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ECHOES

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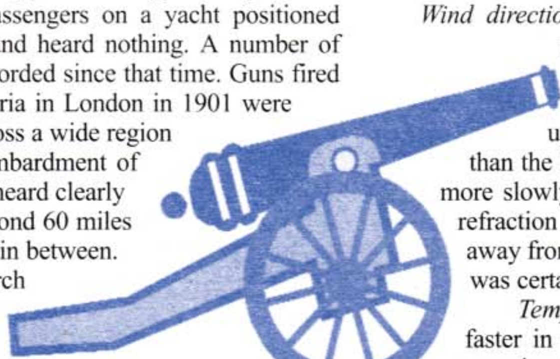
Outdoor Sound Propagation in the U.S. Civil War

by Charles D. Ross

Students of military history know that acoustic refraction and unusual audibility have often played significant roles in the outcome of battles. Before electrical and wireless communications became common on the tactical level, the sound of battle was often the quickest and most efficient method by which a commander could judge the course of a battle. Troop dispositions were often made based on the relative intensity of the sounds from different locations on the battlefield.

Unusual acoustics due to atmospheric conditions or to terrain are sometimes given the catch-all name "acoustic shadows." The first recorded incidence of the phenomenon occurred during the Four-Day Battle in 1666. The naval battle was fought between the coasts of England and Holland, and sounds of the battle were heard clearly at many points throughout England but not at intervening points. Passengers on a yacht positioned between the battle and England heard nothing. A number of other examples have been recorded since that time. Guns fired at the funeral of Queen Victoria in London in 1901 were heard in Scotland, but not across a wide region in between. The German bombardment of Antwerp in World War I was heard clearly for a 30-mile radius, then beyond 60 miles from the Belgian city, but not in between.



In the course of my research for my book on science and technology in the Civil War, I noted examples of similar acoustical phenomena. Some historians were apparently aware of these incidents, but no one had ever investigated their causes. By intensive study of war records, regimental histories, diaries, and period newspapers, I was able to piece together information allowing me to determine the causes of each acoustical shadow. The most famous battles during which these events occurred and affected command decisions were: Seven Pines, Gettysburg, Iuka, Fort Donelson, Chancellorsville, Five Forks, and Perryville. Unusual audibility at great distances was associated with several of these battles and also with the battle of Gaine's Mill.

In each of these seven battles listed above, the inability of commanders to hear and interpret the sounds of battle was directly responsible for the outcome. One might even go so far as to say the acoustical shadows determined the course of the entire war. The unusual acoustics at Seven Pines placed Confederate commander Joseph Johnston in a position of danger when the battle should have been over. Because of Johnston's wound, Robert E. Lee assumed command of the Confederate forces two days later.

The Causes of Acoustical Shadows

Acoustical shadows can usually be traced to one or more of three causes: absorption, wind direction and wind shear, or temperature inversions.

Absorption–Sometimes material between a sound source and an observer will render the sound inaudible. The material can be soil (Gettysburg), forest (Five Forks and Chancellorsville), snow (Fort Donelson) or a variety of other substances.

Wind direction and wind shear–In general, sounds are more likely to be heard downwind of a sound source than upwind. Since winds aloft are usually faster than at ground level, the upper part of a sound wave will travel faster than the lower part when traveling with the wind and more slowly when against the wind. This will cause a refraction towards the ground in the former case and away from the ground in the latter case. Such an effect was certainly at work at Fort Donelson and Iuka.

Temperature inversions–Sound waves travel faster in warm air than cool air (the speed (m/s) is approximately $331.36+0.6067t$, where t is temperature in Celsius). Under most conditions, the air temperature decreases as altitude increases. This causes sound waves to refract upwards and decreases audibility along the ground at a distance. Sometimes, however, the temperature is higher above the ground than near the ground-a condition called a temperature inversion. The effect is to bend sound waves back towards the ground and increase audibility. Temperature inversions are common on clear, cool nights (and the mornings following them) and during widespread rainstorms (at Gettysburg and Seven Pines, for example, and also at the battle of Perryville, Kentucky in 1862).

Sometimes upwardly refracted waves hit a warmer layer higher up and are refracted back down, creating rings of audibility, as in the battle of Gettysburg as well as in the European examples previously described.

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We hear that...

Allan Pierce has been named the Society's Editor-in-Chief. (The announcement occurred too late to prepare a full story in this issue, but Allan is so well known in the Society that he probably doesn't need an introduction anyway). Congratulations, Allan!

New associate editors include **James Hieronymous** (speech processing), **Sid Bacon** (psychological acoustics). **Paul Remington** (Psychological acoustics) and **Mack Breazeale** (nonlinear acoustics) have been reappointed for new 3-year terms.

William Lang has announced his retirement as treasurer effective December 31st. **Paul Ostergaard** has agreed to serve as interim treasurer.

Membership in the Society has increased by 2.7% during the past year.

