen M. Hutchins

Frederick Albert Saunders (1875-1963), a founding member and fifth president of the Acoustical Society of America, is remembered for his research on violin physics as well as his research in optical spectroscopy.



Frederick Saunders shows violinist Jascha Heifetz his violin testing apparatus built with graduate students Leo Beranek and Harry Hall, ca.1935.

After he retired as Chairman of the Harvard Physics Department in 1941 to live in a big house overlooking the Connecticut Valley in South Hadley, Massachusetts, a stream of distinguished scientists, musicians, bird watchers and other friends beat a path to his door. He and Mrs. Saunders specialized in making visitors from all over the world feel welcome. Surrounded by orchard trees and gardens, with a small pond and thick shrubbery, their home was appropriately named "Thicket." Feeding stations and nesting sites attracted many birds, not only those common to the area, but unusual species who lingered because they found a carefully contrived welcome to suit their needs.

The Saunders living room contained a baby grand piano, and in one corner four music stands kept ready for the frequent evenings of string quartets, often participated in by college students.

Saunders was born in London, Ontario on August 18, 1875. At an early age his father, William, had come to Canada from Crediton in Devonshire. His mother, Sarah, was born in Macclesfield, England. The youngest of six children, Frederick grew up in an atmosphere of scientific experimentation concerned with the hybridization of food crops, dedicated to finding those most suitable for the northerly climate of Canada. In 1887, the family moved to Ottawa, where his father became director of the Canadian Experimental Farms. The Saunders family is known throughout the world for the development of Marquis wheat, a project initiated by William Saunders with the help of his son Percy, and carried to ultimate success by his son Charles, who was knighted for his work.

Frederick inherited his love of music from his mother, an accomplished pianist. The five Saunders sons learned to play musical instruments at an early age, so that chamber music was a part of their daily lives. Frederick started playing the violin at the age of six, later turning to the viola as his chosen instrument. His interest in violin research was initiated in the 1930s when a friend asked him what physical differences there might be between an expensive cello and a cheaper one. The research thus started was to last the rest of his life. As an able violin and viola player, Saunders combined the point of view of the musician with that of the physicist.

He received his early education in the public schools of London, Ontario, the Ottawa Collegiate Institute, and the University of Toronto. His doctorate in physics was from the Johns Hopkins University in Baltimore. He was named a Fellow of the American Academy of Arts and Sciences, the National Academy of Sciences, the American Association for the Advancement of Science, the American Physical Society, and the Acoustical Society of America.

During his teaching career, Saunders taught at Haverford College, Syracuse University, Vassar College, and Harvard University (1919-1941). From 1941 until his death in 1963, he continued his research on the acoustics of the violin, viola, and cello in a laboratory provided by the Physics Department at Mount Holyoke College in South Hadley, where he was also a visiting lecturer and member of the college orchestra. His textbook, *A Survey of Physics for College Students*, appeared in several editions.

His early work in the field of spectroscopy, with the astrophysicist Henry Norris Russell, led to the discovery of what is

continued on page 5

We hear that...

• **Daniel Russell**'s website "Acoustics and Vibration Animations" was one of the three sites featured in the Web Watch section of the May 2003 issue of *Physics Today*. <http://www.gmi.edu/~drussell/Demos.html>

• **Martin Klein** received the Award of Merit from the Society for Historical Archaeology for his role in the development of side-scan sonar for use in underwater archaeology and his long service to the Advisory Council on Underwater Archaeology. Klein is the founder and former president of Klein Associates, Salem, New Hampshire.

• A reception on June 2nd honored **Ilene Busch-Vishniac** for her service as Dean of the Whiting School of Engineering at Johns Hopkins. She is retiring as Dean on June 30th.

• New associate editors of JASA include **Armin Kohlrausch** and **Gerald Kidd** (psychoacoustics), **Sean Wu** (general linear acoustics), **Shira Broschat** and **Alexandra Tolstoy**, (underwater sound), and **John Schneider**, (computational acoustics).

• The International Union of Pure and Applied Physics (IUPAP) has declared 2005, which marks the 100th anniversary of Albert Einstein's annus mirabilis, to be the **World Year of Physics**. The American Physical Society (APS) is spearheading the US efforts for 2005, using the theme "Einstein in the 21st Century." They are developing several projects to run throughout the year 2005, including an interactive website, PhysicsQuest (a hands-on experiment targeted at middle school, a poster competition, and several physics roadshows. APS would welcome participation by other member societies of the American Institute of Physics as well. Ideas for ASA participation can be sent to Charles Schmid or (better yet) shared with other ASA members by sending a Letter to the Editor to *ECHOES*.

• The next several issues of *ECHOES* may well be 12 pages each. This issue includes numerous special features, as well as several letters to the editor, which brings a big smile to the Editor's face. The next issue will include advertising by the exhibitors at the Austin ASA meeting, and the following couple of issues should be full of announcements and news about our gala 75th anniversary meeting in New York.

ECHOES 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
Advisors . . . . .Elaine Moran, Charles Schmid

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From the Student Council

By David T. Bradley, Chair

The Student Website is currently being reviewed and should be up and running by the Austin meeting. Also, the second edition of the *Student E-zine* will be sent to all student members in early Fall, and will contain information on such topics as room sharing and alternative accommodations for the Austin meeting.

In an effort to increase the participation and visibility of student members, the Council is currently working in conjunction with the Regional Chapters Committee to create student branches of the ASA. A pilot branch will be established at the University of Nebraska this Fall, and student branch petitions should be widely available by 2004. The Council has also submitted the Student Council Mentoring Award program to the ASA Prizes and Special Fellowships Committee for review.

We expect to see many students at the upcoming Austin meeting. The Student Reception will be the place to be, and we strongly encourage all student members to attend these networking gatherings. Keep an eye out for the new and improved Student Message Board at the Austin meeting, detailing the activities of the Student Council.

