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ECHOES

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Acoustics of the American Reed Organ

by James P. Cottingham

The reed organ flourished in the United States during the nineteenth and early twentieth centuries. These instruments, which were manufactured and sold under a variety of names, are often referred to as "parlor organs" or simply "pump organs." The so-called "American" reed organs have two distinguishing characteristics. One is the use of the so-called "free reed," a vibrating strip of thin, hard elastic material, usually brass. The second is the use of a partial vacuum to draw air past the reeds rather than the use of pressure bellows to drive compressed air through them as in the "European" harmonium.

Until the 1990s there were very few studies of the acoustics of free reed instruments, including the reed organ and its relatives in the accordion-concertina, harmonica, and Asian mouth organ families. The last decade has seen, by comparison, a surge of interest in these instruments, culminating in the special session on free reed instruments at the ASA meeting in Columbus last November (see abstracts for sessions 5aMUb and 5pMU). Recent measurements on individual reeds from American reed organs include measurements of reed displacement with a variable impedance transducer, and measurements of reed velocity as a function of time have been made with a laser vibrometer system. The results show a nearly sinusoidal reed motion which contrasts with the sound pressure waveform near the reed.

Reed Displacement Measurements

There have been few studies of the vibration of individual free reeds. A paper by St. Hilaire, *et al*, concentrated on conditions for reed excitation.[1] In an earlier study with simple equipment, Philip Koopman and I observed the amplitude of vibration as a function of blowing pressure for harmonium-type reed organ reeds of 100-200 Hz frequency.[2] It was observed that once the threshold pressure for vibration is reached (about 0.2 kPa), the vibration amplitude of the reed tip quickly rises to a large value of several millimeters. It then remains nearly constant with increasing pressure until it eventually begins to decrease at high blowing pressures. The equilibrium position of the reed shifts gradually about 1-2 mm in the direction of airflow.

A more detailed set of measurements of the motion of these reeds has been made using a variable impedance transducer (VIT) to measure reed displacement. Because of a range limitation of 2.5 mm, the VIT is used in the middle of the reed tongue, around 2 cm from the reed tip. (The reed tongue is about 4 cm long.) Observations with the VIT confirm our earlier results and also provide information about the full cycle of reed vibration.

Figure 1 compares the motion of the reed with the sound pressure waveforms near the reed tip outside and inside the windchest. Although the reed motion appears to be approximately sinusoidal, the sound pressure waveform somewhat resembles a pulse wave, as the reed acts as a valve, alternately opening and closing the opening in the reed frame twice in each cycle of oscillation. At blowing pressures somewhat higher than normal playing pressure, some indications of the presence of the second beam mode ($f_2 = 6.27 f_1$) are observed in the spectrum of reed vibration as shown in Figure 2.

Reed Velocity Measurements

The laser vibrometer system measurements complement those made with the VIT. The laser vibrometer measures reed velocity, rather than displacement, although the results can be integrated to give displacement curves which agree well with the results from the VIT. Unlike the VIT the laser vibrometer is not limited in range and can be used to explore the motion of the reed along its full length. Figure 3 shows the reed displacement profile at maximum amplitude as calculated from the laser vibrometer data, compared with a curve obtained by fitting Rayleigh's equation for the cantilever beam in mode 1 so that the two coincide at the tip of the reed. It can be seen that the fit is very good.

Figure 4 shows that the velocity waveform for the A# reed observed with the laser vibrometer system at normal blowing pressure (0.8 kPa) is nearly sinusoidal. At a blowing pressure of 1.2 kPa, the waveform becomes slightly irregular and the amplitude is smaller.

continued on page 2

We hear that...