Rick Wells and **Brad Beattie** have recently joined the consulting firm of McKay Conant Brook, Inc., Westlake Village, CA. Rick was formerly with Acromedia System, and Brad has recently completed his master's degree at Tulane.

Student Workshop at Tanglewood

The newly established Concert Hall Acoustics Summer Institute has announced a summer student workshop at Tanglewood, the summer home of the Boston Symphony Orchestra, August 29-September 1, 1999. Sponsors include the ASA Technical Committee on Architectural Acoustics and the NCAC. This educational program will be supported by the Newman Student Award Fund, along with a consortium of acoustical consultants and research organizations.

Participants will have the opportunity to attend concerts at Tanglewood and to perform acoustical measurements at the Serge Koussevitzky Concert Shed, the Seiji Ozàwa Concert Hall, and other buildings within this campus setting. At least five students will receive fellowships to attend without charge. Additional participants will be selected from applicants. Application forms and additional information are available from Timothy J. Foulkes, 327F Boston Post Road, Sudbury, MA 01776 (978-443-7871) or rfoulkes@cavtocci.com

ECHOES

Newsletter of the Acoustical Society of America
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From the Editor

Although most of our contributions are invited (i.e., they result from arm twisting by the Editor), we encourage unsolicited contributions from our readers! Letters to the Editor that raise interesting questions, express thoughtful opinions, or stimulate discussion are especially encouraged. Our only rules are: keep them interesting, keep them short. Photos are welcome; whether we run them depends upon the amount of other material we receive.

Contributions from readers tend to come in spurts. Understandably, there are not many in this issue on account of the Holidays. As you know, we publish four issues per year. Our publication schedule (and hence our deadlines) pretty much follow the ASA meeting schedule. You can generally figure deadlines will occur two months before a meeting and a month or so after a meeting. Submissions by email are welcomed. If you send attachments, it is probably best to attach plain text to assure that they can be easily read.

Acoustics in India

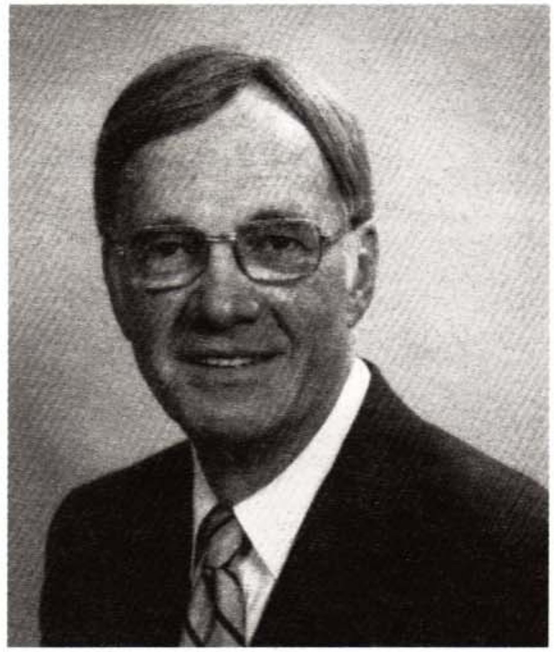
Your editor was privileged to attend a National Symposium on Acoustics (NSA 98) in Calcutta, Dec. 18-20, and to present two papers. The symposium, organized by the Acoustical Society of India, the Sangeet Research Academy, and the Indian Statistical Institute, was held at the Indian Association for the Cultivation of Science. The Inaugural Session included an address by the Governor of West Bengal, who also lighted the ceremonial lamp. On the final evening, we enjoyed a banquet and a concert of Indian music and dance. Proceedings of NSA 98 were published in the *Journal of the Acoustical Society of India* **26** (3,4) 1998. I felt particularly honored to be named an Honorary Fellow of the Society.

At the Symposium, I met several members of the Madras-India Chapter of ASA, the only local chapter outside of the United States. The chapter, formed in 1995, holds an annual technical meeting, which is attended by acousticians from the rest of India as well.

Four generations of Ph.Ds in acoustics, all students of David Bies or students of his students, at a reunion held during the Norfolk ASA meeting. Left to right: Jeff Vipperman (Pittsburgh), Ken Frampton (Vanderbilt), Rob Clark (Duke), Chris Fuller (Virginia Tech), David Bies (Adelaide), Dave Cox (NASA), and Gary Gibbs (NASA).

In Memorium

Daniel Martin (1918-1999)



Another stalwart member of the Acoustical Society has completed a full lifetime of service and has left us. He will surely be missed, but we will benefit from the fruits of his labors for many years to come!

Dan graduated from Harbor Springs, Michigan in 1934, and continued his education at Georgetown (KY) College, where he graduated summa cum laude in 1937, with majors in physics and mathematics. He received his MS (1939) and PhD (1941) in physics from the University of Illinois, and it was during the Illinois years that he became an acoustician, mainly due to the influence of Professor Floyd Watson. He assisted Watson in acoustical tests on the Purdue Music Hall, Indianapolis Coliseum, and Indiana University Auditorium.