Best paper awards for students and young professionals

Acoustical Oceanography
First: Kelly Benoit-Bird, Hawaii Institute of Marine Biology
Second: Mark Fallat, SACLANT Undersea Research Center

Animal Bioacoustics
First: Kelly Benoit-Bird, Hawaii Institute of Marine Biology
Second: Marla Holt, University California Santa Cruz

Biomedical Ultrasound/Bioresponse to Vibration
First: Ajay Anand, University Washington
Second: Yuan Jing, Boston University

Engineering Acoustics
Brian Anderson, Brigham Young University

Musical Acoustics
First: Andrew Morrison, Northern Illinois University
Second: Jared Grogan, Central Washington University

Noise
Matt McDuffee, Columbia College (Chicago)

Speech Communication
First: Om Deshmekh, University Maryland
Second: Cynthia Clopper, Indiana University

Signal Processing in Acoustics
Nicole Collison, Defence R&D Canada

Structural Acoustics and Vibration
First: Anne-Marie Albanese, Georgia Tech.
Second: Vesna Damljanovic, University Illinois

Underwater Acoustics
First: Ben Dzikowicz, Washington State University
Second: Curtis Osterhoudt, Washington State University

Maintaining Breadth in Acoustics

Are acousticans maintaining their breadth in acoustics?

Richard H. Lyon

The following is based upon a portion of Dick Lyon's acceptance speech which he gave upon receiving the Acoustical Society's Gold medal at Nashville on April 30th, 2003

The Acoustical Society was formed — and the *Journal* of the Society begun — just a few months before I was born in 1929. I have been perusing the early issues of the *Journal* over the past few months in preparation for the special session remembering and honoring Dick Bolt that occurred earlier here at this meeting in Nashville. The availability of the articles in the *Journal* on a CD-ROM for all of the back years now makes such a review of the early publications fairly easy. In the course of reading these old articles, I was gratified to see that many of the same areas of current acoustical activity are present in these beginning volumes of JASA. Papers on hearing, instrumentation, room acoustics, and vibrations were placed side-by-side in those early years, without apology or segregation into specific technical fields. And any self-respecting acoustician was presumed to be interested in them all.

When I went into the MIT Building 20 Acoustics Lab run by Dick Bolt and Leo Beranek as a student in 1952, I was surrounded by icons. Along with Dick and Leo (of course I didn't call them Dick and Leo then) were Walter Rosenblith, J.C.R. Licklider, Morris Halle, Ted Hueter, Ken Stevens, Bob Newman, and Uno Ingard. They represented physics, electrical engineering, architecture, brain and cognitive science, speech and hearing, and linguistics. The lab was a microcosm of the field of acoustics. My fellow students included Jim Flanagan, Ira Dyer, Peter Westervelt, George Maling, and Ed Kerwin. If you couldn't learn acoustics in that environment there would have to be something wrong with you!

Although each of us concentrated on a particular aspect for our research work, the constant interaction with the others, including faculty, staff, and students, brought a wide diversity of ideas to our specialty in acoustics. We would meet over lunch, in lab seminars, or in offices, often seeking assistance on some new idea. Having such a diverse group of acousticians around made it natural for all of us to be exposed to — and value — acoustics in all of its breadth. One look at the program for the Nashville meeting would convince any extra-terrestrial visitor that acoustics has maintained that breadth. And although it may be true that acoustics has maintained its breadth here within the Society, I wonder if we acousticians have done likewise.

There are many forces that seek to separate each of us into our specialized areas and thus segregate us from other areas of acoustics. The pressure to get a grant or contract, to choose a unique topic for a dissertation, or to get a prototype product ready for manufacturing, forces us to focus our thoughts and words on one field or maybe even a sub-field of acoustics. I also believe another source of this problem is the general move of acoustical education from general science-based courses like physics to more applied engineering departments. This has tended to replace the more general solutions that seek commonality between fields with problem-solving techniques specific to a particular situation. To be fair, that change has often brought about other interactions and fostered more practical applications. However I feel most acousticians today, academic and otherwise, do not have an opportunity for day-to-day interactions with workers in other fields of acoustics.

And yet, in spite of this situation or perhaps because of it, our ASA meetings remain full and vibrant with papers covering all fields of acoustics. I don't know how many underwater or noise control acousticians go to sessions or read articles on musical acoustics or animal bioacoustics, but clearly our Society provides them with the opportunity to do so. Despite the pressures to focus on one field in acoustics, there remains great resistance towards making our meetings more specialized; for instance by holding separate meetings for psychological and physiological acoustics, and physical acoustics, or by breaking up the *Journal* into such specialty fields.

The next time we have the opportunity to bring our various specialties together will be this November at the Austin meeting. I am involved with one of many such opportunities, namely a series of sessions on the evaluation of sound quality. These sessions are sponsored by the technical committees on Architectural Acoustics, Musical Acoustics, Engineering Acoustics, Noise, and Psychological and Physiological Acoustics. The purpose is to bring about a melding of different interests to develop a new way to think about how sound quality is understood and evaluated. We will search for a common basis for the evaluation of sound quality for musical instruments, lawn mowers, and urban soundscapes. This could only be possible in our Society because it has the breadth to undertake such a task.

So my hope for this profession which has occupied all of my adult life is that its participants maintain their breadth of interests, and not wander too far from the path that the founders of the Acoustical Society laid out for us. We will have an excellent opportunity to reaffirm our commitment in the Spring of 2004 when we meet for the 75th anniversary of the ASA in New York City.

Richard Lyon is president of RH Lyon Corp in Cambridge. He was president of the Society (1993 – 94), and chair of the ASA Cambridge meeting held in June 1994.

Letters to the Editor

Plumbly stamp

Being an acoustics educator who collects stamps and also has an interest in antique acoustical apparatus, it was with considerable interest that I read the article about the stamp honoring inventor Owen Plumbly in the Winter 2003 issue of *ECHOES* (Vol. 13, No. 1). The stamp shows a picture of an acoustical device which Plumbly allegedly invented in 1832 to assist in determining the direction of incoming trains. As I was reading the article, however, I was bothered by the fact that I had seen this picture before and was pretty sure I had read that the apparatus had been invented around 1880 to help ship captains identify the direction of fog whistles in dense fog. I did some digging in my small library and found the picture in an old Time-Life book, *Sound and Hearing* (1965, Time Inc.), and the caption under the figure referred to the device as a "topophone" with an invention date of 1880.

After a little further digging on the internet I found what I believe to be one of the original references to the topophone and its actual inventor. The image on the stamp, along with a description of the device and its inventor appears in "The Topophone, or Sound Placer," *The Manufacturer and Builder*, Vol. 12, No. 11, pp. 253-254, (November 1880), published by Western & Company, New York. The article (with the original figure) is available online at: http://cdl.library.cornell.edu/cgi-bin/moa/moa-cgi?notisid=ABS1821-0012-714.

