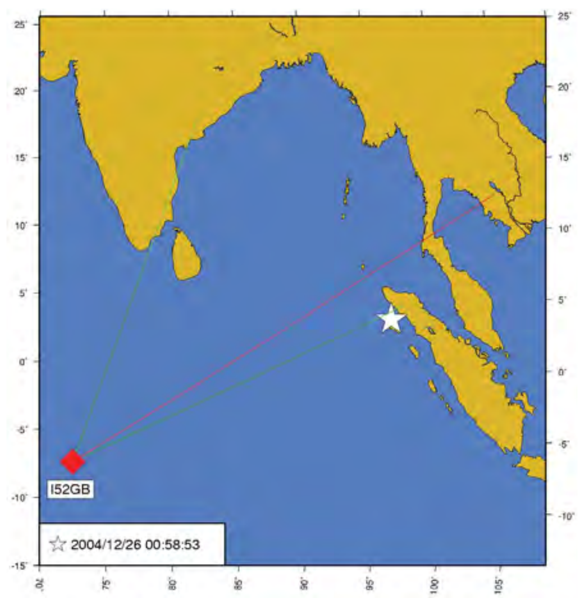
The newsletter of
The Acoustical Society of America

ECHOES

Infrasound from the 2004-2005 earthquakes and tsunami near Sumatra

Milton Garces, Pierre Caron, and Claus Hetzer,

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 [Magnitude (M)9, US Geological Survey (USGS)] and tsunami. The infrasound stations observed (1) seismic arrivals–compressional motion (primary or P-wave that arrives first), shear motion (secondary or S–wave that arrives second) and surface waves from the earthquake, (2) tertiary arrivals (T-phases that arrive third), 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.



Paths of infraound signals from earthquakes.

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 **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 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 (AIP) **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.

• **Ralph Cicerone**, the new president of the National Academy of Sciences, testified before two separate Senate panels on climate change. Cicerone, an atmospheric scientist, is characterized by colleagues as "someone who knows how to talk to politicians, peers, and the public." He is in favor of reducing the funding gap between the life and physical sciences. "In the physical sciences, I think there are many discoveries out there waiting to happen, largely because of our new capabilities in measurement," he told the Senate.

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*. One 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. This 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.

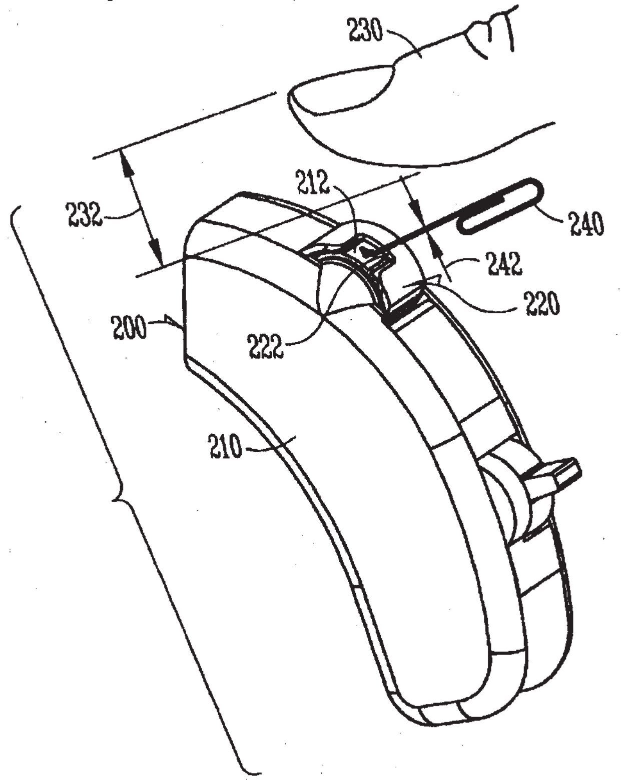
Thomas Rossing

6,741,716

43.66.Ts AFFIXED BEHIND-THE-EAR CHILD RESISTANT VOLUME CONTROL COVER

Nelson Morales and Kyle Ayen, assignors to Starkey Laboratories, Incorporated
25 May 2004 (Class 381/330); filed 19 February 2002

A cover protects the volume control on a hearing aid from being



changed by preventing access of a human finger. The cover need not be removed for adjustment of the control by a tool.—DAP

The ASA Regional Chapters Program

Elizabeth McLaughlin and Juan Arvelo

The Regional Chapters Program certainly embraces the intent of our Society. "The Acoustical Society of America 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 20 active chapters involved in promoting acoustics through outreach and involvement with the public and the number is growing. This article will briefly review the Regional Chapters Program and present new developments in the program within the last few years.

