The newsletter of
The Acoustical Society of America

ECHOES

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# Robert Bruce Lindsay

*by Robert T. Beyer*

If you have obtained a copy of the new Acoustical Society 1998 calendar, you may have noted that January 1 marks not only the birth of the new year, but also the birthday of R. Bruce Lindsay, and the fact that he was born with the century, in 1900. For those who knew him as professor, author and editor, he needs no introduction. But, to the half a generation that has entered the field of acoustics since his death in 1985, it is perhaps worthwhile to recall some of his achievements.

Bruce was born in New Bedford, Massachusetts, to a rather poor family. In some privately distributed memoirs, he noted an early contact with science: in 1905, he had suffered a fall and had apparently broken his arm. He was taken to a local physician with an x-ray machine. Bruce didn't write much about the broken arm, but he marveled that such a "neolithic" (his term) town as New Bedford had such a machine, only a decade after Röntgen's original discovery of the x-ray.


*Robert Bruce Lindsay*

Bruce was off to Brown at an early age and graduated in 1920. It is of interest that the signature book for new members of Brown's chapter of Sigma Xi for that year contains the names of both Bruce and his classmate and later-to-be wife, Rachel Easterbrooks, as young scientists.

Bruce went on to MIT for graduate work, but before obtaining his degree, he received a fellowship to spend a year at Bohr's laboratory in Copenhagen, marrying Rachel the day before they sailed. That year was a remarkable one for Bruce. He became acquainted with all the upcoming greats of the quantum physics era and maintained close relations with them through his life. This accounted for the surprising number of Nobel laureates who gave physics colloquia at Brown during my early years there. Lindsay seemed to know (and to be known by) everybody.

Lindsay worked under Bohr and essentially did his thesis under Bohr's direction, but MIT required that his thesis adviser be an MIT faculty member, so he spent an additional year going through the motions with another professor. In 1924, he went to Yale as an assistant professor and remained there for six years.

Two noteworthy events at Yale shaped his future career. In those days of much smaller physics departments, each professor guarded his upper undergraduate and graduate courses. The only teaching openings were in elementary physics and, after a year or so, in acoustics. Bruce admitted to no special preparation in acoustics, but he did want to teach more advanced courses, so he purchased a copy of Rayleigh's book (in German translation!) and began his study (and teaching) of the subject.

In Copenhagen Lindsay had come under the spell of H. A. Kramers, who employed a Socratic form of teaching, and Lindsay used it for the rest of his life for all courses except the most elementary. In a way, this was unfortunate, for he was a superb lecturer, with a voice that boomed into the high-decibel range (no microphone needed), but the students had to do most of the talking in his classes.

The second noteworthy event was the appearance on the Yale campus of George Stewart, from the University of Iowa. Stewart was teaching or consulting with the Navy at New London and came down to visit an old friend, Louis McKeehan, who was department chair at Yale. Stewart had written a small book on acoustics and was thinking about an expanded edition.

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## Foundation Cornerstone

*by Paul B. Ostergaard, Chair*

The formation of the Acoustical Society Foundation occurred at the Society meeting at Penn State. This represents a great step for the Acoustical Society of America. The Foundation is a separate corporation, incorporated to obtain and manage the endowments intended to support the plans, initiatives and programs of the Society.

Because of the way the Foundation was established, all contributions to the Foundation are tax deductible to the extent permitted under the law. It is also the intent of the Foundation to work with donors who wish to use one of the special instruments for planned giving or providing for money to go to the Foundation in their will. Many of these special instruments can be set up to provide an income for life for one or two persons, secure a tax deduction and remove assets from an estate to avoid estate taxes. These means of giving also can enable one to avoid capital gains taxes on highly appreciated assets. Some of these special instruments will be discussed in future Cornerstones.

The Foundation will also help to establish funds for various time periods which will create special programs or scholarships that can be awarded by the Society. Other funds may be for the general purposes of the Society, such as the Leo Beranek Fund of $50 000 which was announced at Penn State. The Foundation is trying to match this by other donors by June 1998.

Everyone should have received a copy of the Foundation brochure in their dues bill. Look it over carefully. This brochure lists many of the ways in which one can give to the Foundation. For further information on the benefits to you, and the Foundation and the Society, feel free to contact the Foundation.

Show your support and dedication to the Acoustical Society of America by contributing to the Acoustical Society Foundation to support Society plans, initiatives, and programs.