An earlier article (Vol. 12, No. 4, pg. 79-80) describes the use of a much larger topophone which was built onto the top of a ship and employed tuned resonators. According to these articles the devices were invented in 1880 by Prof. Alfred M. Mayer, professor of physics at Stevens Institute of Technology in Hoboken, NJ. The topophone was invented as a solution to the difficulty of ship captains hearing whistles in dense fog. Apparently during the early part of 1880 there had been quite a few serious shipping accidents in New York harbor. Early tests of the topophone, as reported in the 1880 annual report of the United States Lighthouse Board, proved quite successful.

Incidentally, Alfred Mayer had quite a few contributions to the field of acoustics during his professional career, publishing at least 24 papers on acoustics topics. In D.C. Miller's *Anecdotal History of the Science of Sound* (MacMillan, 1935) he is described as having studied the duration of sound sensation, the differentiation between response to frequency and intensity, the application of sound to the measurement of elastic constants, and the laws of tuning fork vibrations. Mayer is credited with inventing the topophone, the acoustic pyrometer, the sound reaction-wheel, and the tuning fork chronograph which he used to determine the absolute frequency of the tuning fork used by Michelson in his velocity of light experiments. He also apparently discovered that the fibrils of male mosquito antennae vibrate sympathetically to notes in the range of frequencies produced by female mosquitoes.

Thank you for publishing the article and the picture of the stamp. It certainly initiated an enjoyable afternoon of "historical research" for me.

Dan Russell
Associate Professor of Applied Physics
Kettering University, Flint, MI 48504

An interesting site

I enjoyed "The Acoustician as Tourist" by Charles Schmid in the Winter 2003 *ECHOES*. One other interesting site which you may have occasion to visit some time: The Rosslyn, Virginia Metro Station entrance. The entrance is via a tube with an elliptical cross section. There are two escalators in the tube, and the foci of the ellipse seem to be about five feet directly above the moving stairs of the two escalators. The result is that if you are on one escalator you can clearly hear vocalizations of someone on the other escalator, regardless of whether they are near your same elevation or at the other end of the tube!!

Bob Anderson
University of Hawaii

Infrasound and thunderstorms

The short article on infrasound in the Spring 2003 edition of *ECHOES* "The Rumble of Destruction" reminded me of a conversation I had many years ago (early 1960's?) with Dr. Richard Cook at the National Bureau of Standards. At the time Dr. Cook was involved with infrasound measurements using a triangular array of microphones to determine direction of signal origin. One day he received a very strong signal from the west. The following day he was able to time-correlate the signal with intense thunderstorm activity in the state of Oklahoma.

Roy Richards
2833 27th Ave. W, Seattle, WA 98199-2825

First medical x-ray

In the Winter 2003 issue of *ECHOES*, the article on Dayton Miller claims that Miller made the first medical x-ray. After Roentgen's announcement of x-rays in 1895, many physicists built their own x-ray apparatus. The high voltage supply was an induction coil, making the system difficult to use.

One of the first applications of x-rays was for medical diagnosis. Soon after the announcement, Prof. Hutchins at Bowdoin College made an x-ray plate of a bullet lodged in the ankle of a patient at the Bowdoin Medical School. This plate is on view in the Department. At about the same time (I have been told) a similar x-ray plate was made for the Dartmouth Medical School by their physics department. At this late date, I suspect that the claim of "first" cannot be clearly established.

Elroy O. LaCasce
Professor Emeritus
Bowdoin College, Brunswick, Maine

Acoustician as tourist

I enjoyed reading "The Acoustician as Tourist" in the Winter 2003 issue of *ECHOES*. It inspires me to tell about the trip that my wife and I made after the April meeting in Nashville. We traveled northward to Spring Mill State Park in Indiana where we met up with three students from the University of Evansville. They came to help with some experiments on the transmission and reflection of low frequency sound in caves. The idea is to determine the shape of the caves using sound. The Spring Mill caves are the path of an underground river that has several openings (cave entrances) in the park. The park naturalist told me that our sounds reached him at another opening more than a mile away. I'm now in the process of analyzing our data.

Dick Lyon
RH Lyon Corp, Cambridge, MA 02138

From the Editor

What is a good abstract?

Having just missed my first ASA meeting in several years, because of being abroad, I have spent quite a bit of time reading "abstracts" of papers I would have liked to hear. What I have found, interestingly enough, is that most of them are not really abstracts, in the usual sense of the word, at least. They often describe the author's intent, but not the results of the investigation. Perhaps this is due to the fact that the investigation is yet to be completed during the rather long time between the abstract deadline and the meeting. This raises a question: Is an abstract primarily intended to entice listeners to hear a paper, provide an introduction to the paper, or to summarize the most important results? I would argue that the latter is their most important function!

The sample abstract, printed in each call for papers, is an example of a good abstract, in my opinion. It clearly states the main result so that readers who miss the presentation can benefit from it. We must remember that only a small fraction of the members who read the abstract will be able to hear the presentation. How can ASA improve the quality of abstracts published in the program? Perhaps by offering prizes for the best abstracts (some societies do this).

I would hope that this brief editorial comment would stimulate some discussion and perhaps inspire some Letters to the Editor.

Thomas D. Rossing
Northern Illinois University, DeKalb, IL 60115

Frederick A. Saunders *continued from page 1*

known as the Russell-Saunders coupling. This principle is important in explaining atomic energy levels.

During the first ten years of his violin research, Saunders had no opportunity to test the effect of structural changes in the violin. In 1948, I offered to make experimental instruments, designed to test certain of his theories. I played the viola myself and had already made two conventional violas.

The first "test" instrument served for some fifty experiments. For the next fifteen years, Saunders and I collaborated on the construction of experimental instruments as well as on conventional appearing ones, which incorporated some of our findings. Many of the latter were found to have such good tone qualities that they were bought by professional musicians. Saunders took great pleasure in handing one of the new instruments to the violist of a visiting string quartet or orchestra and watching the amazed reaction as the musician played it.

Saunders was also joined in his research by John Schelleng, an engineer retired from the Bell Telephone Laboratories and Robert Fryxell, a chemist. Both men were fine cellists. For a while Alvin Hopping, an electronics engineer, was also associated with the work. Our group formed the nucleus of what later became known as the Catgut Acoustical Society, of which Saunders was the first president.