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. You name an activity and chances are a regional chapter somewhere has done it! Also of benefit are the leadership skills that can be obtained and the priceless friendships made along the way.

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. Another new position is that of Co-Chair, a real indication of the level of activity in the Regional Chapters Program in recent years!

In the mid-90s the Society improved the monetary support structure of the chapters. Chapters no longer have 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.

Chapters are also reviving themselves. Five formerly dormant chapters have recently been holding meetings again. Reviving a chapter can be as simple as sending a couple of broadcast e-mails to local ASA members to jump-start meeting attendance and renew interest or one can turn to the use of free modern web technology to access member preferences via a survey. Just a handful of acousticians can make a real impact.

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 of the ASA 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. What a wonderful opportunity for them to be more connected to the ASA and to take advantage of what the ASA has to offer young acousticians.

The CRC website has been updated and expanded. Each chapter now has the ability to update its content quickly and a Chapter Resources Page has been created. The resource area contains useful items such as the newly revised Chapter Start-up Kit, information on the Royster Student Poster Competition, and recently simplified Financial Reporting forms. From the ASA home page, just click on the Chapters button to find the website.

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?

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. At some later time, it might be possible to publish the complete texts.

Violins: Joseph Curtin, Ann Arbor, MI

The violin was perfected in 18th 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 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 that 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. There are many ways to sidestep this and other ergonomic problems. 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 sound post length, the tuning of the bridge, the tension of the bass bar – 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. Once this is better understood, makers will either find ways to modify new wood or else develop combinations of other materials that give the required acoustical behavior.

Twenty-first Century aesthetics—Classical violinmaking ended in the late 1700s, but no one knew what to do next so the same thing was tried 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 that 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 (see Fig. 1) 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 is tempting to ask questions

What's new in string instruments?

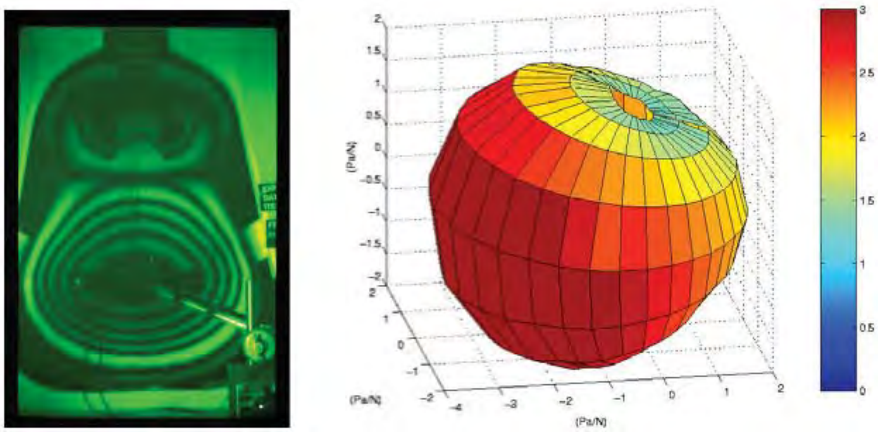


Fig. 1 A structural mode on a guitar by Paul Fischer imaged using holographic interferometry (left) along with its associated sound radiation field (right).

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 overemphasize 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 School 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 that 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 that 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 arch-top mandolins.

The Virzi tone producer was thought by its originators,

What's new in string instruments?

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 that 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 the 1970s 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.