From 1941 until 1949 he worked for RCA Victor Division in Indianapolis and Camden NJ. In 1949 he joined Baldwin Piano & Organ Company in Cincinnati, and remained with them until his retirement in 1983. He published his first papers, on brass instruments, in the Journal (as he liked to have it called) in 1942. Besides his 14 years of service as Editor-in-Chief, he wrote over 3500 reviews of acoustical patents for the Journal from 1951 to the present.

He has received many honors, including Fellowship in the Acoustical Society of America (1950), IEEE (1957), and the Audio Engineering Society (1963); a Distinguished Service Citation from the Acoustical Society (1989); an honorary Doctor of Science degree from Georgetown College (1981); and listing in *Who's Who in America* and *Who's Who in Engineering*.

He has served as President of the Acoustical Society (1984-85) as well as the Audio Engineering Society (1964-65). He chaired a national convention of the Audio Engineering Society (1964), and he served as Technical Program Chairman of the ASA meeting in Cincinnati (1983). He was a Registered Professional Engineer in Ohio, and he taught part-time at Purdue University (Indianapolis extension) and the University of Cincinnati Conservatory of Music.

A message from the President

The following message was sent to ASA members on the electronic mailing list. We reproduce it here for the sake of readers who missed it.

Dan Martin, Editor-in-Chief of the Acoustical Society of America, died on January 7th of cancer at the age of 80. He will be truly missed by the Society both for the excellence of his many contributions, and for his friendship and thoughtfulness. He will be most remembered for, and was most passionate about, his job as Editor-in-Chief of the Journal of the Acoustical Society of America. Dan, with the help of his wife Martha, worked on all aspects of the Journal since the time he was selected to be Editor-in-Chief in 1985 after the death of the previous editor, Bruce Lindsay.

When Dan began as editor, he had just served as President of the Society. Besides being head of the Journal and the Editorial Board, he was also responsible for the Patent Review section, reviewing thousands of patents. There are many other facts about Dan's involvement in the Society and acoustics, and these will appear in an obituary in the Journal. Dan was very active in Musical Acoustics, and a special session honoring Dan will be held at the ASA meeting in Columbus, Ohio this Fall.

Last year Dan announced that he planned to retire at the end of 1999. The Search Committee selected Allan Pierce to be the new Editor-in-Chief last year and his appointment has been made by the Executive Council.

The President and Vice President of the Society attended the funeral for Dan Martin on 9 January. A memorial fund has been established in Dan's name with the Acoustical Society Foundation, and contributions may be sent to the following address:

DAN MARTIN MEMORIAL FUND
Acoustical Society Foundation
11 St. Ebbas Drive
Penfield, NY 14526-9786

James E. West, President, Acoustical Society of America

ASA represented at Dan Martin's funeral

ASA president James West and vice-president William Hartmann represented the Society at the funeral of Daniel Martin at Washington Presbyterian Church on January 9. The service was conducted by the Rev. Dr. Paul Hammer. Bill describes Dan's church (for more than 40 years) as having a colonial neo-classical motif and an organ with a big classical German diapason sound.

Besides the familiar hymns "The Church's One Foundation" and "For All the Saints," the congregation sang a hymn "Thanks, God, for Life" composed by Dan in 1980. A male quartet sang "Were You There" and "Nearer My God to Thee" with barbershop harmonies, and one imagines that Dan may have sung barbershop with some of that group at one time or another. Dan's wife Martha, his three children, and numerous grandchildren were present at the funeral.

(...Civil War, continued from page 1

Five Forks

The scene–On April 1, 1865, Confederate forces under Major General George Pickett held the far western flank of General Robert E. Lee's Petersburg defenses. Pickett's forces were at Five Forks, the intersection of five country roads, located about 12 miles from Petersburg. Lee's forces were stretched thin, and protecting this right flank was crucial to maintaining the integrity of the Confederate position and the safety of the capital in Richmond. Holding the position also offered Lee the possibility of slipping away to the southwest and joining up with forces under General Joseph E. Johnston in North Carolina.

Wary of the threat of losing Lee after having had him clamped down around Petersburg for almost a year, Union General Ulysses S. Grant sent cavalry under Major General Philip Sheridan to probe the position at Five Forks. After being repulsed on March 31, Sheridan informed Grant that he could turn the Confederate right if he had support from an infantry corps. Accordingly, by the morning of April 1, the Union V Corps under G. K. Warren was arriving on the scene.

