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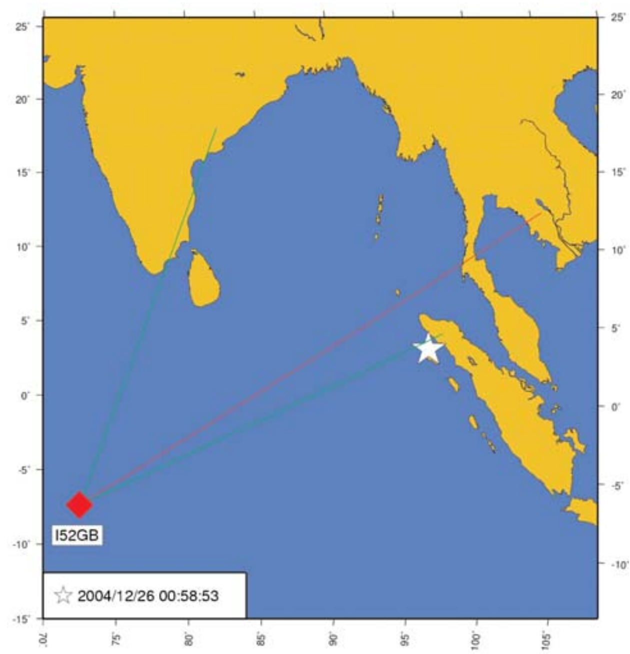
Infrasound from the 2004-2005 earthquakes and tsunami near Sumatra

Milton Garces, Pierre Caron, and Claus Hetzer



Paths of infrasound signals from earthquakes

Infrasound arrays in the Pacific and Indian Oceans that are part of the International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) recorded three distinct waveform signatures associated with the December 26, 2004 Aceh earthquake (M9, USGS) and tsunami. The infrasound stations observed (1) seismic arrivals (P, S and surface waves) from the earthquake, (2) tertiary arrivals (T-phases), propagated along sound channels in the ocean and coupled back into the ground, and (3) infrasonic arrivals associated with either the tsunami generation mechanism near the seismic source or the motion of the ground above sea level. All signals were recorded by the pressure sensors in the arrays. The seismic and T-phase recordings are due to the sensitivity of the microphones to ground vibration, whereas the infrasound arrivals correspond to dispersed acoustic waves propagating through atmospheric waveguides. A similar, but not identical, sequence of arrivals was observed at Diego Garcia Atoll (range of ~2860 km) during the March 28, 2005 Nias earthquake (M8.7) and the April 10, 2005 Mentawai earthquakes (M6.7 and 6.5), suggesting that above-water ground motion can generate infrasound in the Sumatra region. In addition, very low frequency infrasound was produced in the Bay of Bengal region, suggesting that the interaction of the tsunami with the coastal bathymetry can produce sound.

From the prominent features of infrasonic arrivals and infrasonic source location estimates for the selected Sumatra earthquake and tsunami sequence, we deduce that submarine earthquakes can produce infrasound. The sound may be radiated by the vibration of the ocean surface or the vibration of land masses near the epicenter.

It is also apparent that infrasound stations can also serve as seismic and T-phase stations for large events. For the three submarine earthquakes that we investigated, the differences in the observed signals may be due to either source or propagation effects. Although there is a substantial difference between the information contained in the low (0.02 – 0.1 Hz) and high (0.5-5 Hz) frequency bands of the infrasound range, it does appear that both small (Nias) and large (Aceh) tsunamis may produce infrasound.

The candidate source locations near the epicenter, in conjunction to the unique signal observed at Diego Garcia for the Aceh event, suggests that infrasound may be combined with other technologies as a discriminator for tsunami genesis. Fundamental research is needed on how low-frequency sound from large earthquakes and tsunamis can be utilized in hazard warning and mitigation.

Milton Garces, Pierre Caron, and Claus Hetzer are at the Infrasound Laboratory at the University of Hawaii. This article is based on paper 2aPA1 at the Vancouver ASA meeting.

We hear that...

• ASA Fellow **Jan Achenbach**, Walter P. Murphy Professor and Distinguished McCormick School Professor of the Departments of Mechanical Engineering and Civil and Environmental Engineering at Northwestern University was awarded the National Medal of Technology. He was presented this award, the nation's highest honor for technological innovation, by President Bush in Washington D.C. at the White House on March 14, 2005.