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.

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## *We hear that...*

Alice Suter and Larry Crum

*Echoes* Founder **Alice Suter** received a Distinguished Service Citation from president Larry Crum. The Distinguished Service Citation is awarded to a present or former member of the society in recognition of outstanding service to the society. Suter chaired the committee on public relations which submitted the proposal for the the newsletter, and she is well known to us for her seven year editorship of *Echoes*.

**Neil Thomas Shade** was awarded the 1997 Theodore John Schultz Grant for Advancement of Teaching and Research in Architectural Acoustics, sponsored by the Robert Bradford Newman Student Award Fund. The grant money will be used to develop a Sound Systems Design Guide for instructional use by faculty and students in schools of architecture.

**Charles Thompson**, University of Massachusetts Lowell received the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring at a ceremony in the White House on September 11. This award recognizes outstanding individual efforts and organizational programs to increase the participation of underrepresented groups in science, mathematics, and engineering at the K-12 through graduate level.

Thompson was cited as a role model and mentor for a diverse set of undergraduate and graduate students in the Center for Advanced Computation and Telecommunications at the University. His success is shown in the professional levels attained in industry by his former students. Thompson has also worked with the Bell Laboratories Cooperative Research Fellowship and AT&T Laboratories fellowship programs for underrepresented students.

In November 1997, Professor **Robert L. Clark** of Duke University, received a Presidential Career Award for Scientists and Engineers in recognition of outstanding research and development in the field of adaptive structures involving active noise and vibration control. The award was presented by Dr. John H. Gibbons, Assistant to the President on Science and Technology, on behalf of President William J. Clinton. The award will provide up to $500,000 in research funding.

## The Write Slant on Sound: The ASA Science Writers Awards

*by Jim Lynch*

Two of the most painful things for the majority of scientists and engineers are: 1) writing in a popular vein about their science and 2) reading what journalists and other non-technical types write in a popular vein about their science. Most scientists are far less comfortable at the word processor than in their labs—equations and measurements are generally our strong points, not sentences and paragraphs. If we have to write, we tend to stick to our beloved "journalese," a language few lay persons can penetrate. In the second case, reading the often inaccurate and occasionally outrageous prose that "non-technicals" cavalierly toss out about science and engineering can so make our blood boil that we won't even talk to journalists. Following a suggestion by Alice Suter, the Public Relations Committee proposed, and the Executive Council approved two ASA Science Writers Awards, one for journalists writing about acoustics and the other for acousticians writing a popular article about acoustics.

This year's awards, presented at the Plenary session, went to Richard Wolkomir (journalist) and to Mike Buckingham, John Potter, and Chad Epifanio (acousticians). Wolkomir's award was for his amusing and informative article in the *Smithsonian* about the R. H. Lyon Corp., while Buckingham, Potter and Epifanio were honored for their *Scientific American* article on acoustic daylight. A special award was made to Jeff Seaver for his cartoon-style artwork in the *Smithsonian* article.

This years awards are perhaps typical of both the quality and diversity of the material that is judged and rewarded. The range of topics covered every facet of acoustics, including articles on: noise control, the evolution of communication, medical ultrasound, "acoustic daylight," steel-drum music, the acoustics of hippo's jaws, computer design considerations in architectural acoustics, and the civilian uses of the Navy's SOSUS underwater surveillance system. The publications represented ranged from well-known magazines and newspapers like *Scientific American*, *Smithsonian*, and the *New York Times* to relatively small ones like *Quantum* (a bimonthly magazine for students of physics and mathematics) and the *New London Day*, a newspaper in a small Connecticut city. An effort is being made to get the winning papers of the last few years on the ASA web site.

The Science Writers Awards Committee (a subcommittee of the Public Relations Committee) asks the continuing help of the membership in identifying papers that should be submitted for these awards. The Committee tries to get a good selection of papers through searches of newspapers, magazines, and even the Internet (an Internet article won one of the awards last year), but there are always some articles that we miss. If you see an article that looks like a possible entry, please let Elaine Moran, Ben Stein (AIP), or me know by April 15. And if you're interested in winning an award yourself–start writing!