What happened–The Confederates were entrenched at Five Forks, with cavalry units dug in on the flanks, Pickett's infantry in the center, and reserves under Brigadier Thomas Rosser behind Pickett's men. On the morning of April 1, Rosser invited Pickett and Major General Fitzhugh Lee (in command of the cavalry) to his position (on a stream a mile behind the lines) to a "shad bake" or fish roast. Despite the imminent danger from the enemy, both generals inexplicably accepted the offer. When Sheridan and Warren began their attack in mid-afternoon, the Confederate commanders were blissfully unaware of their impending doom. In between the front lines and Rosser's position was a dense pine forest which completely absorbed the sound of small arms fire. In the crucial opening minutes of the battle, the leaderless Confederates were overwhelmed by Union forces on their left. The battle of Five Forks quickly turned into a rout and signaled the beginning of the end for Lee's army. With his flank turned, Lee was forced to abandon Petersburg and Richmond and flee to the west. Eight days later, Grant and Sheridan caught the Confederates at Appomattox Court House, where Lee surrendered.

Chancellorsville

The scene–Spring of 1863 found the Union Army of the Potomac and the Confederate Army of Northern Virginia in a standoff across the Rappahannock River at Fredericksburg. After the crushing Union defeat there in December 1862, Union morale was low. The new Union commander, Major General Joseph Hooker, unveiled a plan designed to surprise and crush the Confederate forces. Leaving a large force in front of Fredericksburg, in late April he took five infantry corps upriver and crossed fords to the southern bank. Confederate commander Robert E. Lee was not aware of the maneuver until the Federals were already over the river. Lee now had an enemy force in front of him and one on his left flank, each larger than his whole army. It seemed his only choices were either to retreat towards Richmond or be crushed in the Union vise.

What happened–Defying conventional military strategy, Lee separated his forces despite being outnumbered. Leaving a small force on the heights behind Fredericksburg, Lee took the rest of his army to meet Hooker head on. The armies clashed on May 1 near the crossroads of Chancellorsville. Though his troops outnumbered the Confederates, Hooker seemed momentarily stunned by the opposition and halted his men in a defensive position along the Orange Turnpike. The next day Lee gambled again. He sent forces under Lieutenant General Thomas J. "Stonewall" Jackson on one of history's greatest flanking attacks. Using a guide and traveling over little-known farm roads, Jackson managed to get his men on the left flank of the Union position without being detected. Near sundown on May 2, Jackson's forces attacked, rolling up the stunned Union army. Hooker, at Chancellorsville, was shielded from the sounds of battle by the dense forest known locally as "The Wilderness" and first became aware of the rout as panic-stricken Federal soldiers overran his position. There was undoubtedly a refractive effect at work on this day as well: Confederate Major General Cadmus Wilcox, 10 miles to the east near Fredericksburg, noted the sounds of battle clearly. This refraction may have been due to wind shear (high winds kept Union balloonists grounded).

Seven Pines

The scene–After the Union debacle at Bull Run, George C. McClellan was placed in command of the forces around Washington. Rather than move towards Richmond directly overland, McClellan decided to save his infantry some work by shipping them to the peninsula southeast of Richmond to begin his attack from there. Working against the able but cautious Confederate General Joseph E. Johnston, McClellan's men worked their way slowly but steadily up the peninsula until by late May 1862 Mc Clellan could hear the clocks of Richmond striking from his headquarters. Under pressure from the Confederate government to take some action to save the capital, Johnston mapped out a plan. He formulated a three-pronged attack in which Confederate forces would be funneled by three different roads towards a convergence on the Union forces at the intersection called Seven Pines.

What happened–The plan was complex and required perfect timing on the part of Johnston's subordinates. Instead, what Johnston got was bickering and arguments about seniority among the Confederate generals as their troops ran into each other and blocked each other's routes. Still, by early afternoon the Confederates had managed to attack and were holding their own against the Federals. Johnston, at his headquarters near Fair Oaks a few miles from the front lines, did not hear the battle and could not be convinced by others that a fight was raging. He held key reserves back until a desperate note from Major General James Longstreet at 4 o'clock convinced him that a battle was indeed underway. By then it was too late; the Federals had been reinforced by troops under Edwin Sumner, and the battle ended in a draw. Near dusk, Johnston went to observe the closing moments of the conflict and was seriously wounded. Two days later, Robert E. Lee assumed command of the Confederate forces, replacing the wounded Johnston.

The battle, silent to Johnston two miles from the front, was heard clearly by citizens of Richmond ten miles to the west and to Federals as far to the east. The probable cause was a temperature inversion bending the sound back to the ground. On the night before the battle, a violent thunderstorm (many soldiers said it was the worst they had ever seen) raged over the area. The day of the battle dawned with widespread, low cloud cover–ideal conditions for a low- atmosphere temperature inversion.

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Gettysburg

The scene–In the summer of 1863, the Confederacy was in dire straits. The vital garrison at Vicksburg, Mississippi was under siege and near collapse. In the east, things looked better, but the situation was still bad. The Army of Northern Virginia had withstood all Union attempts to take the war to Richmond, but General Robert E. Lee knew that he faced an uphill battle. The Union seemed to have a never-ending supply of men ready to volunteer, filling holes in the ranks, while the Confederate rosters dwindled to ever-smaller numbers. And the war-ravaged land north of Richmond could not long support his men and horses.