Over the years he worked with various electromagnetic devices for vibrating an instrument, and with a bowing machine, but he always came back to the bowing techniques of the good violinist. He found that, in evaluating an instrument, musicians hesitated to accept judgments based on mechanical techniques. To this end he developed what is known as the "Saunders loudness curve," made by bowing a violin, viola, or cello at each semitone, as loudly as possible and with no vibrato and recording the sound level of each note on a graph. He always hoped that some day every violin would have its own loudness curve included in its identification papers.

His study on audience judgments of violins played behind a screen by fine artists showed that the controlling factor was the order in which the instruments were played, not their real tone quality. With single instruments, as well as with a string quartet, the audience invariably chose the second to be played.

In reading the scientific literature in this field, one is impressed by the fact that whether a paper is in French, Italian, German, Japanese, or English, it is not complete without reference to the research of F. A. Saunders. His correspondence on the subject was voluminous. Anyone seriously working on violin acoustics might receive letters of twenty pages or more in his closely written fine hand, discussing the intricacies of the subject. A German scientist who had received five such handwritten pages less than a month before Saunders died, wrote that it seemed as if he were listening to one of the last great works of Bach or Beethoven.

Frederick Albert Saunders died on June 9, 1963 at his home in South Hadley. Those who knew him will always be grateful for his quick intelligence and wonderful sense of humor, his generosity, interest in people and birds, as well as his contagious enthusiasm for violin research.

Carleen Hutchins is a Fellow of the Acoustical Society of America and received the Silver Medal in Musical Acoustics in 1981. She is a founding member of the Catgut Acoustical Society and, more recently, of the New Violin Society.

An Acoustical Tourist in Cambridge

Thomas D. Rossing

Open Corridor at Trinity College where Newton measured the speed of sound.

This is a follow-up to Charles Schmid's article "The Acoustician as Tourist" in the Winter 2003 issue of *ECHOES*.

Part of my program as a Leverhulme Trust Visiting Professor at the University of Edinburgh is to visit and give lectures at other universities in the UK. On my visit to Cambridge University, I headed for Trinity College, where Newton once lived and where he measured the speed of sound by clapping his hands in an open corridor leading to the Wren Library. Pacing off the corridor, I estimated a length of about 74 meters, and standing at one end it was relatively easy to clap my hands in synchrony with the echoes from the far end, as Newton did. Apparently his remarkably precise measurement didn't agree with his calculated value, and so he introduced several "corrections" ("fudge factors," as students might call them today). Actually, his error was quite understandable today: he lived some years before Gibbs and others realized the significance of adiabatic and isothermal compressions and that the adiabatic bulk modulus should be used to describe sound waves.

Jim Woodhouse using a Rayleigh milk bottle as a Helmholtz resonator.

In the Department of Engineering, Professor Jim Woodhouse keeps a glass bottle from Rayleigh's Dairy to use as a Helmholtz resonator for his classroom demonstrations. Since glass bottles have given away to paper cartons at the Rayleigh Dairy as elsewhere, his bottle is a bit of a museum piece. Jim is well known for his acoustical research on violins and other bowed string instruments.

On the same trip I gave a lecture at London Metropolitan University, which is not too far from St. Paul's, so I made another visit to the famous whispering gallery that Rayleigh wrote about. This was a little disappointing, however, since the renovation that is going on has pretty much blocked the acoustical path for "Rayleigh waves" around the dome.

F.V. Hunt Postdoctoral Research Fellowship in Acoustics

Wayne M. Wright

This year the Acoustical Society of America (ASA) celebrates the twenty-fifth anniversary of the Hunt Postdoctoral Fellowship program. The purpose of this Fellowship is to further the science of, and education in acoustics. The list of recipients is impressive, and this ASA educational program seems to have fully lived up to its early promise.

With initial funding from the ASA and the U.S. Office of Naval Research, and subsequent earnings from an endowment provided by the estate of former ASA President, Gold Medalist, and Harvard University professor Frederick V. Hunt, the first Fellow was selected for the 1978-79 academic year. Steven Garrett, with fresh doctorate from the University of California, Los Angeles, spent that year at the University of Sussex in the UK investigating acoustics in superfluid helium. Succeeding Fellows have worked in almost every technical area represented by the ASA. They have included individuals who have achieved noteworthy academic and research careers, and who have served the Society in many ways. Past Hunt Fellows, who will join together for a commemorative luncheon at the ASA Austin meeting in November, include R. B. Lindsay Award and Silver Medal recipients, Technical Committee Chairs, and Officers of the Society.

The annual selection of a Hunt Fellow attempts to determine "that individual who, through personal qualifications and a proposed research topic, is judged to exhibit the highest potential for benefiting some aspect of the science of sound and promoting its usefulness to society." Thus special attention is given toward preparing a new PhD for a potentially productive career in some area of acoustics. Applications are judged from two perspectives. First, the successful candidate should show promise of becoming a leader in his or her field. Second, the fellowship year should provide a marked transition from student to independent scientist. Effective mentoring is an important factor in this transition. The Fellow may benefit by moving from the doctoral topic into new areas of research, learning about proposal preparation and the administration of grants, and in general making a transition to independent investigator, in order to "hit the ground running" in his or her first regular position. (see http://asa.aip.org/fellowships.html#hunt for a list of Hunt Fellows)

Applications for the 2003 Hunt Fellowship competition will be accepted if postmarked no later than September 2. Both applications and supporting letters should be prepared with the understanding that they will be read by a diverse group of ASA Fellows, and not by specialists in the applicant's research area. The announcement and application form are available through the Society's web site: http://asa.aip.org/fellowships.html.

Wayne Wright, University of Texas, is Chair of the ASA Prizes and Special Fellowships Committee.