*Jim Lynch, who chairs the Science Writers Awards Committee, is at the Woods Hole Oceanographic Institute. His email address is: jim@vaquero.whoi.edu.*

## Women in Acoustics Networking Page

The Committee on Women in Acoustics (WIA) has set up an informal web page (http://www.acoustics.org/WIA) at a site provided by the ASA World Wide Press Room. We encourage ASA members and nonmembers alike to visit the site, forwarding any comments to Barbara Sotirin (sotiribj@acq.osd.mil). The WIA committee would also like to promote an informal, ad-hoc NETWORKING program to replace the earlier, more formally organized mentoring program (which was difficult to implement successfully in ASA, where members meet only infrequently).

The networking program will simply provide points of contact by listing willing participants on the web site by name, technical area, email, phone and/or web address, such that anyone with questions and/or similar interests might be encouraged to contact them. These contacts should serve as good listeners to support and advise younger members in their endeavors to function more successfully in their work environments. They should provide information and suggestions for less experienced members, and encourage participation in ASA activities. Networkers listed can come from government, academia, industry, and consulting. Anyone interested in serving as a point of contact should contact Alex Tolstoy (atolstoy@ipdinc.com) or Barbara Sotirin (sotirin@nosc.mil).

# Echoes From San Diego

## Hands-on Acoustics for High School Students

This session, arranged by Scott Sommerfeldt and Uwe Hansen, communicated the excitement of "doing" acoustics to approximately 80 students from San Diego area high schools. Following short introductory presentations, the students were encouraged to discover the fun of acoustics by visiting experiments on acoustic levitation, active noise control, spectral analysis of musical sounds, normal mode vibrations, and Chladni patterns, and to "twiddle the knobs" under the guidance of the presenters. Nearly all of them did, and the results were cacophonic.

*Dean Ayers demonstrates a tuba with a glass mouthpiece at Hands-on session.*

## Computer Jazz Improvisation

Computers provide an interesting way to extend jazz improvisation and composition. Five talented musicians demonstrated how computers "learn" jazz styles through interactive programs during a session on Computer Jazz Improvisation organized by James Beauchamp. One system, for example, asks the computer to "listen" to an improvised jazz melody played on a MIDI instrument and to join in the performance with a synthesized rhythm section. Climax to the session was a jazz performance, continuing the popular tradition of sessions combining technical papers with musical performance.

*Computer Jazz Improvisation*

## Take Fives: A New Tradition

Once again, the sign-up board at this popular session was filled up with volunteers who enthusiastically shared ideas for teaching acoustics, 18 of them in 90 minutes. Like the initial take-fives session at Penn State, the focus was on demonstrations of acoustical phenomena for use in lectures to students or for lectures to the public: acoustic levitation, the role of a loudspeaker baffle, the Bernoulli effect, an inverted pendulum oscillator, and many others. Organizers Tom Rossing and Uwe Hansen have agreed to organize take-five sessions on teaching acoustics at the Seattle and Berlin meetings, so think about ideas you would like to share with your colleagues: excerpts from favorite videotapes, demonstration experiments, laboratory experiments, new courses, etc.

*Bob Apfel demonstrates a loudspeaker baffle at Take Fives session*

*Dean Ayers demonstrates the Bernoulli effect at Take Fives session*

*Carr Everbach demonstrates acoustic levitaion at Take Fives session.*

## Informal Science Education in Acoustics

Exhibits at three major West-coast science museums, designed to teach students and the public about acoustics, were discussed, as were the experiences of a high school teacher who has created interactive exhibits to teach sound to elementary as well as high school students in his area. Elsa Feher, former director of the Reuben Fleet Science Center in San Diego, set the tone of the session by posing the question, "What and how can visitors learn from the interactive exhibits in a science museum?" Using examples of exhibits that deal with sound, she described the process of developing them, and the ways in which visitors use them and interpret the phenomena that are displayed. Paul Doherty described some very large-scale acoustics exhibits at the Exploratorium in San Francisco and invited everyone to copy their experiments, large and small, by consulting the Exploratorium "Snacks Online" and other publications at www.exploratorium.edu

Christopher Chiaverina, New Trier High School, described experiments that he and his students as well as teacher colleagues have created for illustrating the close connection between the arts, mathematics, and physics (including acoustics). Brian Holmes, San Jose State University, shared several interesting demonstrations from his popular public lecture on brass musical instruments, and for the grand finale, he played Beethoven's Sonata for Horn and Piano, Op. 17 on a valveless horn similar to those in use in Beethoven's time.