In the hopes of relieving the pressure on Vicksburg and giving his men access to the fertile bounty of the north, Lee decided to invade Pennsylvania. The Confederates and the Union troops, now under Major General George Meade, met at the town of Gettysburg. The Confederates had the better of it on the first day, but the Federals dug in along a series of hills and ridges behind Gettysburg.

What happened–July 2 dawned hot and sunny, and Lee had a plan for dislodging the Union army from its perch. While forces on the Confederate left under Lieutenant General Richard S. Ewell made a show of force, troops under Lieutenant General James Longstreet on the Confederate right would attack and take the virtually unoccupied Round Top mountains at the south end of Cemetery Ridge. Confederate artillery would be able to sweep Meade's men from the hills. Ewell's demonstration was to begin when he heard the artillery barrage which would signal the beginning of Longstreet's attack. For a long time after Longstreet had begun his attack, Ewell heard nothing, and hence did not move his troops. As a result, Meade was able to shift troops from the right of his line down towards the Round Tops, just in the nick of time to defeat Longstreet's attack.

Ewell's inability to hear Longstreet's artillery appears to stem first from the shielding effects of Cemetery Ridge and Culp's Hill between the two Confederate forces. More importantly, the hot temperatures near the ground probably caused a dramatic upward refraction of sound waves. Upon hitting another warm layer higher up, these waves could be refracted back downwards. On the previous day, Meade had been unable to hear the Gettysburg fighting from his position at Taneytown (12 miles away), yet the battle was clearly audible in Pittsburgh, 150 miles from Gettysburg.

Iuka

The scene–In September of 1862, Confederate forces under Major General Sterling Price struck and ran off the small Union garrison at Iuka, Mississippi. After confiscating supplies left behind by the Federals, Price decided to stay put in Iuka until he received orders for his next move. Twenty miles away, someone was making plans for Price, but not of the type he expected. Ulysses S. Grant, headquartered at Corinth, decided that Price's resting period would be a perfect time to strike and annihilate his forces. Though Grant had only 17,000 men on hand (Price had 15,000), he had an idea for a trap that would ensure Price's defeat. While forces under Major General Edward Ord approached Iuka from Corinth in the northwest, the other half of Grant's force under Brigadier General William Rosecrans would swing around and approach Iuka from the south, trapping Price from the rear. On September 17, Grant put the plan in motion.

What happened–Following Grant's plan, Ord stopped his battle lines four miles from Iuka and waited for the sounds of battle between Price and Rosecrans before proceeding (Grant wanted to make sure that the southern escape route was blocked before striking from the north). Late in the afternoon, Ord saw dense clouds of smoke coming from Iuka but assumed that Price was burning his supplies to keep them out of Union hands. In fact, Price and Rosecrans had been engaged for several hours, but Ord was unable to hear the battle. A strong wind blowing from the northwest had carried the sounds of battle away from Ord and Grant. When Grant finally learned the next morning that Rosecrans had been in a fight with Price, he immediately ordered both forces to advance. The Union troops met only each other; Price and his men had slipped out between them during the night.

Fort Donelson

The scene–In early February 1862, Union forces under Brigadier General Ulysses S. Grant had easily taken Confederate Fort Henry on the Tennessee River and reestablished the Stars and Stripes on Tennessee soil. Twelve miles to the east was Fort Donelson (on the Cumberland River), which Grant also vowed to take. If both the forts fell into Union hands, the Federals would have control over both rivers, providing valuable transportation arteries into the heart of the Confederacy. While Grant's men surrounded Donelson on three sides, gunboats under Flag Officer Andrew Foote steamed down the Cumberland to attack the fort from the fourth side. After their easy submission of low-lying Fort Henry, the gunboats were believed by both sides to be nearly invincible. To their surprise, the gunners in Fort Donelson, elevated much higher above the water than Fort Henry, shot the Union boats to pieces. Elated, the Confederates planned a breakout through the Union lines for the next day, February 14.

What happened–Nursing their wounds, Foote's sailors steamed five miles north of Fort Donelson to regroup. Not suspecting that the Confederates might go on the offensive from their precarious position, Grant rode north at dawn on February 14 to confer with Foote and plan the next move of the siege. At Fort Donelson, Confederate commander John Floyd planned for forces under Brigadier General Gideon Pillow to force a breakthrough towards the south while troops under Simon Bolivar Buckner held the other Union forces in position and then forced their way through the same opening. Attacking in early morning, the battle raged between Pillow and Union forces under John McClernand for over three hours before McClernand's men gave way. Grant was completely unaware of the battle; five miles away he could hear nothing. This due to two factors. On the previous day , a spring snow had blanketed the ground, absorbing sound in all directions. Also, a howling wind blew from north to south, carrying sounds away from grant and refracting sounds upwards. Only indecision by Pillow and Buckner at the crucial moment prevented the entire Confederate force from escaping. Notified by courier, Grant raced back to the battlefield and reorganized his men to the point where they drove the Confederates back into the fort, forcing their surrender the next day.