• ASA Fellow **Clive Dym**, Professor of Engineering at Harvey Mudd College, has been awarded the Ruth and Joel Spira Outstanding Design Educator Award for "exceptional contributions to design education through widely-cited authorship on engineering design, through sponsorship of the ASA workshops and conference panels, and through enthusiastic mentoring of engineering students in the art and science of design."

• ASA Fellow **Ira Hirsh** has received a Life Achievement Award from the American Auditory Society. The announcement was made at the Society's 2005 Scientific and Technology Meeting in Scottsdale, Arizona.

ASA Fellow **H. Vincent Poor,** George Van Ness Lothrop Professor in Engineering at Princeton University, has been named the 2005 winner of the Distinguished Alumnus Award by the Tau Beta Pi engineering honor society at Auburn University. A $2000 scholarship will be given in Dr. Poor's name to a deserving student member of Tau Beta Pi.

• The American Institute of Physics **State Department Science Fellowship** represents an opportunity for scientists to make a contribution to U.S. foreign policy. At least one Fellow annually will be chosen to spend a year working in a bureau of the State Department, providing scientific and technical expertise to the Department while becoming directly involved in the foreign policy process. Fellows are required to be U.S. citizens and members of at least one of the 10 AIP Member Societies at the time of application. Please visit http://www.aip.org/gov/sdf.html for details. All application materials must be postmarked by November 1, 2005.

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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• **Masakazu Konishi** and **Eric Knudsen** will share the $200,000 Neuroscience Prize from the Peter Gruber Foundation for their research on the neural circuits and mechanisms that underlie sound localization in barn owls. Konishi is at the California Institute of Technology, while Knudsen is at Stanford University.

From the editor

A big event for the Acoustical Society of America is the launching of the new magazine *Acoustics Today*. Dick Stern is especially to be congratulated for creating this new magazine. *ECHOES* is proud to become a part of this new magazine.

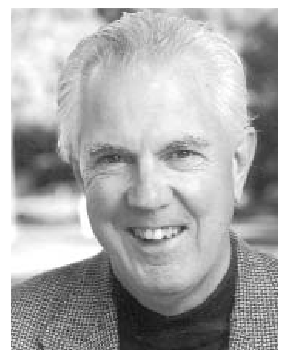
Since the publication of ECHOES has been tied to ASA meetings and since the Fall meeting in Minneapolis is being held earlier than usual, it was decided to publish two slightly different versions of *ECHOES*. This version will be printed and mailed to members so they will receive it well in advance of the Minneapolis meeting, and it will go online, as usual. The other version will be incorporated into *Acoustics Today*. In the future, only one version is planned.

As usual, I urge readers to submit Letters to the Editor, which are more interesting to read than letters from the editor.

Thomas Rossing

Message from the President

William A. Yost



As I start my presidency the ASA is in very good shape and there are several new developments underway. The Society will be publishing a new magazine, *Acoustics Today*. *ARLO* (*Acoustics Research Letters OnLine*) is undergoing change under the new editorship of Keith Wilson. The upcoming ASA meetings in Minneapolis and Providence will be excellent, and I hope you will attend one or both. The Minneapolis meeting will be a joint ASA/NOISE-CON meeting. The work of Dick Stern's *Vision 2010* Committee is coming to an end, and a report on suggestions for ASA's future will be forthcoming. We continue to monitor the financial health of ASA. The Society is fiscally sound and we have several groups working to make sure we stay that way.

I thought I would take a few words to explain a little bit about the organization of the ASA that is responsible for its management. The ASA is a largely volunteer organization, but we do have a small, but outstanding staff in both the Headquarters and Standards offices. While the President of the ASA is its CEO, the main day-to-day operations are expertly managed by our Executive Director, Charles Schmid. The ASA office is under the leadership Elaine Moran, ASA Office Manager, and is located in Melville, New York on the site of the

continued on next page

Acoustics in the City of Lakes

Technical Program Organizing Meeting in Minneapolis

ASA's 150th meeting will be a joint meeting with NOISE-CON 2005 in the beautiful city of Minneapolis. It is hard to believe that this is only our second meeting in this lovely city, and it is a meeting you will not want to miss. Minneapolis has seven lakes within the city limits, and there are many more in neighboring St. Paul and the suburbs, not to mention over 11,000 of them throughout the state of Minnesota. Strolling or biking around these lakes is a favorite pastime of visitors, but if shopping is more to your liking, the Mall of America is the largest indoor shopping mall in the United States.