- ASA Fellow **Sheila Blumstein** has been named interim President of Brown University. Blumstein, the Albert D. Mead Professor of Cognitive and Linguistic Sciences and chair of the Department of Cognitive and Linguistic Sciences, served as Dean of Brown College from 1987 to 1995.
- ASA Fellow and past president **Frederick Fisher** has been selected to be a recipient of the IEEE Third Millennium Medal. This award honors IEEE members for their outstanding contributions in their respective areas of activity. Fred's nomination was submitted by the IEEE Oceanic Engineering Society.
- ASA member **Pranab Saha** has been selected as the "2000 Outstanding Engineer in Private Practice" by the Michigan Society of Professional Engineers and the American Consulting Engineers Council of Michigan.
- ASA Fellow **Thomas Rossing** has been selected to receive the Robert A. Millikan Medal and deliver the Robert Millikan Lecture at the summer meeting of the American Association of Physics Teachers in Guelph, Ontario, July 29–August 2. The Millikan Medal is awarded each year for "notable and creative contributions to the teaching of physics."
- ASA Fellow **Vladimir Krasilnikov**, professor at Moscow State University, died after being struck by a car on a small road near his home. Professor Krasilnikov, 88 years old, was formerly Head of Acoustics at Moscow State University.
- **Monohar Lal Munjal** is the first recipient of the Mira Paul Memorial Award, established by the Acoustical Foundation of India to "promote international understanding in the diverse field of acoustics."
- Panart (Bern, Switzerland) received an award at the 52nd International Craft Fair in Munich for outstanding technical achievement in developing a new family of steelpan instruments. These new instruments will be discussed in a paper at the ASA meeting in Atlanta.

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(Reed Organ..., continued from page 1)

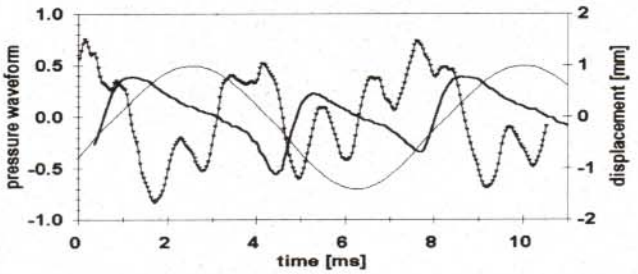

Figure 1. Reed displacement and sound pressure waveforms for a C_3 reed at p = 0.9 kPa. The thin solid line is the reed displacement [in mm], the heavy solid curve is the pressure waveform [arbitrary units] from a microphone just above the reed, the dotted curve is the pressure waveform inside the windchest just below the reed.

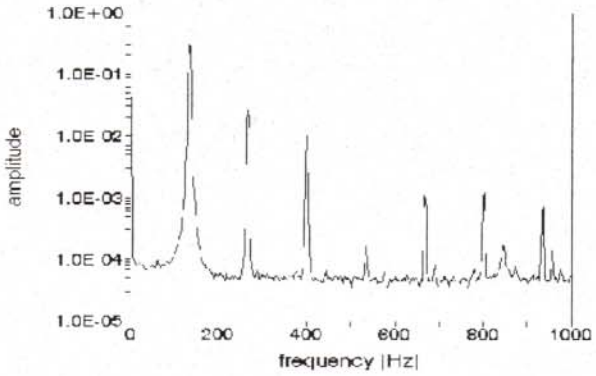

Figure 2. Spectrum of the reed displacement waveform from Figure 1.

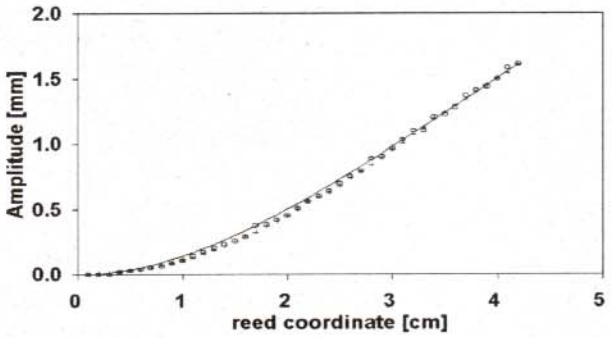

Figure 3. Reed profile at maximum amplitude calculated from laser vibrometer velocity data. The solid line is the theoretical curve from Rayleigh (3). Data points are from 4 cm H_2O [+] and 6 cm H_2O blowing pressure.

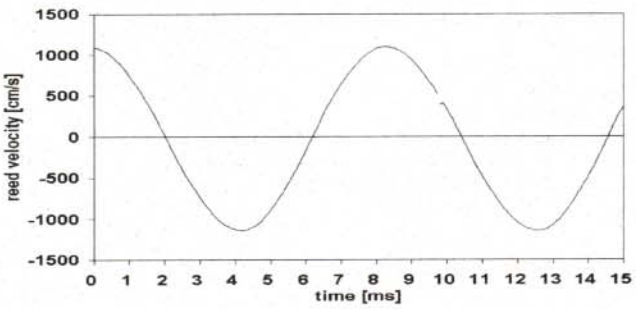

Figure 4. The reed velocity waveform for the A# reed (118 Hz) at 0.8 kPa.