Charles Ross is assistant professor of physics at Longwood College in Farmville, Virginia. His book, Trial by Fire: Science, Technology and the Civil War *(White Mane Publishing Co.) is due out in late Fall 1999."*

Scanning the Journals

Thomas D. Rossing

• Researchers at the Naval Postgraduate School report observing the acoustic analogue of the Casimir effect in a paper in *Physics Letters* **A248**, 151. Andrés Larraza and Bruce Denardo produced a uniform acoustic filed inside a large steel tank and measured the force between two aluminum plates 15 cm in diameter as the separation between them was increased. When the separation was so small that no waves could exist between the plates, the force was independent of distance, but as the separation was increased, the force became repulsive and then attractive. The repulsive force at small separations is not seen in the normal Casimir effect, which describes the force on plates in an electromagnetic field. The experiments are also reported in a paper by Larraza, Holmes, Susbilla, and Denardo in *J. Acoust. Soc.* **103**, 2267 and are the subject of a story by Stephen Battersby in the November 28 issue of *New Scientist*.

• Comparisons of gyro-scale acoustic and direct thermal measurements of heat content in the Pacific Ocean, satellite altimeter measurements of sea surface height, and results from a general circulation model show that only about half of the seasonal and year-to-year changes in sea level are attributable to thermal expansion, according to a paper in the August 28 issue of *Science* by the ATOC Consortium. Fifteen months of acoustic data from the Acoustic Thermometry of Ocean Climate (ATOC) project are compared with an oceanic general circulation model. Ocean acoustic tomography has the ability to sample and average the large-scale oceanic thermal structure, synoptically, along several sections and at regular intervals.

• At speeds around 200 km/hr, German Transrapid TR07 maglev trains were found to be 7 dB(A) quieter at 25 m than an InterCity (ICE) train at the same distance, and over 10 dB quieter than the French TGV-A, according to an article in the August issue of *Sound and Vibration*. Even when operating at a speed of 400 km/hr, the ambient noise, where the track is routed along a highway, is increased by only 1 dB(A). Nearly all of the noise of the magnetically-levitated vehicle is aerodynamic noise. Measurements were made at the Emsland Transrapid Testing Center.

• By playing synthetic vowel sounds that rose or fell in level, John Neuhoff (Lafayette College) showed that listeners overestimate the change in level of sounds that get louder as compared to sounds that start loud and get softer (*Nature* **395**, 123). The results suggest that there is an asymmetry in the neural coding of harmonic rising and falling intensity sweeps, either in the response patterns of the peripheral auditory system, or in the summation of these patterns higher in the auditory pathway. The asymmetry occurred with harmonic sounds but not with broadband noise. Neuhoff suggests that in a natural environment this overestimation could provide a selective advantage because rising intensity can signal an approaching sound source, such as an approaching predator.

• Observation of third sound in superfluid ^{3}He ("helium-3") is reported by A. M. R. Schechter, R. W. Simmonds, R. E. Packard, and J. C. Davis, University of California, Berkeley, in a letter in *Nature*, 10 December. "Third sound" is the name given to a surface wave traveling on a thin superfluid film. The superfluid component oscillates parallel to the substrate while the normal-fluid component held stationary by viscosity. Third sound has proven to be a powerful probe of fundamental phenomena in superfluid ^{4}He. The number and significance of these has stimulated strong interest in whether similar surface waves can exist in films of superfluid ^{3}He.

To search for third sound in ^{3}He, the authors used a thin film of ^{3}He on the flat top surface of a polished copper disk. An oscillating electrical force was applied to the film. Several resonant modes, analogous to those in a drum head, with frequencies varying with changing temperature, were observed. According to the authors, the observation of third sound in superfluid ^{3}He should open the door to the study of a number of important phenomena for which no experimental technique was previously available. These include the limit on how thin a ^{3}He film can be made and still remain superfluid, the transition to two-dimensional superfluidity, the superfluid analogue of the quantum Hall effect, and the potential for two-dimensional ^{3}He superfluidity in submonolayer coverages.

• Using an open-earphone technique that allows sound to be presented either from a real free-field source or as a virtual image, Abhijit Kulkarni and H. Steven Colburn (Boston University) have shown that head-related transfer functions (HRTFs) can be smoothed significantly in frequency without affecting the perceived location of a sound, according to a letter in the 24/31 December issue of *Nature*. The researchers delivered the virtual sounds into the ear canal through small tubes so that, without removing the tube-phones, sounds originating from an external speaker could enter the ear unimpeded. They found that listeners could not distinguish real from virtual sources until the HRTF has lost most of its detailed variation in frequency, at which time the perceived elevation of the image was the reported cue. This suggests that for an accurate reproduction of real three-dimensional auditory space, a virtual space signal need compensate for only the most prominent features of the individual listener's HRTF. (See discussion of HRTFs in the Spring 1998 issue of *Echoes*).