Minneapolis is the cultural center of the Upper Midwest, with the Tyrone Guthrie Theater, the Walker Art Center, the Minneapolis Institute of Art, and Orchestra Hall all close to downtown, and the Weisman Art Museum not far away on the University of Minnesota campus. Minnesota's Scandinavian heritage is evident at the American Swedish Institute as well as by listening to local accents spoken on the street. In the direction of the airport, Minnehaha Falls is in a park dedicated to Longfellow's Indian heroine. When the sun goes down, some locals head to the Warehouse District, a collection of renovated buildings that now house nightclubs, restaurants, shops and galleries.

Meanwhile, a smorgasbord of papers and special events awaits meeting attendees. More than 70 special sessions have been scheduled by the two societies, and 779 technical papers will be presented. ASA has scheduled a distinguished lecture by Manfred Schroeder, and NOISE-CON has scheduled plenary talks by Carl Burleson, Paul Donavan, and James West. A one-day colloquium and discussion on the topic "Imaging and Control of HIFU-Induced Lesions" will be held on Tuesday, October 18, and a seminar on Power Plant Noise will be given by Frank Brittain on Sunday, October 16, 1:00 p.m.-5:00 p.m. A tutorial on Diagnostic Imaging in Biomedical Ultrasound will be given by E. Carr Everbach on Monday, October 17, at 7:00 p.m.

ASA/INCE members are invited to attend a rehearsal of the Minnesota Orchestra (Osmo Vanska, conductor) on Tuesday afternoon, October 18, followed by a guided tour of Orchestra Hall with Cyril Harris as tour guide. A concert by the St. Olaf Cantorei at Central Lutheran Church on Thursday, October 20, will close the session on Acoustics of Choir Singing.

An exposition, jointly sponsored by ASA and INCE, will feature over 40 displays with instruments, materials, and services for the acoustical community. Buffet socials are scheduled Tuesday and Thursday evenings, a Fellows' Luncheon is scheduled Thursday noon, and the Women in Acoustics luncheon on Wednesday. The joint ASA Plenary session and INCE Awards Ceremony will be on Wednesday afternoon, while NOISE-CON plenary sessions will be on Monday, Tuesday, and Wednesday mornings.

Message from the President, cont.

American Institute of Physics (AIP) New York offices. As anyone who has worked with the ASA knows, without the incredible efforts of Elaine Moran, there would be no ASA. The Society contracts with the AIP for many services that make the ASA an efficient organization.

A few blocks away from the ASA office is the Standards Office, under the outstanding direction of Susan Blaeser, Standards Manager. Paul Schomer, Standards Director, oversees the ASA's commitment to standards. In addition to the ASA staff we have the ASA Managers who report to Charles Schmid. They include the ASA Editor-in-Chief, Allan Pierce, and his many Associate Editors; David Feit, ASA Treasurer; and Paul Schomer, Standards Manager.

The Executive Council of the ASA includes six elected Council Members, and the ASA Officers: President and Vice President, President-Elect and Vice President-Elect, and Past President and Vice President, Editor-in-Chief, Treasurer, Standards Director, and Executive Director. The Vice President chairs the Technical Council consisting of the Chairs of the ASA's thirteen Technical Committees (TCs). The TCs are the heart and soul of the ASA's scientific meetings and are responsible for making most of the decisions concerning the dissemination of scientific information. The membership is served well by many Standing Committees and a few Ad Hoc Committees appointed (or re-appointed) by the President.

However, without the volunteer efforts of the membership there would be no Society, or least it would be prohibitively expensive to run the ASA. From our members' willingness to serve as Officers and on committees to the large commitment many make in organizing and running our twice per year scientific meetings, the ASA is extremely well served by hundreds of member volunteers.

As I stated, the ASA is in excellent shape. A large part of the ASA's success is the outstanding science produced by its members and those who contribute to our journals. But it is also due to our excellent staff and to the many members who volunteer their time, energy, and wisdom to make the ASA the premier acoustical society in the world.

What's new in string instruments

Thomas D. Rossing

At the ASA meeting in Vancouver we had a special session on Design and Construction of String Instruments followed by a workshop on this same subject. The workshop leaders were experienced builders of string instruments, and they shared their insights and some of their "trade secrets." What follows are some excerpts from their presentations. A slightly longer version of this article appears in the first issue of the new magazine *Acoustics Today*. At some later time, it may be possible to publish the complete texts.