continued on page 8

Atlanta: A Big Small Meeting

Reflecting on the blockbuster Spring meetings in Seattle (1998) and Berlin (1999), Charles Schmid wrote an editorial "Big meetings–Small meetings" in *Echoes* (Spring 1999). He pointed out that big meetings have great value but so do small ones. One might guess that the Atlanta meeting May 30–June 2 will be somewhere in between "big" and "small." It's a great

Yves Berthelot (chair) and Jerry Ginsberg (technical program chair) at the Atlanta paper sorting meeting.

time of year to explore the Appalachian Mountains, and Atlanta itself has a lot to offer the tourist. Your Editor intends to drive to Atlanta, stopping along the way to explore the Great Smokey Mountains as well as some of the Civil War battlefields where my grandfather fought. I may meet some of you on the hiking trails.

Attendance speculation aside, a big program is planned for Atlanta. Besides the regular features, such as buffet socials, technical tours, a Fellows luncheon, student luncheons, there will be lectures on the history of architectural acoustics and engineering acoustics, 34 special sessions on various areas of acoustics, a book fair, and a workshop on finding a job in acoustics. An interesting program is planned for accompanying persons.

Book Fair

Books published by ASA and other publishers will be on display in the registration area at the Atlanta meeting from Tuesday through Friday. Books from all areas of acoustics will be featured. Authors will be available to discuss their publications at the entrance area to the social buffet on Wednesday between 6:30 and 7:30 p.m. ASA books can be ordered at a 15% discount, and a few books will be sold at a 50% discount while the supply lasts.

Workshop on Finding a Job in Acoustics

A workshop to help those interested in improving their skills in finding a career in acoustics will be offered on Tuesday evening, May 30 at the Atlanta ASA meeting. Stephen Brieger, a human resources specialist, will discuss proven techniques for writing resumes and attending interviews. Brieger is a Senior Human Resources consultant for Aradigm and Etak, Inc. In Silicon Valley. He has managed staffing needs and issues for the Lawrence Livermore National Laboratory and has held positions in employee training and development at Unisys and the American Electronics Association. The workshop in Tower 1406 will be preceded by a reception in Tower 1405 from 6:00 until 7:00 p.m. for attendees and speakers.

Cost of the workshop is $10 for students and $20 for others. Professors with students seeking employment in acoustics are encouraged to attend at no cost. Interested persons should contact Charles Schmid or Elaine Moran at 516-576-2360 or by email at <asa@aip.org>.

ASA's Headquarters Office on Long Island

The Acoustical Society headquarters office will soon celebrate its first anniversary in Huntington Quadrangle in Melville, New York, in western Suffolk County on Long Island. Also located in the building is the American Institute of Physics (AIP) Publishing Center.

Over its 71-year history, the Society's office has been located in a variety of places and spaces. The first headquarters was at the office of ASA Secretary Wallace Waterfall at the Celotex Corporation in Chicago. In the 1940s the ASA office was moved to New York and briefly located on the 64th floor of the Empire State Building. It was then moved to East 57th Street, the headquarters of the American Institute of Physics, upon Waterfall's being named Secretary of AIP. The next move occurred in the early 1960s when ASA and AIP relocated to 335 East 45th Street, across the street from the United Nations buildings. In March 1985, ASA moved to Woodbury, Long Island.

The current ASA address is 2 Huntington Quadrangle, Melville, NY 11747-4502. Instructions for getting there appear on the AIP website <www.aip.org/pcinfo.html>.

Officers Report on Results of the ASA Member Web Survey

by Patricia K. Kuhl and Mauro Pierucci

When we took office as ASA's President and Vice President, one of our goals was to open up new lines of communication with our members. We wanted to hear their opinions, so one of us (MP) developed a method to survey our members on line. We are happy to report that 15% of the membership (an excellent response rate according to survey experts) responded to the web page survey, and that we have analyzed what you had to say. We would like to give you a small sampling of the data and encourage you to examine the results in more detail on the ASA's home page, which includes all figures in color. (http://asa.aip.org/survey/survey.html).