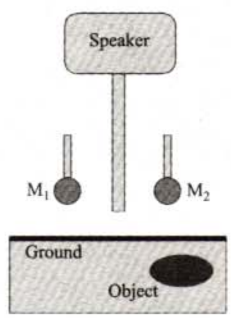
*Brian Holmes plays Beethoven at Informal Science Education session.*

## Detecting Buried Objects, Such as Land Mines, Using Acoustic Impulses

*by C.G.Don and D.E.Lawrence*

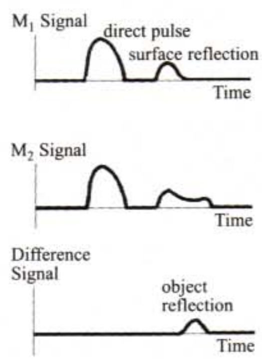
If the acoustic impedance of a buried object is sufficiently different from the surrounding medium, then an incident acoustic pulse will be partially reflected back and can be detected, especially if it is time isolated from other pulses. This principle applies to nonmetallic as well as metal objects, which allows the plastic casings often used in land mines to be located. A major problem is to isolate the small object pulse from other, perhaps more dominant, signals.

To achieve this goal, a system based on the following principle has been used. A loudspeaker source creates a pulse of sound which is very reproducible and about 1 ms in duration. With no buried object, the difference signal between two equally spaced microphones M1 and M2 is ideally zero as the direct pulses from the source and the ground surface reflections cancel. With a buried object present, a small delayed reflection remains after subtraction of the microphone signals. Further, the depth of the object can be determined from the delay of its reflection compared to that from the surface.




Alas, things are not quite that simple. Ground contours and irregularities cause the timing of the surface reflection to vary, leaving significant residues which swamp the object reflection if simple subtraction is used. Consequently, precise alignment of the two pulse waveforms before subtraction is required to reduce this residue. One difficult consideration is whether or not to arbitrarily scale the two peaks to have the same height. It may be that one is larger because the surface is closer or that a more reflective object, such as a land mine near the surface, is causing enhancement. Such considerations have required a number of selection rules to be built into the analysing algorithm.

Further signal enhancement can be achieved by correlating a predetermined object reflection, or mask, with the subtraction residue. Considerable effort has gone into determining the most appropriate signal to use as a mask. It is depth dependent and also can alter with the type of object, opening up the possibility of using various masks to determine the probable type of mine. Additional improvements are possible by using more microphones, especially off the line of the detector sweep to pick up sideways reflections from curved objects.




An example of the type of image currently being produced using acoustic impulses shows a 12-cm diameter plastic land mine located about 5 cm below the surface of a lightly compacted loamy garden soil with agglomerates ranging up to 2 cm in diameter scattered over the surface. The position of the surface is determined by the arrival time of the surface reflection.

*C. G. Don and D. E. Lawrence are in the Department of Physics, Monash University, Australia*

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*...Lindsay, continued from page 1*

What he really wanted was someone else to do the major work, and when he found that Bruce was teaching acoustics, he prevailed on him to do so. Thus, resulted the classic book Acoustics by Stewart and Lindsay.

Bruce returned to Brown in 1930 and became department chair in 1934, serving 20 years in that office. He then spent seven more years as Dean of the Graduate School. During this long period, he turned out book after book: two volumes on elementary physics, a very popular book on mechanics, a somewhat philosophical text (with Henry Margenau of Yale) on advanced theoretical physics, and later volumes on theoretical physics, statistics, and mechanical radiation, as well as shorter pieces on energy and on the philosophy of science. He edited two remarkable Benchmark reprint series–in acoustics and energy–nearly twenty volumes of reprints with commentaries by scholars in these fields. In the volumes that Bruce edited personally, all the foreign language articles were translated by him into English (from French, German, and Latin).