Violins: Joseph Curtin, Ann Arbor, MI

The violin was perfected in eighteenth century Italy – or so traditional wisdom would have us believe. But for all its beauty, the instrument is rife with unresolved design issues: It is easily damaged, musically unstable, uncomfortable to play, tricky to adjust, and it must be played for decades or even centuries to sound its best. Today a growing number of makers are trying new approaches to their craft. As one of them, I believe there are at least seven directions in which the instrument can evolve:

Increased durability—To put an instrument in a musician's hands is to put it in harm's way. Most of the damage is entirely predictable–and most is preventable with fairly modest changes to the violin's design and construction.

Stability with changing humidity—Wood is hygroscopic. Changes in moisture content throw violins out of adjustment and can cause the wood to crack. Traditional varnish does little to impede vapor transfer. It is not hard to imagine alternative finishes that do a far better job, and there are a variety of wood treatment processes which promise decreased sensitivity to moisture. Alternatively, non-hygroscopic materials such as graphite fiber can be used.

Ergonomic—The shape of violin-family instruments, while pleasingly symmetrical, makes it difficult for players to access the high positions, especially in the case of the viola, cello, and double bass. Innovative designs will make instruments that are less taxing to play, thus reducing the risk of tendonitis and carpel tunnel syndrome.

Adjustable by the player—Virtually all adjustments other than tuning the strings must be performed by a professional violinmaker, who must try to interpret the player's often highly subjective requests. Makers are currently experimenting with configurations that allow the player to quickly and safely adjust the neck angle, the soundpost length, the tuning of the bridge, the tension of the bassbar – and even the frequency of the lowest air resonance.

Ultra-light construction—The best old violins tend to be relatively light in weight, and this contributes to their power and responsiveness. Alternative materials such as graphite, balsa, and synthetic foam (along with innovative ways of using traditional materials) allow the construction of vastly lighter instruments. I believe that within a decade these will radically redefine our concept of the violin.

High quality when new—There are well-documented acoustical differences between old Italian violins and our own–most significantly the ability of the old ones to suppress the high-frequency overtones that can make new instruments sound harsh. An old Italian top, when taken off the instrument and tapped, sounds more highly damped than a new one. I believe this is mainly a question of what happens to wood over time.

Twenty-first Century aesthetics—Classical violinmaking ended in the late seventeen hundreds, but no one knew what to do next so we kept trying to do the same thing over and over. Old Italian violins are classics because they could not have been built in any other time than their own. Today's violins will become classics only if they reflect the aesthetic and design ideals of our own time. It is happening already. I cannot imagine a more exciting time to be a violinmaker!

The Violin Octet: George Bissinger, East Carolina University

The Schelleng 1963 scaling, employing a two-mode basis set (main air = A0 and main wood = B1) was partially successful since the flat plate scaling for the top and back plates generally placed the B1 where desired, even though there were substantial variations in instrument shape. The real failing came in the Rayleigh relationship scaling for A0. This came about because A1 was never included in the octet scaling but was seen to be coupled to A0 as can be seen directly in the Shaw model of 1992, and this affected its volume dependence strongly.

An important improvement in scaling would be to go to a four-mode basis set: A0 and A1 for the cavity modes using Shaw's two-degrees-of-freedom model with a semi-empirical wall compliance correction, and B1- and B1+ using flat plate scaling plus empirical relationships between top and back mode frequencies and assembled instrument B1 modes.

Classical Guitar Construction: Bernard E. Richardson, Cardiff University

As an acoustician passionately interested in the making of classical guitars, it is all too easy to get wrapped up in modes of vibration of the body and the effects which changes to shape and materials have on these modes. The complete chain of music making on the guitar, of course, involves the player and his or her interaction with the string, the string vibrations and their coupling to the body, and finally the coupling of the body with the surrounding air. We might importantly add the ear and brain of the listener, too, for without the due regard to the subjective evaluation of a listener, much of our acoustical endeavors would be wasted. Our recent guitar studies have involved an amalgamation of real measurements of both structural vibrations and their associated sound fields and modeling of a plucked string coupled to a radiating body. The model is used as the source of psychoacoustical evaluations of sound quality. Although it's tempting to ask questions such as "What makes a great guitar?," for the moment, at least, we are interested in determining what sort of structural changes make audible changes to the sound quality. In this way, we might build up a check-list of constructional aspects which makers should treat carefully and those which are of less importance in determining sound quality.