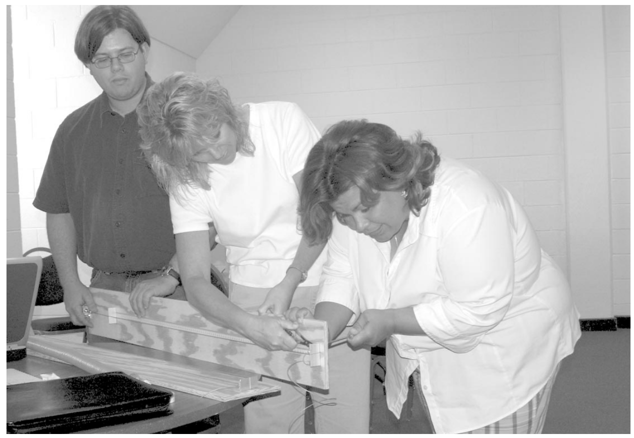
Echoes from Nashville

Although Nashville was not the largest meeting of the Acoustical Society, it was noteworthy in several respects. It certainly attracted the attention of the media (see Acoustics in the News), especially the sessions on singing (by country musicians, birds and animals, sessions 3aMU, 4aABa,b). The sessions on acoustic inertial confinement fusion (aka sonofusion) went virtually unnoticed by the media, but invoked a lot of discussion by acousticians, and Larry Crum has summarized them on the following pages.

Acoustics education had a nice presence in Nashville. Session 3aED on demonstration experiments on Wednesday, brought together lots of old hands and some new hands as well. The ever-popular hands-on session for high school students was directed particularly at female students from rural high schools this time (4aED), and followed by a session on "Teaching Architectural Acoustics to Non-Acousticians" (4pAA). An acoustics workshop for high school teachers was held at Tennessee Technology University on Friday afternoon. Photos from these activities appear below.

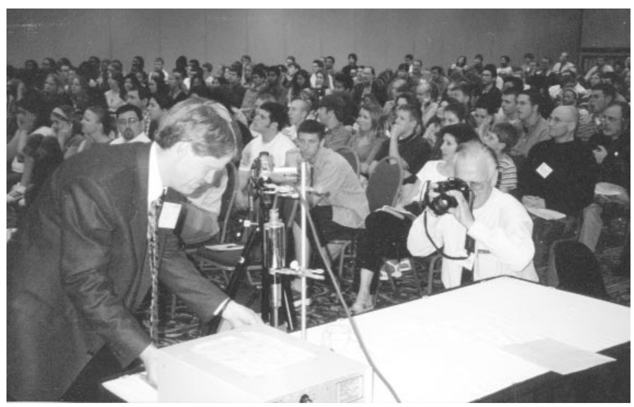
The social schedule, which reflected the Music City theme, included a buffet social in the historic Ryman Auditorium, still ringing with the music of Hank Williams, Patsy Cline, Bill Monroe, and many other old-timers (sounds never completely die out; they only decay exponentially with time), and a few new-timers added their music to the event as well, including Dick Stern at the piano. Although the Grand Old Opry no longer convenes in Ryman, more than a few acousticians found their way out to the new Opryland.

High school students observe a Chladni pattern in the "Hands-On" session in Nashville



Science teachers assemble a monochord at the workshop

Acoustic levitation at the session "Demos for all Ages: 2003" at Nashville



Carr Everbach levitates styrofoam balls in a sound field in the "Demos for All Ages" session.

New Fellows of the Acoustical Society of America

Reducing Confusion about Fusion

Lawrence A. Crum

A special session on acoustic inertial confinement fusion (ICF) was held at the ASA Spring meeting in Nashville. This session, which was appropriately called "sono(con)fusion" for its remarkable claims and the controversies surrounding these claims, attracted a large audience. (By the way, the terms "sonofusion" and "bubble fusion" are not favored by proponents of "acoustic ICF" because these terms have been used before by conventional "cold fusion" believers who use ultrasound to enhance conventional cold fusion.)

The central premise for acoustic ICF involves the ability for a bubble to concentrate energy during its collapse. The simplest form of this remarkable energy concentration is found in single bubble sonoluminescence (SBSL), in which a single bubble is acoustically levitated in a liquid due to the radiation pressure forces exerted on the bubble. Under the appropriate conditions, these acoustic radiation pressure forces exactly balance the buoyancy forces exerted by gravity and the bubble remains at a fixed position with respect to the container that contains the standing wave sound field. Consequently, this levitated bubble is driven into radial oscillations by the sound field. Again, under certain relatively restricted conditions of acoustic pressure amplitude and frequency, and with a considerable amount of gas removed from the liquid, the bubble gives off a steady glow of light—hence the term "sonoluminescence." Because this phenomenon is quite unique, it has been a subject of considerable interest for more than a decade. [See S. J. Putterman, *Scientific American* 272, 46 (February, 1995) and L. A. Crum, *Physics Today* 47, 22 (September, 1994)].

The scientific community was quite surprised when *Science* published an article by a group at Oak Ridge National Laboratory [Taleyarkhan, et al., *Science* 295, 1868 (2002)] in which evidence was presented for thermonuclear fusion from a cloud of collapsing vapor bubbles. This paper was greeted with enormous skepticism, even ridicule, but there were also believers—indeed, we all WANTED to believe that acoustics was involved in the "discovery of the century." Efforts to gather both the proponents and critics of this purported discovery for a grand debate had previously been unsuccessful. Thus, this session to do just that, organized by Felipe Gaitan, Glynn Holt, and Tom Matula was a unique event.

The session opened with a broad review of the theory behind the acoustic ICF claims by Robert Nigmatulin, President of the Academy of Science of Bashkortostan and a member of the Russian Duma. In an animated and spirited defense of acoustic ICF, he described in some detail the modeling and analyses related to the physical and chemical kinetics that were used in their hydrodynamic shock code evaluations that predicted plasma compression and temperature states suitable for nuclear fusion under conditions of their experiments. That is, these simulations predicted conditions to obtain the extreme conditions required by the Oak Ridge group to justify their claim of over 100,000 neutrons per second emitted by their apparatus.

Nigmatulin's dramatic defense of the acoustic ICF was followed by a skeptical Seth Putterman, UCLA, who pointed out a number of weaknesses in the Oak Ridge experiments. Putterman, a proponent of searching for acoustic ICF, described his own attempts to measure neutrons emitted by cavitating bubbles, and in particular, the construction of one of the world's most sensitive neutron detectors. So far, he has been unsuccessful in detecting any neutrons that were coincident with sonoluminescence during cavitation collapse. Putterman argued that his own extensive spectroscopic data suggested that reports of temperatures of only 6,000 degrees inside a sonoluminescing hydrogen bubble were misleading, in the same way that measurements of our sun give similar values—because they only measure the temperature at the surface of the sun, while internal temperatures can reach several million degrees. His own molecular dynamics simulations predict SBSL temperatures closer to 10^6 K.