Our first step was to verify that those who answered the survey questions (the "responders") represent the membership as a whole. Two things suggest that they do. First, we compared the percentages of responders in each of the various categories of membership (Member, Associate, Student, Fellow, and Emeritus members) with the percentages of members actually falling into these categories. The match is good, indicating that the responders come from all categories of members in the ASA. Second, we examined the percentages of members and responders by technical area, and saw that there is a very close correspondence between the two. For example, Underwater Acoustics represents 12% of the actual ASA membership and 10% of the survey responders; Psychological and Physiological Acoustics represents 14% of the membership and 10% of the responders; Speech Communication represents 14% of the membership and 14% of the responders. The responders appear to be a highly representative sample of our members.

What did the survey tell us? Many of the results were gratifying (80% gave the leadership/management of ASA good or excellent marks), and some reinforced previous results from surveys. For example, 85% of the responders indicated that the technical scope of ASA is "about right." Similarly, we expected that when we asked whether ASA should publish a separate journal on applied acoustics, the answer would depend on the technical area affiliation of the responders: Architectural Acoustics and Engineering Acoustics responders said yes, while responders from Music, Noise, Signal Processing, and Structural Acoustics were evenly split. Responders from other technical areas did not see a need for an applied journal.

But there were some surprises. Your responses to the question about whether our meetings should result in the publication of a Proceedings were unexpected. The ASA has occasionally published Proceedings, the most recent covering the joint meeting of the ICA and the ASA held in Seattle in 1998. But the responders voted strongly for published Proceedings, with 58% indicating that proceedings of all meetings should be required. The breakdown by various categories of membership indicated that students were most likely to favor a proceedings (73%) followed by associate members (68%) and members (65%).

The vote for a proceedings was strongly influenced by the responders' tendencies to attend meetings themselves. The survey asked responders to indicate which of the last seven meetings of the ASA they attended. For the analysis, we considered those who attended 3-7 of the last 7 meetings "frequent attendees," those attending 1-2 of the last 7 meetings "occasional attendees," and those attending none of the last 7 "non-attendees." Of the frequent attendees, 31% favored proceedings; the vote was much stronger for occasional attendees (63%) and non-attendees (77%). This makes sense; those who do not attend meetings find proceedings more valuable.

We were also surprised by your responses to the query regarding meeting frequency. The question of one versus two meetings per year is one of ASA's most discussed issues, so we included the question in our survey. We asked whether ASA's national meetings should be held once per year, twice per year, once every two years, or allowed responders to say that it made no difference. Across all responders, 51% indicated once per year, and this was unexpected.

Further analyses showed that the preference for one meeting per year depended on the responder's technical area affiliation, and the responders' tendency to attend meetings. Figure 1 shows the breakdown by technical area, and suggests that one meeting per year wins approval for 7 of the 13 technical areas (Animal Bioacoustics (AB), Architectural Acoustics (AA), Biomedical Ultrasound/Bioresponse to Vibration (BB), Engineering Acoustics (EA), Noise (NS), Psychological and Physiological Acoustics (PP), Speech Communication (SC)); 3 of the 13 strongly prefer two meetings per year (Acoustical Oceanography (AO), Musical Acoustics (MU), Structural Acoustics and Vibration (SA)) and 4 technical areas are virtually tied (Physical Acoustics (PA), Signal Processing in Acoustics (SP), Underwater Acoustics (UW)).

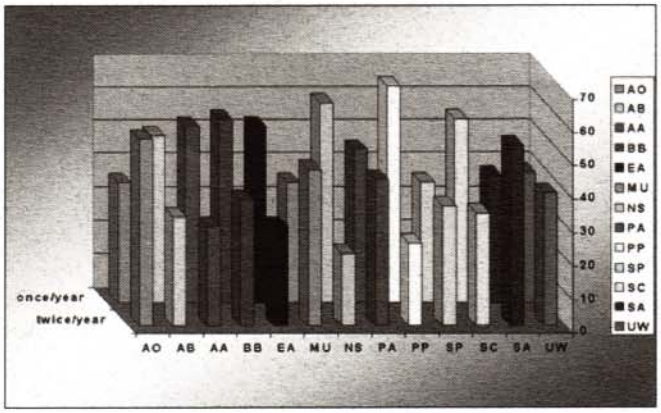

Figure 1 – How often should national meetings be held.

Figure 2 displays the preference for one meeting versus two for frequent attendees, broken down by technical area. Among frequent attendees, only 4 of the 13 technical areas indicate a strong preference for one meeting per year (NS, PP, SP, SC).