Hammer/string/bridge interaction—Standard wooden dulcimer hammers are much lighter (8-12 grams) and have harder heads than felt covered piano hammers. Light, hard hammers and the playing position facilitate the percussive sound (hammer clicks lasting 20 ms or so are quite pronounced), percussive playing techniques (e.g., double stroke rolls), and very fast hammer strokes that help define the unique sound of a hammered dulcimer. Hammer/string contact time is typically 2-4 ms, depending on string tension (lower pitched strings are at lower tension on a hammered dulcimer). Using padded hammers, (typically leather) changes the sound radically. Hammer contact time is increased and higher harmonics are significantly damped, leading to a more mellow sound. In general, padded hammers change the sound of an instrument more than any other design feature.

Dulcimer bridges extend about 1.25 inches above the soundboard. The resulting vertical force (10-30 lb) allows the bridge to be driven vertically and laterally, and also produces a rocking motion. The in-phase mode for paired strings does decay much faster than the out-of-phase mode, but the marked dual decay rate found in pianos seems to be absent or at least less important in hammered dulcimers. The sustain of heavyweight pre-1970 dulcimers was comparable to that of an undamped piano, but is somewhat less on lighter more flexible modern instruments.

Playing range—The traditional American hammered dulcimer had 12 treble courses and 11 bass courses. The musical weakness of such instruments is an inaccessible key of A and weak bass. Adding three more courses at the low end gives 3 octaves for a standard 15/14 instrument (D3 to D6).

The standard 15/14 instrument has 2x15 + 14 = 44 possible notes to play, but only 30 of these notes are distinct—the others being repetitions of the same pitch available elsewhere on the instrument. It is possible, but inconvenient, to play chromatic scales. The more expensive professional models have additional notes to extend the chromatic range and/or bass range.

Strings—Most hammered dulcimer builders use steel piano wire ranging from 0.016 in. in diameter (#6) to 0.024 in. 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.

String tension (treble bridge, right side):

String	freq	rad.	L	T	% of breaking strength
G5	784	0.009 in.	9 in.	35 lb	60%
D5	587	0.010	12	43	60
G4	392	0.010	15	30	34
D4	294	0.011	18	29	33
G#3	196	0.012	21	21	20

Efforts to improve the sound of lower strings include the use of 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 lb, with a total downward force on each bridge of about 150 lb. The resulting bending moment must be overcome with relatively deep side rails (3-4 in.) and internal bracing. Before 1970, the instruments were strong boxes with hardwood backs, heavy pin blocks, floating soundboards, and several braces glued to the back.

The current trend toward lighter instruments makes use of the soundboard as a structural element by gluing it to the frame. The pin blocks are minimal, the back is high strength 3/8 in. Baltic birch plywood, zither pins replace piano pins, and the internal bracing is tapered and honeycombed. Soundboards have gotten thicker but less dense through the use of softwoods. Some builders are experimenting with tapered soundboards that are composites with a softwood interior core. The acoustical goal of this design work is a more mellow tone with less sustain.

The miracle bridge cap—Traditional bridge caps were made of thin steel wire, brass, or wooden dowels. About 1985, builders started experimenting with the hard plastic rods made of delrin, invented by Dupont. Delrin has high mechanical strength and stiffness, good wear and abrasion resistance, and a low coefficient of friction. Thus steel strings can easily slide over the bridge caps without making grooves. Perhaps more importantly, delrin has much higher internal damping than brass and steel so that higher frequency string vibrations have reduced decay times. The positive effect on hammered dulcimers is to reduce sustain and hammer noise.