The highlight of the session was a presentation by Rusi Taleyarkhan of Oak Ridge National Laboratory describing the experiment that claimed evidence for thermonuclear fusion from cavitating bubbles. In this experiment, Taleyarkhan's group introduced two significant changes to the typical SBSL scenario. First of all, they increased the acoustic intensity inside their cavitation chamber by more than an order of magnitude over that normally used for SBSL studies. Secondly, they removed all traces of dissolved gases from the liquid undergoing cavitation, and initiated the cavitation nucleation process by using a pulsed neutron source. In this way, they could generate a cavitation nucleus—necessary for the production of a cavitation bubble—by the "bubble chamber effect," in which an incoming high energy neutron would interact with a deuterated (hydrocarbon) liquid which was under significant tension and produce VERY SMALL (nanometer scale) vapor bubbles. These very small vapor bubbles were produced exactly at that precise time during the acoustic cycle when the liquid was under maximum tensile stress. The creation of a very small vapor (rather than gas) bubble, in the presence of an intense acoustic pressure field, resulted in a bubble growing to a large size (building up a huge reservoir of work potential), and then subsequently imploding without significant retardation or repulsion by the interior components of the bubble—that is, much of the vapor would condense as the liquid interface advanced toward the center of the bubble. The Oak Ridge group chose a liquid that could be "deuterated," i.e., the normal hydrogen atoms being replaced by deuterium atoms, a material that can undergo thermonuclear fusion. Evidence for acoustic ICF was of two kinds: (1) the presence of 2.45 MeV neutrons coincident and time correlated with the emission of sonoluminescence flashes, and (2) a radioactive material that is the byproduct of D-D fusion, viz., tritium.

Taleyarkhan's presentation was followed by one from a second group at Oak Ridge that was asked to obtain data using a different neutron-gamma detection system. D. Shapra and M.

Saltmarsh described in great detail their analysis of neutron-gamma data supposedly created by acoustic ICF and found that the excess neutrons they detected with cavitation on (versus cavitation off) were lower than what one would expect from the reported tritium data. This apparent "failure-to-reproduce" the results of the Taleyarkhan group was a major argument, said the critics, that the entire experiment, including the unexplained tritium data, was suspect. Shapira pointed out that the neutrons from the pulse neutron generator were probably the source of the "excess" neutrons that Taleyarkhan attributed to acoustic ICF.

Felipe Gaitan, who discovered SBSL, reported the attempts of his company, Impulse Devices, Inc., to construct sophisticated experimental systems to routinely produce neutrons from cavitating bubbles. The key feature of such systems is the employment of high ambient pressure to increase densities and energies in the collapse zone. These systems, although still in development, are expected to reach extreme acoustic conditions and, if the Oak Ridge experiments are confirmed, much higher levels of neutron emissions.

Ken Suslick of the University of Illinois is another skeptic of acoustic ICF. He described in some detail the chemistry within a highly compressed and heated gas. He noted that atomic and molecular dissociation and ionization were difficult barriers to breach because they required lots of energy, and described his own detailed experiments to measure the temperature within a sonoluminescing gas bubble. These facts indicate that there are several liquids that would not be suitable for generating acoustic ICF, and that the role of vapor in preventing the heating of a fusion plasma must be carefully considered. His experiments suggested that, counter to the claims of others, temperatures could reach millions of degrees. His own data, using a variety of molecular liquids, suggested that a paltry 7,000-10,000 degrees was much more likely in the absence of a converging shockwave. (Countering Suslick's claims were simulations from Putterman's group which showed that even when cooling due to ionization is allowed, the interior of a xenon bubble reaches a million kelvins if shockwaves form). Suslick also described the results of a joint experiment with Putterman using an acoustic horn to induce cavitation, but no cavitation-correlated neutrons were observed.

Tom Matula, University of Washington, described his attempts to utilize powerful stone-crushing acoustic sources, such as lithotripters, to generate extremely high acoustic pressures and thus to maximize the intensity of the cavitation bubble collapse. The key features of these devices are that the acoustic pressures (positive and negative) are much greater than have been achieved by the Oak Ridge group. He showed a successful experiment in which a small neutron source was used to nucleate bubbles that resulted in sonoluminescence emissions.

Larry Forsley, a researcher in laser-induced fusion for the past two decades, brought his perspective to the search for an acoustic means to induce nuclear fusion. He expressed excitement at the relatively rapid (and inexpensive) success of acoustic efforts at inertial confinement implosions, but he cautioned that, even if fusion reactions were confirmed, that this was only half the battle. The other half would be to trap the resulting fusion products in order to achieve "yield" from the reactions. He noted that the figure of merit for achieving yield would be the product of the density times the radius for the material immediately surrounding the reaction site to be greater than or equal to 0.3 gm/cm^2. This is a rather daunting figure that would require compressed and heated deuterium located 1 mm from the bubble center to have a density of 3 times that of normal water!

Perhaps the best part of the entire session was a panel discussion at the end of the afternoon session in which the various supporters and critics of the Oak Ridge acoustic ICF experiment offered arguments for their stated positions. Nigmatulin explained that while chemical reactions can be important limitations in SBSL experiments, they are overcome in acoustic ICF experiments due to the significant additional energy available for compression. Taleyarkhan challenged Shapira's analysis of his neutron data by stating that Shapira's detection system was set up to discard most of the 2.45 MeV neutrons, and therefore, the calibrated measured efficiency was several orders of magnitude lower than what one would compute for an ideal detector. He pointed to the fact that the independent detection system set up by Shapira also measured statistically significant (~10 standard deviations) "increases" in nuclear emissions which were time-correlated with sonoluminescence flash emission and as such should be considered an instance of limited confirmation of the reported results in *Science*. No tritium data were taken by Shapira during the experiment, and as such, meaningful comparisons can not be made with the tritium data obtained under different operation conditions reported in *Science*.

Colin West, a member of the Oak Ridge group, proposed an experiment that could be done rather easily by other groups having acoustic systems expertise to confirm the presence or absence of tritium during acoustic cavitation of a deuterated liquid. Finally, Taleyarkhan promised to show additional new data, once it was approved for release by Oak Ridge, and that these data would provide additional strong evidence in support of their earlier experiments.

All in all, this session was a most exciting one, and as is typical of such debates in science, ended without any resolution of the major issues. The traditional call for further experiments is a valid one and hopefully it will be heard by the funding agencies; however, if the history of science repeats itself, the truth is out there, and perhaps it will be revealed at some future ASA meeting.