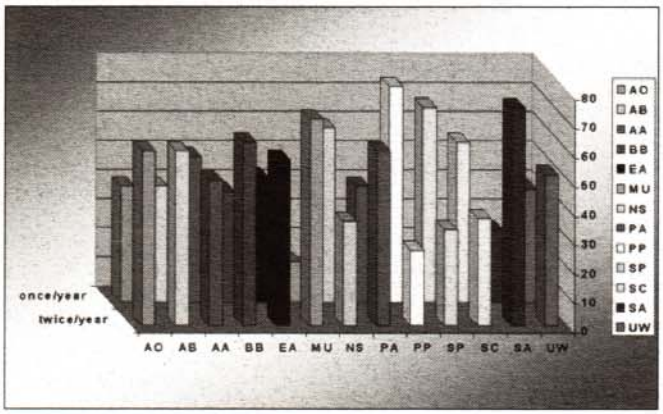

Figure 2 – How often should national meetings be held (Frequent Attendees).

In Figure 3, the data are shown for occasional attendees, and here we see the increase in the preference for one meeting per year. Occasional attendees in 7 technical areas indicate a preference for a single meeting each year. In other words, the answer to how frequently we should hold national meetings depends upon whether or not we are asking individuals who typically attend meetings.

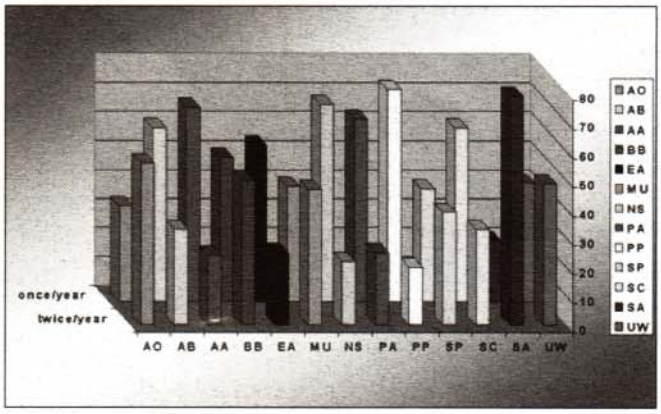

Figure 3 – How often should national meetings be held (Occasional Attendees).

What will we do with these results? Rest assured, we will not immediately recommend that the ASA go to one meeting per year. But we will recommend that the technical committees continue to explore options regarding meeting frequency with their members. We think these data help focus the discussion.

Turning to another question posed by the survey, we queried members about the value of ASA services. Figure 4 shows the overall value of 17 services ASA provides to its members across technical areas.

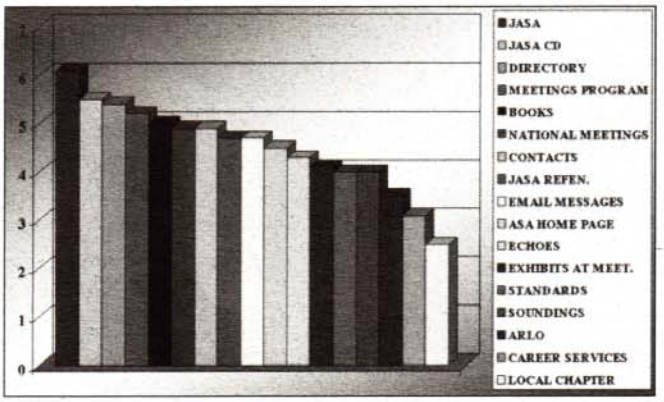

Figure 4 – Value of services (7 being highest rating and 1 being lowest rating.

**Note that the list of services on the right side of the figure corresponds to the order of the bar graphs from left to right.*

It is clear that for most members JASA is our Number 1 product. Services that provide information, such as the Membership Directory and Meeting Programs, also rate highly. It is also clear that we need to improve our career services, and highlight the activities of our Regional Chapters, if they are to be valued by the members.

We hope that this small tour through the survey data has peaked your interest and that you will take a look at the data and examine it yourself. We would love to hear your personal interpretations.

Thanks to all of you who took the time to respond to the ASA web survey. Web surveys are likely to become a tool used frequently by the ASA in the future. They allow us to examine members' views, and over time, tell us how they change. As the ASA attempts to adjust to your future needs, this line of communication will become increasingly valuable.

Patricia K. Kuhl is President of the Acoustical Society of America. She is the William P. and Ruth Gerberding Professor of Speech and Hearing Sciences at the University of Washington, Seattle.