• Ever since the principle of thermoacoustic refrigeration was pioneered during the 1980s by the late John Wheatley and his colleagues at the Los Alamos National Laboratory, there has been considerable interest in developing practical refrigerators in which loudspeakers replace rotating machinery. A small thermoacoustic refrigerator, in fact, was tested aboard space shuttle Discovery (see the Summer 1992 issue of *Echoes*). Until recently, thermoacoustic refrigerators used a closed acoustic resonator with two heat exchangers and filled with a gas mixture such as helium-argon or helium-xenon. The system is designed to receive heat at low temperature and to reject it at higher temperature while absorbing acoustic power supplied by the loudspeakers. There is a theoretical lower limit (based on the Carnot cycle) to the work required to produce a desired cooling power, so the power required depends upon the temperature difference.

Recent experiments at Los Alamos demonstrated a new arrangement in which the resonator is opened at both ends and the flowing gas stream to be cooled is used as the thermoacoustic work gas. The thermodynamic lower bound on the required power is now reduced by about one-half. The new arrangement eliminates the cold heat exchanger that previously carried heat from the gas being cooled to the thermoacoustic gas. These experiments, reported by R. S. Reid, W. C. Ward, and G. W. Swift in the May 25 issue of *Physical Review Letters*, are also discussed in an article in the August 13 issue of *Nature*. The authors expect that the concept of cyclic thermodynamics with open flow can be used with Stirling and Rankine cycles as well as with the Brayton-like thermoacoustic cycle used in their experiments.

Berlin

Berlin: The Largest Acoustics Meeting Ever Held

With 1953 papers, the joint meeting of the ASA and the EAA Forum Acusticum in Berlin, March 14-19, promises to be the largest acoustics meeting ever held! The Seattle ASA/ICA meeting, with 1504 papers will move into second place. More important, the Berlin meeting program will stand out for quality as well as quantity. From the gala opening session to the banquet in a medieval fortress, the meeting offers a full program of social activities as well as technical tours. The technical program includes nearly 100 special sessions, plus lecture sessions, poster session, and a short course on thermoacoustics. In addition to the paper copy service, a CD-ROM of voluntary preprints will be produced.

Integrated into the meeting will be the 25th anniversary meeting of DAGA (German acoustics meeting). The ASA and European technical committees will meet to discuss international issues in acoustics. There will be awards for best student papers.

See and Hear the Famous Berlin Philharmonie

The Opening Session of the joint ASA Meeting and EAA Forum Acusticum, on March 15, 1999, will take place in the well-known concert hall of the Berlin Philharmonic. Following the official part of the opening, the hall and its acoustics will be presented in a plenary lecture by Profs. Helmut Müller and Jürgen Meyer with assistance of the Hanover Youth Symphony Orchestra.

The Berlin Philharmonie, designed by architect Hans Scharoun, was a milestone in concert hall design. In this concert hall, built 40 years ago, the audience surrounds the orchestra. Much of the credit that the Scharoun design, which won first prize in architects' competition, was actually built goes to Herbert von Karajan, director of the Berliner Philharmoniker at the time. Of course there have been some severe room acoustical difficulties, which were solved by acousticians Lothar Cremer and Fritz Winckel. Due to the fruitful cooperation between architect and acousticians, the room acoustical problems were solved, so that this hall has become a model for many later concert halls.

In the first part of the lecture, the history, the peculiarities, and room acoustical data will be presented. In the second part of the lecture, the acoustical properties of the hall will be explained from the musical point of view and demonstrated by short sound examples played by an orchestra. Effects such as the interaction of dynamic levels and reverberation, masking or clarity of fast musical figures, blending of woodwind sounds to an integrated new tone color, localization of instruments, spatial impression during long crescendo passages and the development of the full orchestral sound will be shown as well as the freedom from echoes and audible background noise. As the hall is particularly suitable for romantic music, the sound examples will be taken from the 4th Symphony of Johannes Brahms, and a whole movement of this Symphony will be performed by the orchestra conducted by Jürgen Meyer.

Workshops and Satellite Conferences

Integrated into the ASA/EAA meeting is a workshop on Active Noise and Vibration Control. Approximately 100 technical papers, covering current aspects and latest developments of active noise and vibration control, will give a broad overview of current activities.

The 2nd International Conference on Voice Physiology and Biomechanics will be held at the Hotel Albrechtshof in Berlin, March 12-14. According to the organizers, 30 oral papers and 10 poster papers have been accepted for this conference. About 50 participants are expected, and registration is still open. [http://itb.biologie.hu-berlin.de]

The one-day workshop on Auditory Display announced in the Call for Papers has been cancelled.