Larry Crum, University of Washington, a past ASA president, is a pioneer researcher in sonoluminescence. He is also well known for his research on medical applications of acoustics.

Scanning the Journals

Thomas D. Rossing

• Sound waves can be used to **explode electron bubbles** in liquid helium and thus detect electron bubbles in excited states, according to a paper in the 17 January issue of *Physical Review Letters*. When an electron is placed in liquid helium, it expels about 1000 helium atoms from around itself and creates a vacuum bubble that contains nothing but its wave function. There is an optimal bubble size that minimizes the total energy. Researchers at Brown University injected electrons into liquid helium with a tungsten tip, used a CO^2 laser to excite some of them into a 1p state, and then used focused ultrasound at 1.4 MHz to explode the bubble. The excited bubbles were momentarily large enough to scatter light from a HeNe laser which could then be detected by a photomultiplier.

• Turbulence of **scroll waves** is a special kind of spatiotemporal chaos that exists exclusively in three-dimensional excitable media, according to a paper in the 14 March issue of *Science*. A chaotic wave pattern develops through the negative-tension instability of vortex filaments, which tend to stretch; bend, loop, and produce an expanding tangle that fills up the volume. Either suppression or induction of turbulence can be brought about by nonresonant modulation of the medium excitability.

• It is known that the wavelike disturbance set up in the cochlea by a sound stimulus is amplified by an active system consisting of self-tuned critical oscillators. How the concepts of a travelling wave and of self-tuned oscillators can be combined to describe the **nonlinear wave in the cochlea** is discussed in a paper in the 18 April issue of *Physical Review Letters*. It is suggested that the range of frequencies at which the basilar membrane resonates is determined by the frequencies of the oscillators that are ranged along it rather than by the stiffness or inertia.

• Wideband white noise was used to examine the role of low frequency components in **sound localization in the median plane** in a study reported in the March issue of *Acoustical Science and Technology*. Components above and below 4800 Hz were presented simultaneously from different directions. The results indicated that the higher frequency components are dominant in median plane localization.

• A letter to the editor in the April issue of *Physics World* identifies the discordant phenomenon in violin strings reported in the February issue of the same journal (see Spring issue of *ECHOES*) as an example of **wolf note** behavior. When a note on a string falls close to a strong resonance of the instrument body, vibrational coupling at the bridge can shift both resonances away from their expected value and beating occurs.

• Although auditory cortex neurons have been described as being narrowly tuned and preferentially responsive to narrowband signals, natural sounds are generally wideband. Through the use of parametric wideband stimuli, authors of a paper in the 14 February issue of *Science* found that such neurons in marmoset monkeys responded vigorously to wideband sounds having complex spectral shapes. This indicates that spectral contrast reflects an important stimulus decomposition in the auditory cortex and may contribute to the **recognition of acoustic objects**.

• Laser Doppler anemometry measurements of acoustic particle velocity, utilizing photon correlations spectroscopy, provide the basis for a working **microphone calibration system**, according to a paper in the March/April issue of *Acustica/Acta Acustica*. Unlike the reciprocity method, optical methods provide a direct approach where the sound pressure is determined from the measurement of acoustic particle velocity.

• Calculated **phonon spectra of plutonium** at high temperatures are reported in a paper in the 9 May issue of *Science*. Although it has not been possible to measure that spectrum experimentally because of plutonium's extreme toxicity, knowledge about the spectra of lattice vibrations is important in addressing issues that are important for long-term storage and disposal of this critical material. Plutonium has six crystallographic allotropes with puzzling volume variations among them.

• Software that corrects resonant frequencies in **recorded voice samples** is described in the May 5 issue of *Electronic Engineering Times*. A team led by Mark Smith at Purdue University began by analyzing hundreds of virtuoso performances to glean the traits that set the professional apart from the amateur and to capture those characteristics in software. The software, demonstrated at the Nashville ASA meeting (see *Acoustics in the News* on page 12) can perform modifications that can correct pitch errors, introduce vibrato, introduce a singer's formant, and extend or shorten the duration of a sound. The key innovation in the software is using successive-approximation decomposition instead of standard Fourier decomposition, according to the authors.

• "Listen Very Carefully" is not only good advice, but also the title of a paper in issue 24 of *Newsline*, the journal of the Engineering and Physical Sciences Research Council (UK). It looks at the role played by meteorological conditions in the lower atmosphere, such as wind and temperature gradient, in the **propagation of noise**. To get a real picture of changing air patterns, noise monitors often employ LIDAR, which bounces laser light off particles in the atmosphere to monitor their motion.

• **1/f noise in rural and urban soundscapes** is discussed in a paper in the March/April issue of *Acustica/Acta Acustica*. Self-organized criticality is shown to occur at different levels in the underlying system. The power spectral density in rural and urban soundscapes often follows a 1/f frequency dependence with a breaking point around 0.2 Hz, corresponding to a period of about 5 seconds.

• Possible **hearing injury due to airbag deployment** is discussed in the *Proceedings of the May 2003 Noise and Vibration Conference* of the Society of Automotive Engineers. Medical evidence is presented from 71 case histories. The acoustic impulse generated by the deployment consists of two components: overpressure which is the low-frequency compression of the air in the passenger compartment; and noise which is the higher frequency sound of bag inflation. The problem is aggravated by the increasing use of multiple airbag systems in cars. A possible solution is

Scanning the Journals

the so-called breathing airbag whose outer structure inflates with gas from the inflator and whose inner structure draws in air from the compartment, thereby reducing the overpressure. The noise component also is reduced because less gas is used in the inflation.