While serving as department chair, he assembled a formidable group of researchers in physical acoustics and underwater sound, including Arthur Williams, Bob Morse, and Peter Westervelt (and I was there, too). When we went to meetings of the Acoustical Society of America, the papers from the Brown Physics Department made up a significant fraction of the total, but Lindsay's greatest influence was through the Journal. He had served the Society in the usual collection of offices: councilman, associate editor, vice-president, and in 1956-57, as president. At that time, Floyd Firestone suddenly resigned as editor, and the Society was looking for a replacement. I was on the Council at the time. We had one nominee put forward and there was general discussion. Then I heard a voice (not mine) from somewhere say "how about Dr. Lindsay here?",

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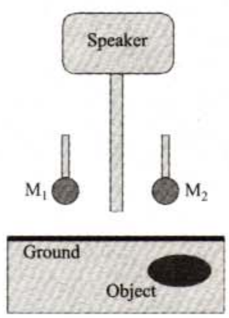


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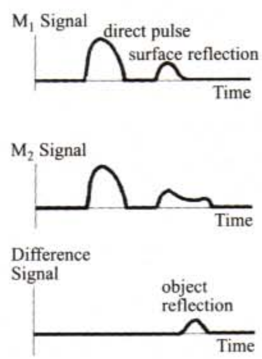


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## Cold Water on Cold Fusion

*by A. Prosperetti*

A small pulsating bubble becomes a furnace hotter than the sun. There is the prospect of a new device for nuclear fusion and clean energy, table-top relativistic and quantum effects, and most likely new physics. And it's not difficult either: a Coca Cola glass, a piezoelectric transducer–about 100 bucks total. It's called sonoluminescence. You don't believe it? Then you are a sour skeptic–or maybe not?

The fact is that what goes on is much more complex than meets the naked–or camera enhanced–eye. For starters, this bubble is only apparently fixed in place. In addition to an alternating expansion and collapse in sync with the sound field, it executes up-and-down motion in its periodic struggle between buoyancy and acoustic radiation force. A bubble that shrinks while translating cannot remain spherical; a jet of liquid is pushed along the axis of the bubble in the direction of translation. In the course of the subsequent expansion, the liquid thread snaps and the bubble becomes nice and spherical again like an inflated wrinkly balloon.

Where does the light come from? In a recent paper (J. Acoust. Soc. Am. **101**, 2003 (1997)), I suggested that the impact of the jet is so sudden and violent that the water cannot respond by flowing. Rather, it cracks–for a brief moment–like a solid. That certain substances, such as Silly Putty, behave as liquids or solids depending on the deformation rate is well known. This difference in behaviors presupposes a time scale intrinsic to the fluid, which is long for Silly Putty but very short ($10^{-11}$s) for water. The liquid cannot flow over these time scales, and it cracks. Fracto-luminescence–the emission of light from fractured or severely stressed solids–is well known from Life Savers Wint-O-Green™ candy, which produce flashes of light when chewed in the dark; scientists still don't know exactly why.

Before continuing to test the reader's forbearance, let me mention two recent experimental findings that cast at least a strong doubt on the conventional picture of spherical implosion and shock focusing. Weininger, et al. (UCLA) have detected sonoluminescence emission from a bubble sitting on a solid, while Lauterborn et al. (Göttingen) report a similar observation from a laser-generated bubble collapsing near the container wall. With some stretch, one may still save the conventional picture in the first instance, but there is no question that in the second case there is a strong jet directed toward the wall.

This jet-cracking hypothesis may account for a host of other unexplained phenomena by bringing the liquid structure into play. Among all liquids, water stands out due to the unusual strength of its intermolecular hydrogen bonding. If energetic cracking must occur for light emission, it is therefore natural that water should be the "friendliest" liquid for sonoluminescence. Lowering the temperature strengthens the bonds, makes the water more "rigid" and gives more light. Ditto for heavy water, whose structure is very much like that of normal water, only colder.

In order to nucleate a crack, one needs a flaw. This may be why a small amount of noble gas is necessary for sonoluminescence: these atoms keep the hydrogen bond cage open and act as "weak spots" in an otherwise hard structure. One may also understand the brevity of the light pulse: the hypercompression due to the impact can only last until the compression wave is reflected off the jet surface. With a jet diameter of 0.1 microns and a sound speed of 2000 m/s, one gets about 100 ps.

This new hypothesis is presented as an alternative to the hypothesis that sonoluminescence has its origin in the generation of a shock wave in the gas, its focusing at the center of the bubble, and the consequent formation of a plasma. A substantial amount of work is needed to confirm or disprove this new hypothesis. If true, it will dash the hopes for another road to cold fusion, but it may result in a new tool for the investigation of liquid structure. Either way, sonoluminescence remains the most exciting new development in physical acoustics. Thank you, Crum and Gaitan.