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

Materials—The exterior frames are made of hardwoods—walnut, cherry, and exotic imports—chosen for appearance, stability, and marketability rather than for acoustic reasons. Soundboards use Baltic birch plywood on less expensive models and mahogany, spruce, redwood, or cypress on more expensive models. Arched and tapered soundboards, if properly done, give more strength and stability than flat soundboards, but all hammered dulcimers bend eventually. Hardwood bracing runs parallel to the end rails. These can be tapered to give the most strength per weight. Relatively small perpendicular hardwood rods are used to support the bridges on the braces. The placement of these braces is important for uniform sound but there is no consensus as to size and location. The trend in hammered dulcimer construction is to make lighter instruments with less sustain. Extremely lightweight 15/14 instruments are now advertised at 12 lb or less, although most are about 20 lb. 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 curvature does not help, and as much of the characteristic grace and elegance of a harp derives from the neck shape; it cannot be overbuilt. Very strong many-layered plywood seems to be the best material, covered with veneer for beauty's sake. The soundboard has to be both thin and also be able to withstand all the string tension (12 K in the case of a concert harp). Sitka spruce is the material of choice for its acoustical properties and anisotropic strength. The grain runs horizontally, and thin veneer with vertical grain is applied to prevent cracking (although it degrades the sound slightly). The sound box is a light, hollow shell, with holes at the back for improved sound radiation and access to the strings. The whole structure bends under the string tension, so the veneer has to be very well bonded. In the following panel I have placed my own Celtic and lever harps in the context of harp evolution. The harp has been basically triangular-shaped for about 1000 years. The gothic harps had small, thick sound boxes and soundboards carved out of two solid pieces of wood, and needed "brays" to buzz against the strings and increase the sound output. Larger, more efficient soundboards came with the Celtic harps. In the Renaissance, soundboards were made ever thinner, especially in Spain. Chromatic tuning was achieved by having two or three rows of strings, making the harps very difficult to play, and multiplying the total force on the soundboard. Sharpening levers to raise the pitch of the strings by a semitone went some way to solving this problem. The ultimate "modern" concert harp was developed by Erard in Paris and London around 1800; these had pedals attached to a complex mechanism which could raise the pitch of the strings by one or two semitones.

Strings—The string material is determined by harmonicity (the overtones should sound pleasant) and "feel." Harmonicity

Evolution of Harps				
Small soundbox, thick soundboard	Larger soundbox	2,3 string rows: chromatic	Levers for semitone sharpening, thin soundboard	Double-action, pedals
				
Gothic Harp (C15), Hofburg Museum, Vienna	Homemade Celtic harp (18 strings)	Arpa a tre file (1625), Museo Civico, Bologna	Handmade lever harp (36 strings), copy of George Morley model (London, 1820)	Erard Harp c. 1800 (modern concert harp), Hofburg Museum, Vienna

What's new in string instruments?

Fig. 2. Six carved Baltic psalteries along with a violin and a Swedish nyckelharpa

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. The ingredients which distinguish the sound of a harp from any other plucked instrument, such as the guitar, are as follows:

The string is plucked in the middle, which reduces even harmonics. In some music, the harp is sometimes plucked close to the soundboard in order to imitate a guitar.

There is very strong coupling, via the soundboard, between any two strings with overlapping overtones. In the case of a large harp, many strings vibrate when only one is plucked.

The strong interaction with the soundboard causes the strings to vibrate in collapsing and expanding ellipses, which gives a long pulsed tail to the sound.

The large number of strings allows for glissandi, a feature most people immediately associate with the harp.

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 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) (see Fig. 2). 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-sound box coupling also appears to play a role. A useful method for studying string-to-sound box 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.

It is desirable to have a body resonance with high radiating efficiency between the keynote and the tone above. In many cases, it is also desirable to have a body resonance close to the low dominant. The frequencies of the two lowest body resonances can be adjusted, to some extent, by adjusting the areas of the sound holes. As replicas of carved Baltic psalteries are often played together with other instruments, such as bagpipes, violins, and accordions, this in effect imposes absolute tuning ranges. Wood is a notoriously irreproducible material; in many cases string instruments with the same dimensions made out of similar woods do not sound alike. Adjusting the areas of the sound holes provides a limited method for custom optimization.

Scanning the journals

Thomas D. Rossing

• 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 acoustic 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 neturons 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 the International Congress on Acoustics (ICA 2004), included 20 invited oral presentations and 63 poster presentations, of which 12 papers, one technical report, and 12 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.eg/asp/.

• 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."

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* that also appeared in the 24 June issue of *Science*. 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.

6,700,985

43.38.Kb EAR LEVEL NOISE REJECTION VOICE PICKUP METHOD AND APPARATUS

Jon C. Taenzer, assignor to GN ReSound North America Corporation
2 March 2004 (Class 381/356); filed 30 June 1998

The patent describes an exemplary embodiment as follows, "...a standard miniature pressure gradient type microphone element is provided and mounted very close to the side of the user's head, preferably near the user's ear. The microphone element is oriented so that its direction of maximum sensitivity is parallel to the side of the user's head, and pointing as much as possible toward the user's mouth." Makes sense, but where is the invention?—GLA