Our studies so far have thrown out a few interesting observations. For example, it is often suggested that materials for guitars should have low damping, but we can see quite positive benefits from reducing Q-values of modes. Indeed, one of the major "problems" with making a good guitar is that the general design principles adopted in virtually all instruments over-emphasize coupling of the strings and body. Another observation has been to note that some of the low-order modes, which might be expected to radiate with largely monopole radiation fields, have, in fact, considerable dipole components. The relative strengths of the monopole and dipole components vary considerably from one instrument to another, dependent on the overall construction of the body (soundboard, back plate and ribs). This can have a profound effect on radiation from the instruments at both low- and mid- frequencies and may have a marked influence on balancing the various registers of the instrument.

The Five-String Banjo: James Rae, Mayo Clinic College of Medicine

Formants—Either by plucking individual strings near the bridge or by brushing all five strings at many positions between the neck and bridge, it is possible to establish a sound signature for an individual banjo.

The spectra thus obtained tended to show a formant in the 200-1500 Hz range and another in the 2000-4000 Hz range. The lower and stronger one appears to be related to vibrational modes of the head, while the upper one may be due to mechanical properties of the bridge.

Total sound power—At least 99% of a banjo's sound power occurs below 5000 Hz, and about 95% of the power comes from the sum or the first five to seven harmonics. Higher harmonics contribute markedly to the timbre but not to the radiated sound power.

Cavity tuning—Unlike most other string instruments, cavity tuning can occur after the assembly of the banjo. By installing adjustable screws to hold the top of the banjo (the pot) to its resonator, the spacing between the bottom of the pot and inner floor of the resonator can be adjusted. As the pot-resonator separation is increased, the response of the banjo is shifted to higher frequency which "brightens" the sound. We have made small spacers, which our friends call "Raejustors" to facilitate this tuning.

Bridges—Most commercial bridges have a single resonance at about 2000 Hz. By using different woods and orienting the grain differently it is possible to construct bridges that show accelerance peaks anywhere from 650 to 3300 Hz. A particularly useful bridge is one made of a vertical grain wood with a pedestal structure of different woods so that particular parts of the bridge are "tuned" to the string being served.

Mandolins: David J. Cohen, Richmond, VA

The mandolin is a plucked string instrument whose origins appear to go back to the medieval gittern (also known as guittarra, chitarra, and guitaire in various European countries). The modern mandolin is descended from two instruments which developed during the 18th century. The first was the mandola or mandolino, which carried six courses of two strings tuned in 3rds and 4ths and is sometimes referred to as a Milanese mandolin. The second was the mandoline or Neapolitan mandolin, which had four courses of two strings tuned like a violin. The modern mandolin is tuned like the latter. The stiff bowls of the Neapolitans do not contribute to corpus vibrations below about 1200 Hz.

Mandolin makers have used a variety of brace patterns. Gibson mandolins generally featured longitudinal braces, whereas such makers as Gilchrist and Smart preferred crossed braces. The crossed or X- bracing pattern imparts more cross-grain stiffness than other bracing patterns. Coupling between the lowest plate mode and the air cavity resonance is stronger in f-hole type mandolins than in Neapolitans or oval hole archtop mandolins.

The Virzi tone producer was thought by its originators, Joseph and John Virzi, to provide a secondary vibrating surface, thereby producing a more complex set of overtones and a more mellow tone. While the original premise is debatable at best, the device does act as an addition mass which could split the lowest body resonance into two resonances.

Building Trends in Hammered Dulcimers: David Peterson, University of Central Arkansas

The hammered dulcimer, a stringed instrument played with two wooden hammers, probably originated in the Middle East, but has become part of the musical culture of many countries. In the U. S., the folk revival in 1970's sparked renewed interest in the hammered dulcimer as a concert instrument. Today, despite some consolidation, there are still hundreds of builders, mostly amateurs, who experiment with the basic design. The most important design parameters are: soundboard size, shape and composition, internal bracing, bridge shape, string arrangement and composition, hardness of bridge caps, hammer weight and stiffness, instrument resonances due to the unique string splitting and also the stiffness of the body, and soundboard modes.