Acoustics in the News

• "Ancient Instruments Yielding Secrets of Their Music" is the title of an article by William Broad in the *New York Times* of January 19. The article focuses on flutes ("and their kin, including whistles, ocarinas, recorders and pipe organs") and features the research of Marc-Pierre Verge and Avraham (Miko) Hirschberg, as well as Julius Smith, Perry Cook, and Benoit Fabre, all familiar names to musical acousticians and other readers of the Journal. The article points out how makers of electronic and acoustic musical instruments, such as Yamaha, are making good use of the results of research on wind instruments being done in Japan, Europe, and Canada as well as in the United States.

The article presents to *Times* readers some of the remarkable schlieren photographs of air jets in flute-type instruments that many of us have enjoyed in the "World of Sound" calendar. "It was by looking at the pictures that we noticed many, many things that weren't obvious at first," Verge is quoted as saying. His new company, Applied Acoustics Systems Inc. in Montreal, is soon to release music-making software based on physical modeling. But the flute research

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has uses beyond music and pleasure: the models of turbulent noise and note generation can be applied to industrial design, where ventilation system as well as gas and water pipes often develop unwanted sounds.

• The ATOC experiments have proved that sound can be used to measure the temperature of the world's oceans and detect long-term climate change, but the project has spent so much money meeting demands by environmental groups that its leaders expect to end the program a year from now, according to a story in the October 27 issue of *The New York Times*. ATOC results, reported at the 1998 Ocean Sciences Meeting, February 9-13 and published in the Feb. 27 issue of *Science* indicated that temperature readings of the Pacific Ocean are even more precise than projected and that marine mammals apparently aren't bothered by the sounds (see *Echoes*, Spring 1998). Nevertheless the experiment aroused strong opposition from several environmental organizations. After spending $2.9 million from its acoustic research budget on animal studies and legal expenses, ATOC finally began its experiment in 1995, modified to comply with the requests of environmentalists.

• To provide relief for tinnitus sufferers, ADM Tronics has developed a device that introduces sound-canceling vibrations to the cochlea through the mastoid bone behind the ear, according to an article in the August 8 issue of *New Scientist*. The user adjusts the frequency of the probe until the sound is minimized. Unlike devices introduced into the ear canal, this device would not interfere with ordinary hearing, it is claimed. ADM Tronics is hoping to get permission from the US FDA to market the device as a short-term solution while clinical trials test the lasting effects, according to Alfonso Di Mino, the inventor.

• The resort town of Winter Park, Colorado has passed an ordinance against the blowing of train whistles in town and threatening engineers with a $300 fine or 90 days in jail if they do so, according to an AP story in the *Boston Globe* (August 22) and other papers. The Moffat Tunnel under the Continental Divide routes heavy Denver-Salt Lake City train traffic through this popular ski resort town, and the Union Pacific Railroad has been routing more trains through the town since another route closed down. The railroad points out that Federal law requires train engineers to blow their horns a quarter-mile from a crossing to warn drivers and pedestrians, however, and Winter Park has three crossing, one without signals. Since Federal law supersedes local ordinance, the railroad will ignore the ordinance.

• A team of physicians at the Naval Medical Center in San Diego have developed a technique that may be able to save delicate hair cells that have been damaged by loud sounds, according to a report in the September 1 *New York Times*. Miniature catheters are inserted deep into the ears of guinea pigs and chinchillas, through which antioxidant drugs can be introduced to counteract toxic compounds generated by sound-induced injury. The research team of navy and army physicians who developed this technique is headed by Col. Richard Kopke. The military is especially interested in treating hearing and other ear problems that affect more than 11 percent of members of the armed services and cost an estimated $1.5 billion a year in compensation, retraining and equipment costs.

• Two new fibre-optic sensor for ultrasound detection with high spatial and temporal resolution have been developed at the Physikalisch-Technische Bundesanstalt in Braunschweig, according to an article in the *PTB News* (98.2). One sensor uses a metal coated tip of a fibre which forms the measuring arm of a Michelson interferometer. The second sensor system uses dielectric optical layers deposited on the fibre tip forming a Fabry-Perot interferometer. These small-sized sensors are intended for precise measurement of the sound pressure in ultrasonic fields in medical and technical applications.

• A rather interesting article on the nature and uses of intense acoustic waves by two Russian authors appears in the September/October issue of *Quantum* magazine, a magazine for high school science students (see Fall 1998 issue of *Echoes*). The article considers some applications of ultrasound, including ultrasonic imaging, parametric radiators and antennas, ultrasonic surface cleaning, hole drilling, and kidney stone therapy. *Quantum* is jointly published in English and Russian (under the title *Kvant*).

• Scientists at Leeds University in England are exploring alternatives to the traditional sound of sirens on police, fire, and other emergency vehicles, according to an article in the online edition of *Washington Post* for September 23. They have observed that motorists have considerable difficulty in localizing sound of traditional sirens, whereas white noise is more easily localized because it covers a wider range of frequency. Better yet is a warning sound that combines white noise with the authority of a traditional siren and goes something like: "wow-wow-sheesh." According to the National Fire Protection Association, the number of accidents involving emergency vehicles rose about 25 percent from 11,325 in 1990 to 14,200 in 1996.

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