Mauro Pierucci is Vice President of the Acoustical Society of America. He is Professor of Aerospace Engineering at San Diego State University.

Acoustics in the News

• The noise of snowflakes on water (see ECHOES, Winter 1999 and JASA, October 1999) continues to make the news media. An article "Noisy Snowflakes" by Lee Dye dated March 15 in ABCNEWS.com reports on work done by Larry Crum, Andrea Prosperetti, Hugh Pumphrey, and Ronald Roy. Snowflakes falling on the sea can add 30 decibels to underwater noise levels, which can be significant to Naval submarine trackers, for example. Like the noise of rain on water, the noise of snow on water is due to creation, entrainment, and oscillation of bubbles. Similar stories on the subject have appeared in the *Toronto Star*, and the *Guardian* (London) and other newspapers.

• Renowned violinist Mariss Jansons announced that he was quitting as musical director of the Oslo Philharmonic after 20 years to protest bad acoustics in the Oslo Concert House, according to a story in the *San Francisco Chronicle*, February 12. Latvian-born Jansons, who has been musical director since 1979, said he has complained about the Oslo Concert House for two decades with anything being done about it.

• Research on musical performances by neuroscientist Manfred Clynes was featured in the Science section of the *New York Times*, February 22. Clynes, a former neuropsychology professor at the University of Melbourne who now lives in Sonoma, California, is also a concert pianist. He has identified patterns in the music of master composers. Performances of Beethoven, for instance, carry his characteristic strength and intensity when, in four-note sequences, the second note is played shorter and softer than the others, whereas the notes in Mozart's sequences are more consistent in length and amplitude. These discoveries resulted from a series of experiments that built on the work of Gustav Becking, a German musicologist, who put forth the idea of composers' pulses in 1928. Listeners touched the pad of a sentograph, a device invented by Clynes, and their finger pressure was translated into shapes. "When several musicians reacted to the same composers with similar shapes, we knew we had something good," Clynes is quoted as saying.

For many instruments, like a violin, individual notes can be shaped differently, depending on how the amplitude rises and falls during a note. Clynes noted that the rise and fall is affected by the next note. If the next note is a higher pitch, the amplitude will fall more sharply at the end, but if the next note is lower, the amplitude will fall more gradually. Time and amplitude equations that represented virtually every shape a musician could use for a note were developed. "Dr. Clynes' software is useful in interpreting not just the works of great masters, but whatever music a user wants to perform with a computer," commented composer Jeff Harrington. Clynes hopes that his software will also appeal to beginners.

• A report to Swedish defense chief Bjorn von Bydow claimed that a school of red herring–mistaken for a Soviet submarine–may have led Swedish leaders to put the armed forces on alert during the Cold War, according to a story in the *Army Times*, March 20. Sounds emitted by the herring were found to be similar to the sounds of a submarine propeller. This wasn't the first time Swedish forces have gone on alert for an unusual reason. Previously, the Swedish military determined that a pack of mink, which had escaped from a farm and were living in the wild, also emitted submarine-like noises.

• The work of Chris Jaffe and his colleagues in the renovation of Cleveland's Severence Hall is reported in the February issue of *International Arts Manager*. Unlike some renovation projects which try to correct acoustical defects, Severence Hall was a concert hall of some renown, due in part to the "Szell shell" which has enveloped the space above, behind, and to the sides of the orchestra since its construction in 1958. The new shell includes louvered grills which vary the reverberation time by providing more or less access to the space behind the shell. The new shell also provides access to the pipe organ which is being refurbished by the Schantz Organ Company.

• Some flute manufacturers and brass instruments players believe that immersing their instruments in liquid nitrogen improves their playability, according to a story in the November 2 *New York Times*. Among them are Steven Wasser, president of Powell Flutes and Joseph Markoff, a Philadelphia ophthalmologist and substitute trumpet player in the Philadelphia Orchestra. Markoff has been spreading the word about cryogenics among musicians in the Philadelphia Orchestra, and about 45 instruments have been "frozen." Results were not uniform but some musicians describe the sound as "richer" and "more focused" and the instruments as having "easier response." One instrument repair shop in Arlington Heights, Illinois has a cryogenics tank big enough to hold a tuba. The instruments are gradually lowered in temperature over a period of 35 to 50 hours. Very little scientific work has been done on cryogenically-treated brass, to say nothing of the effect on solder joints.