Strings—Most hammered dulcimer builders use steel piano wire ranging from .016" in diameter (#6) to .024" in diameter (#10). Because of the trapezoidal shape of the instrument, string tension decreases as strings get longer and are tuned lower, and this becomes a problem. Efforts to improve the sound of lower strings include the use brass or phosphor bronze strings with approximately 10% higher densities than steel or using single wound strings.

Side rails and bracing—Total longitudinal tension string tension is about 1900 lbs, with a total downward force on each bridge of about 150 lbs. The resulting bending moment must be overcome with relatively deep side rails (3-4") and internal bracing. Before 1970, the instruments were strong boxes with 3/4" hardwood backs, heavy pin blocks, floating soundboards, and several 3/4" braces glued to the back.

Bridge design—The most common design is a solid bridge.

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The ASA Regional Chapters Program

Elizabeth McLaughlin and Juan Arvelo

The Regional Chapters Program certainly embraces the intent of our Society. "The ASA was founded…to increase and diffuse the knowledge of acoustics and promote its practical applications. Any person. . .interested in acoustics is eligible for membership." There are currently twenty active chapters involved in promoting acoustics through outreach and involvement with the public and the number is growing.

Each chapter is formed by a group of motivated people and each has its own unique program. The ASA does not assign national ASA members to chapters. Instead, local groups of ASA members and non-members petition the ASA to form a chapter. Chapter activities are tailored to the interests of its members and may include group tours of facilities, talks at schools, dinner meetings with invited speakers, science fairs, networking, scientific demonstrations, mini-conferences, awards, student competitions, current events discussions, presentation practice, and published article reviews.

The Committee on Regional Chapters (CRC) promotes the formation and growth of regional chapters and provides liaison among the chapters and between the chapters and the Society's office. This committee is somewhat different than other committees of the ASA in that each chapter elects its own representative. Other members of the committee include the Society's treasurer, the chair of the Education Committee and a newly requested position of Student Council Liaison. In the mid-90s the Society improved the monetary support structure of the chapters. Chapters no longer need to collect dues (a time-intensive task) and therefore the volunteers are able to spend that time on more productive endeavors. The new structure encourages chapters to build their programs, increase attendance, advertise more, and host events which increase awareness of the ASA.

The mid-90s also saw the incorporation of international chapters into our Society. We now have two very active international chapters: the Madras-India Chapter and the Mexico City Chapter. The entirety of the chapters now reflects more of the cultural diversity of the Society and the CRC is richer for the added perspectives of the international chapter members.

Larry and Julia Royster, long time champions of the Chapters Program, have started and are generously supporting the Chapter-run Royster Student Poster Competition through a grant to the ASA. The competition is held once a year; the yearly scholarship award totals $5000 and the posters should be on any hearing conservation or noise control topic. Scholarship recipients must enroll as full-time graduate students in a program involving acoustics. The CRC has administered this competition for three years.

The ASA approved its first Student Chapter, the University of Nebraska Student Chapter, at the 75th Anniversary Meeting in New York City. At the ASA meeting in Vancouver the Brigham Young University Student Chapter was approved. The students are the Society's future.

Involvement in a chapter is a great way to give back to the ASA, to have fun, to learn and promote acoustics, to socialize, to network and to involve new persons in our exciting field! Please contact the authors for more information.

Elizabeth McLaughlin and Juan Arvelo are co-chairs of the ASA Committee on Regional Chapters.

What's new in string instruments?

(continued from page 5)

Saw cuts and individual caps are sometimes used in an attempt to de-couple adjacent courses. Inlaid scale markers make the instruments much easier to play accurately.

The trend in hammered dulcimer construction is to make lighter instruments with less sustain. Extremely lightweight 15/14 instruments are now advertised at 12 lbs or less, although most are about 20 lbs. To some extent this has been accomplished by using fewer strings per course with smaller course separation (both of which make the instrument more difficult for the amateur to play accurately).

Harp Design and Construction: Chris Waltham, University of British Columbia

The harp is triangular in shape. The easiest part of the triangle to make is the post as it plays little part in the sound production and can therefore be over-engineered; the compressional force is in any case mostly axial. The neck has to withstand the total tension of all the strings, and also a large torque, as all the strings are mounted on one side. The soundboard has to be both thin and also to withstand all the string tension. Sitka spruce is the material of choice for its acoustical properties and anisotropic strength.