*Andrea Prosperetti is a fellow of ASA, ASME, and the American Physical Society. He holds the Miller chair in Mechanical Engineering at Johns Hopkins University.*

*...Lindsay, continued from previous page*

whereupon Bruce excused himself and left the room. Ten minutes later, he was back as Editor-in-Chief, a position he occupied to the day of his death 28 years later.

The Society was 28 years old when Bruce became its Editor-in-Chief. Thus, at his death he had served in this position for half of the history of the Society. During this time, the size of the Journal tripled, growing from 1449 pages in 1957 to 4534 in 1985, while the number of associate editors increased from 8 (besides Lindsay) to 27. Bruce developed a smoothly working editorial machine that served to produce the premier acoustics journal in the world.

To his death, Bruce loved the Society and the Journal. Three days before his death, Rachel Lindsay sent me (acting editor) the draft of a letter to be sent to an associate editor, a letter that Bruce had dictated to her, explaining his position on an editorial dispute clearly and firmly. May we all be so fortunate in having a loving wife, a beloved occupation, and a mind to be cognizant of both, to the very end!

# Acoustics in the News

• "Calming Bad Vibes" is the title of an article about active vibration control in the November 22 issue of *Science News*. More than ever before, engineers are using computers in combination with new materials with controllable properties to create what they call "smart structures" that can sense their environment, process the information, and then react appropriately. From microscopes to skyscrapers, smart structures help control vibrations.

• Ronald Stearman, an aerospace engineer at the University of Texas, has found a way to use airplane voice recorders to help crashes, according to a story in the November issue of *Discover*, Analyzing the fourth (unused) track of a voice recorder from a small commuter plane that crashed in 1991, Stearman found evidence of whirl flutter that probably stemmed from a cracked engine mount. "The wires to the tape recorder, because they were attached to the plane's superstructure, acted as a simple microphone and picked up the aircraft's vibrations," he pointed out. He also found warble on the three recorded tracks, which could be evidence that the recorder was vibrating, making the tape slip. Regular analysis of the recordings could warn of mechanical problems, such as the cracked engine mount.

• What is claimed to be the smallest guitar in the world has been developed in the Nanofabrication Facility at Cornell University, according to a note in the October issue of *R&D Magazine*. Just 10 μm long and 20 times thinner than a human hair, the six-stringed instruments were carved out of crystalline silicon to demonstrate a technique that could have a variety of uses in fiber optics, displays, sensors, and electronics. Although the strings can be strummed, the instrument is too small to be heard.

• Sound pulses as short as a picosecond ($10^{-12}$s), generated with pulsed lasers, are used to probe connections inside computer chips, according to an article "Picosecond Ultrasonics" by Humphrey Maris, Brown University, in the January 1998 issue of *Scientific American*. To measure the thickness of thin film conductors, a light pulse is focused onto the film and absorbed by the uppermost layer of the stack. The heating and resulting expansion generate a sound pulse that travels through the stack. Echoes from boundaries between successive layers are used to determine the thickness of each layer.

• The cloning of a string of genes that, when mutated, cause deafness without any other symptoms is opening a view of the inner workings of the auditory system and how it develops, according to an article in the November 14 issue of *Science* entitled "The Architecture of Hearing." Geneticists Eric Lynch and Mary-Claire King of the University of Washington worked with Pedro León, a molecular biologist at the University of Costa Rica to track down the cause of deafness in a Costa Rican family whose history goes back to Spanish explorers in the $17^{th}$ century. Family members have a tendency to go deaf, often beginning at age 10. King, Lynch, León, and their colleagues mapped the chromosomal location of the gene at fault.

• Smart materials can reduce the weight of structures by allowing designers to incorporate extra stiffness without adding bulk. Piezoelectric materials, for example, change shape when an electric current passes through them and generate electric signals when they flex. These materials are therefore doubly useful for controlling small vibrations. Researchers at Sandia National Laboratories used three small strips of smart material in the platform that holds the silicon wafer underneath the photolithography head during semiconductor manufacture, reducing the magnitude of its vibrations from 240 nm to 4 nm.

Smart dampers, which are essentially controllable versions of large shock absorbers, represent another effective way to counter large forces in massive structures. One type of smart damper contains a magnetorheological fluid, a material that can undergo considerable changes in its viscosity when subjected to a magnetic field.

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