- A very informative **biography of Hermann von Helmholtz** appears in the March/April issue of *Acoustics Bulletin*. His father, a teacher in Potsdam gymnasium, was poorly paid, and in order to attend the university, his son agreed to study medicine and serve as a doctor in the Prussian army. He spent all his spare time in research, first in physiology, later in physics and mathematics. He eventually became professor of physics in Berlin. He devoted his life to seeking the great unifying principles underlying nature. "Helmholtz was probably the last great scholar whose work embraced all the sciences as well as philosophy and the fine arts."
- **Rayleigh jets from levitated microdroplets** are discussed in a brief communication in the 9 January issue of *Nature*. High-speed microscopic images were used to observe the oscillations, and subsequent disintegration of charged droplets of ethylene glycol formed by a piezo-driven nozzle. During disintegration, small daughter droplets are formed.
- Experiments with wild and captive harpy eagles that provide evidence of experience-dependent **plasticity in auditory processing** are described in the 21 February issue of *Science*. The orienting responses of adult and juvenile harpies with or without experience preying on howlers were compared. For naïve harpies, howlers elicit the same kind of orienting response as do pure tones, whereas for experienced harpies, howler calls elicit the same orienting response as do harpy contact calls. These results provide evidence of an orienting asymmetry, altered by explicit hunting experience.
- A book review of *Analog Days* (by Trevor Pinch and Frank Trocco, Harvard University Press, 2002) tells the story of the Moog synthesizer, and provides some interesting historical perspective on the early **development of music synthesizers**. Moog, a classic tinkerer, became enamored of the theremin, one of the first electronic instruments (designed by Russian physicist Leon Theremin), and started to make and sell his own version of the theremin while still in high school. After receiving a PhD in physics, Moog started building music synthesizers with voltage-controlled modules. Musician-physicist W. Carlos used a Moog synthesizer to record the runaway success "Switched-On-Bach," and the rest, as they say, is history.
- Issue 25 of *Newsline*, the journal of the Engineering and Physical Sciences Research Council (UK) is a special report on **science and the arts**. It includes an article "Music in Mind" which highlights research on musical perception, including an understanding of how and why people tend to group notes together, as well as how people perceive music. Another article in the same issue describes an exhibit on waves created by Edinburgh acoustician Clive Greated and his daughter Marianne, an artist. The exhibit explains to the public that wave breaking is the key to understanding many of the important problems in pollution and erosion associated with our coastline.

Acoustics in the News

- The Nashville ASA meeting, especially the sessions on music and singing, received excellent coverage from the press, both local and national. UPI Science News and Nature News Service, for example, picked up on the software described by Matthew Lee and Mark Smith (paper 3aMU7) that can change strong frequencies in the singing voice and "make weak voices sound professional." They are working on teaching their software to reproduce good country and Broadway voices, according to the story, although "quality" in these genres is less clearly defined than in opera.
- A colorful story by Associated Press, entitled "Researchers examine science of music in Music City," began "Nearly every night in downtown Nashville, the sounds of Music City flow from the propped-open doors of smoky bars and honky tonks. A stretch of Broadway, anchored by the world-famous Tootsie's Orchid Lounge, has long been a favorite of struggling singers and country music tourists. But this week, it became a makeshift laboratory as the Acoustical Society came to Nashville for its 145th meeting." The story goes on to report that a "Yale University researcher outlined the evidence of perfect pitch while another from the University of Iowa discussed the 'lower vocal tract adjustments' of country and Western twang." Charles Schmid is quoted as saying "We always have a session on musical acoustics and if we can gear it to the local scene, we do," and Joe Dickey began his paper "As a banjo player, I can't tell you how thrilled I am to be on stage here in Nashville."
- The British magazine *New Scientist* picked up on two Nashville papers, one on use of infrasound by tigers and the other on using vibrational analysis to monitor stress in rails and prevent buckled rails in hot weather. Tigers produce a wide variety of sounds, from deep roars and growls to the raspberry-like "chuffing" they use to greet each other. A roar followed by a growl is probably designed to intimidate rivals. A common feature of all tiger calls is a large amount of low frequency sound, which is less likely to be affected by climatic conditions such as humidity and also by ground cover which is important to forest-dwelling tigers. Peak power is reported to be around

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Acoustics in the News

continued from page 11

300 Hz, but components stretch down to the ultrasound range, below 20 Hz.

Buckled rails are a significant cause of serious train crashes. A simple way to prevent crashes caused by buckled rails is to vibrate the rails from side to side at 200 Hz by means of an electromagnetic shaker. Although the displacements are only about one micrometer, they can be detected with a laser beam.

• Singing sands (see *ECHOES*, Volume 8, Number 3, Summer 1998), first mentioned in an 8th century Chinese manuscript, have been described by many explorers. According to a note in the 4 April issue of *Science*, a team of French researchers at the École Normale Supérieure in Paris have succeeded in replicating the sound by slowly churning 72 kg of Moroccan sand in an annular container. According to the researchers, the sound results from Reynolds dilatency, which describes a vibration created by the dilation and compression of air as grains separate and come together. Yet to be determined is what makes all the grains in a layer of sand start moving at once.

• *Science News* prints excerpts from the magazine from 70 years ago. Ben Stein, of the American Institute of Physics Media and Government Relations Division, called attention to the following item from the May 13, 1933 issue entitled "Passing sound through gases helps study of molecules." "It is lucky we do not live in an atmosphere of straight oxygen—at least in weather of desert humidity. We would not be able to hear sounds of high pitch at a considerable distance. Recent investigations carried out in the University of California at Los Angeles suggest that the excessive absorption of sound in air of certain humidities is due to collisions between oxygen and water molecules. Prof. Vern O. Knudsen described to the meeting of the Acoustical Society of America at Washington the Los Angeles experiments, in which Dr. H. O. Kneser, visiting physicist from the University of Marburg, cooperated.

"Sound travels freely through chemically dried air, particularly at low temperatures, according to the electrical recording instruments of the California laboratory. Perhaps this accounts for the common opinion that audibility is keen on a clear, cold night. The introduction of small quantities of moisture promptly damps off the sound, especially tones of high pitch. Peculiarly this phenomenon does not occur when pure nitrogen is substituted for the air, despite the fact that air is nearly 80 percent nitrogen. A shift to pure oxygen in the experiment reveals this latter gas as the guilty party. But oxygen alone is rather ineffective. Water vapor must also be present to affect the sound waves."

Your editor remembers reading these papers of Knudsen and Kneser when he was writing his doctoral thesis on sound dispersion in gas mixtures some 50 years ago.

• A wireless sonar system that can map the seafloor thousands of feet below the surface, where divers and global positioning system equipment cannot go, is described in the *New York Times* of June 12. This system, developed at the Massachusetts Institute of Technology, has been tested off Cape Hatteras, NC, where the MONITOR sank in 1862, and it will soon be used to explore a spot off the coast of Israel where two Phoenician vessels sank in 1300 feet of water around 750 B.C. The sonar can penetrate six feet into the sediment with a powerful pulse of ultrasound and reveal small objects.

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