Strings—The string material is determined by harmonicity (the overtones should sound pleasant) and "feel." Harmonicity requires that the string be strong, heavy enough, but not stiff. "Feel" is how hard the player has to pull to move the string center a given amount before release; it should be large enough that the strings do not touch, and not vary too much from string to string. Nylon or gut would probably suffice for all strings if the lower strings followed the curve set by the upper strings and became very much longer than they actually are. Gut is mechanically similar to nylon but has a warmer tone for the mid-register. Practical reasons make the harp neck a double curve (an ogive, so it isn't too tall) and so much heavier strings are needed for the low register. Nylon/gut strings would have to be very thick here, very inharmonic, and the feel would be so small that the strings would interfere with each other. Steel wrapped with helical copper wire is used, although there is an awkward change in feel at the break.

My current aim is to produce a thorough map of resonances in different harps, and to ascertain what features are desirable and what are not. In the process I hope to achieve a better understanding of how best to optimize soundboard

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Scanning the Journals

• Theory predicts abundant production of **acoustic waves in subsurface layers of the Sun**, and such waves are believed by many to constitute the dominant heating mechanism of the chromosphere, according to a paper in the 16 June issue of *Nature*. Such waves are difficult to detect because of disturbances in the Earth's atmosphere. This paper reports the detection of such waves and numerical simulations to show that the acoustic energy flux of these waves is too low, by a factor of at least ten, to balance the radiative losses in the solar chromosphere. Acoustic waves therefore cannot constitute the dominant heating mechanisms of the solar chromosphere.

• There is widespread belief among players and listeners alike that **violins improve with age** and/or playing. Although mechanical measurements show noticeable differences between two violins built from the same wood samples, rankings of the instruments by experienced playing and listening panels showed no statistical differences in the finished instruments, according to a paper in the April issue of *Acoustics Australia*. One instrument had been played regularly and the other had been kept in museum condition.

• Tree frog embryos have a remarkable ability to **sense and interpret vibrations**, according to a paper in the July issue of *Animal Behaviour*. Eggs of the red-eyed tree frog usually hatch after seven days, but the embryos can emerge up to 30% earlier to escape a predator's attack. Upon hatching they drop into the water and, as tadpoles, swim away to safety. They are more likely to hatch when exposed to vibrations recorded from a snake attack than when exposed to recordings of heavy rain. The embryos must therefore be able to distinguish between these different kinds of motion.

• The **Australian didgeridoo** is a simple musical instrument that is capable of a spectacular variety of timbres, according to a brief paper in the 7 July issue of *Nature*. Simultaneous measurement of the didgeridoo sound and the acoustic impedance of the player's vocal tract just inside the lips indicated that the maxima in the envelope of the sound spectrum are associated with minima in the impedance of the vocal tract. This acoustical effect is similar to the production of vowel sounds made during human speech or singing, although the mechanism is different, and leads to the conclusion that experienced players are subconsciously using their glottis to accentuate the instrument's tonal variation.

• New evidence for **bubble fusion** or sonofusion is reported in the May issue of *Nuclear Engineering and Design*. Engineers at Purdue University used the same test chamber filled with deuterated acetone as in previous experiments (see Summer 2004 issue of *ECHOES*) but with californium-252 as a continuous source of neutrons instead of the pulsed source previously used. The acetone was exposed to the neutron source and then bombarded with ultrasound to produce tiny bubbles that expand before imploding.

• The March issue of *Acoustical Science and Technology* is a special issue on **Room Acoustics** in honor of RADS 2004 (International Symposium on Room Acoustics: Design and Science 2004) held on the Island of Awaji in April 2004. The symposium, which was a satellite symposium of ICA 2004, included 20 invited oral presentations and 63 poster presentations, of which twelve papers, one technical report, and twelve acoustical letters appear in this special issue.

• A novel method of controlling **reflections in a listening room**, using flat panel loudspeakers, is described in a paper in the May issue of the *Journal of the Audio Engineering Society*. Models and implementations are presented for single-channel, two-channel, and five-channel arrangements. The results of a pilot listening test showed that differences in reflection patterns were readily detected by a panel of experienced listeners.

• *EURASIP Journal on Applied Signal Processing*, Volume 2005, Issue 9 is a special issue on **Anthropomorphic Processing of Audio and Speech**. Some papers are paid for by the authors and can be downloaded free of charge at http://www.hindawi.com.journals/asp/volume-2005/issue-9.html.