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• Piano tuners have used a variety of electronic aids to tune accurately but none as sophisticated as the laptop computer with a software program called CyberTuner. Not only does CyberTuner provide a highly accurate visual readout of frequency but it allows the tuner to store a customized tuning for each piano tuned. The parameters are thus available for future tunings. Use of a computer also makes it easier to tune pianos and other keyboards to historic temperaments and to vary the amount of "stretch" to fit the style of music played. A less sophisticated but widely used tuning aid is the Accu-Tuner, developed by physicist Albert Sanderson. Some tuners shun the use of all electronic aids. "I learned to tune aurally by a tuner who learned aurally," commented one tuner. Even with electronic aids, tuning remains an artistic and creative task. "Don't leave your ears at home," cautions Sanderson.

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• Piano tuners have used a variety of electronic aids to tune accurately but none as sophisticated as the laptop computer with a software program called CyberTuner. Not only does CyberTuner provide a highly accurate visual readout of frequency but it allows the tuner to store a customized tuning for each piano tuned. The parameters are thus available for future tunings. Use of a computer also makes it easier to tune pianos and other keyboards to historic temperaments and to vary the amount of "stretch" to fit the style of music played. A less sophisticated but widely used tuning aid is the Accu-Tuner, developed by physicist Albert Sanderson. Some tuners shun the use of all electronic aids. "I learned to tune aurally by a tuner who learned aurally," commented one tuner. Even with electronic aids, tuning remains an artistic and creative task. "Don't leave your ears at home," cautions Sanderson.

Acoustics in the News

• A tiny primitive organ in the inner ear known as the sacculus detects some musical frequencies and relays them to the brain's pleasure centers, according to a story in *The Times* (London), February 17. Psychologist Neil Todd (University of Manchester) notes that the sacculus is particularly sensitive to loud music. The musical sensitivity of this primitive organ may have been overlooked because it is in the area of the inner ear normally linked with balance. However, this area has a connection to the brain's hypothalamus, linked with strong drives such as hunger, sex, and hedonistic behavior. The organ's sensitivity appears to peak between 300 and 350 Hz. The only other creatures known to use the organ for hearing are fish. In fish, the sacculus is in the swim bladder used for balance.

• The February 24 issue of *The Hindu* carried a story about electrostrictive loudspeakers consisting of a soft silicone polymer sandwiched between two layers of flexible, electrically conducting material made from graphite powder bound in a mixture of gelatin and glycerol.

When a voltage is applied to the graphite electrodes, the electric field causes the polymer film between them to flatten and spread, as if squeezed. But since it is enclosed in a fixed area, the sheet bulges inwards and radiates sound. The speakers, developed by SRI International in Menlo Park, California, are about 5 centimeters square and can generate high sound levels over a wide range of frequencies, according to the story. One of the possible applications for such electrostrictive polymer-film (EPF) speakers is not to create noise but to suppress it. By oscillating out of phase with an acoustic signal, the polymer film could absorb sound energy from the air. Flat speaker panels on the cabin walls of an aircraft, for example, could reduce cabin noise.

• A story on non-contact ultrasound imaging in the *Boston Globe* is based on a paper by Joie Jones at the Columbus ASA meeting. Ultrasound imaging usually requires direct contact between the imaging device and the body of the patient. While this is fine for pregnancy checks, it is not so good for burn victims. Jones and his colleagues at the University of California, Irvine have reported a better way to couple the ultrasound to a human body by passing it through a sequence of layers gradually interpolating between the transducer and air. Burns can be imaged at distances up to a couple of inches.

• The Learning section of the *Washington Post,* December 8, has an article on musical scales, their history and their acoustical basis. Beginning with Pythagoras, who found that simple mathematical ratios between string lengths determine whether their tones sound pleasing together, scientists and composers have dealt with frequency ratios and scales. The opinions of scientists William Sethares and Neville Fletcher, as well as composers Leonard Bernstein, Peter Schickele, and Robert Gibson are quoted.

• "South Pole Snooping: Listening for sounds of illegal nukes" is the way the infrasound detection station in Antarctica is described in the February 28 issue of *U.S.News & World Report*. The listening station, one of 60 around the globe, is designed to detect infrasound from such sources as volcanic eruptions, sea storms, and clandestine atmospheric tests of nuclear explosives.

(Reed Organ..., continued from page 2)

Conclusion

The measurements we have made on American reed organs are a part of a continuing study of free reed instruments made by the author and a series of undergraduate students at Coe College.

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