• The July/August issue of *Acta Acustica/Acustica* includes a two-part review article on "**Noise** and its Effects—A Review on the Qualitative Aspects of Sound." The first part deals with "Notions and Acoustic Ratings," while the second part deals with "Noise and Annoyance."

• The **ear of a locust** combines in one structure the functions of sound reception and frequency decomposition, according to a paper in the *Journal of Experimental Biology* **208**, 157-168 (2005). Although less sophisticated in structure than the ear of most vertebrates, auditory systems in these, and other insects, perform similar sound frequency analysis. The traveling wave in the ear of a locust rides on an anisotropic membrane suspended in air.

What's new in string instruments? *(continued from page 6)*

parameters, particularly the thickness, as this is where good engineering and good acoustics seem most at odds.

Carved Baltic psalteries: Andres Peekna, Waterford, WI

The Baltic psaltery family of plucked string instruments includes the kantele (Finland), the kannel (Estonia), the kokle, (Latvia), the kankles (Lithuania), and the wing-shaped gusli (Northwestern Russia). Over the years, we have studied the modes of vibration of several psalteries by various makers, many of which are faithful copies of ancient instruments. On the better instruments, the main body resonances are well distributed in frequency so that they support the various strings. Good string-to-soundbox coupling also appears to play a role. A useful method for studying string-to-soundbox coupling involves scanning at intervals as low as 0.1 Hz for narrow peaks within the nominal tuning range of the strings, and comparing them to their neighboring body resonances, while using electronic TV holography. Predictions of the Helmholtz resonance from sound hole dimensions and air cavity volume while neglecting damping in the sound holes yield upper limits when many small sound holes are involved. The locations of the sound holes, as well as their area, are found to have significant effects on sound quality and volume.

Acoustics in the News

• The songs of birds can have warning calls coded into them, according to a story in the 28 June issue of *The New York Times*. Consider the black-capped chickadee. By varying the call, a bird communicates to other birds the size of the predator, and thus the scope of the danger. They vary the number of "dee" sounds at the end of the call depending on the size of the predator. The more "dees" the more chickadees show up to harass the predator, by dive-bombing it or making noises in its face.

• Musical hallucinations can occur when neurons go awry, a story in the July 12 issue of *The New York Times*. Researchers have found that in two thirds of the cases studied, musical hallucinations were the only mental disturbance experienced by the patients. A third were deaf or hard of hearing. Women tended to suffer musical hallucinations more often than men. People tend to hear songs they have heard repeatedly or that are emotionally significant to them. Plans are being made to use MRI in order to catch second-by-second changes in brain activity.

• The male club-winged manakin, a tiny red-headed bird, literally sings with its wings, according to a story in the August 2 issue of *The New York Times*. In an effort to attract the attention of females, the bird rakes its feathers back and forth over one another, using an acoustic trick that also allows crickets to sing. While the technique is common among insects, it has never been documented before in vertebrates. When the bird raises its wings over its back, it shakes them back and forth over 100 times a second. The frequency of the sound by raking the feathers, however, is around 1400 Hz. The sound is reported to be loud and clear, not unlike the sound of a violin.

• Technological wizardry will transform the changing shapes of clouds into live music, according to a story in 22 July issue of *Science*. The new instrument, called a "Nomadic Cloud Harp," will translate the shapes of clouds into sound as they pass over. The cloud harp will use a laser to read cloud surfaces and a computer program to convert the shapes into an acoustic wave. "The sound is modulated by the height and density of the clouds," says its creator.

• Computer analyses of audio recordings made in the woods of Arkansas have convinced ornithologists that the ivory-billed woodpecker is not extinct after all, according to a story in the August 2 issue of the *Chicago Tribune*. Using audio equipment set out in various places near the Cache and White Rivers last winter, Cornell University ornithologists made 17,000 hours of recordings. Some sounds, which included the bird's distinctive double raps on a tree, were explainable only as being an ivory-billed woodpecker, they concluded.

• The noise inside the mouth of a didgeridoo player reaches levels almost as high as a jackhammer according to a story in the July 7 issue of *News in Science*. The noise in the mouth reaches about 100 dB, which is about as loud as a noisy nightclub and about 10 dB lower than a jackhammer.

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