

**COVER PHOTO**

To visualize audible sound, artist Martin Klimas used vibrating pigments on a loudspeaker membrane, at around 9,000 Hz. Audible sound has frequencies between 20 and 20,000 Hz. That is in the heart of human hearing.

# 20 – 20,000 HZ IN THE HEART OF SOUND



# "MUSIC ENVELOPS OUR ENTIRE RANGE OF HUMAN PERCEPTION – WHAT FOR US AT SENNHEISER HAS ALWAYS BEEN A MATTER OF THE HEART."

A master luthier takes the resonances of a Stradivarius and makes them visible for the first time. An archaeologist enters an underground labyrinth to divine the moans of an oracle. And a world-renowned vocal coach finds himself in the vibrations of the singer's formant, those unique frequencies that carry the Heldentenor's voice back to the very last rows of an opera house.

These captivating personalities and the many others found on the pages of this issue transport us to the "Heart of the sound" – those frequencies between 20 and 20,000 Hz audible to the human ear. Such as the mystical sounds of Peruvian conch-shell horns blown at frequencies between 272 and 340 Hz, a master violin's main resonances from 440 to 450 Hz, and the 2,800 Hz brilliance of the human voice.

In the first part of our trilogy, we explored the imperceptible infrasound frequencies from zero to 20 Hz as we marveled at what lies "In the depths of sound." Next year, we will complete our series by entering the domain of bats and moths "In the heights of sound," the powerful, yet inaudible, range of ultrasound (20,000 to 200,000 Hz).

But what sounds await us on the following pages of "In the heart of the sound"? The howl of a race car engine, the murmur of an oracle and – above all – a lot of music. Music en-



velops our entire range of human perception – what for us at Sennheiser has always been a matter of the heart.

That's why we want to use this magazine to show you how we were able to transform David Bowie's greatest hits into a three-dimensional audio panorama; how we provided a casting show with a unique uncompressed digital wireless system with audio transmission far exceeding that of analog wireless technology; or how receivers and sports headphones are helping

soccer players hit better crosses by beaming the right kind of music into their ears!

Of course, we at Sennheiser are perfectly aware that passion is not technical. It can't be assigned a frequency, but rather fluctuates in many different directions. Technology, however, can also be art. And with the help of technology, art can be transported from person to person and even across continents and into space. To make this issue as perfect as possible, we followed the credo "The Pursuit of perfect Sound" – no matter what the frequency range.

*J. Sennheiser*  
Prof. Dr. Jörg Sennheiser



WE CREATE TODAY THE  
AUDIO WORLD OF TOMORROW –  
THAT IS THE CHALLENGE THAT  
WE TAKE ON EVERY DAY

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# MY PURSUIT OF THE PERFECT SOUND

From the lowest depths to the highest heights: Music envelops the complete spectrum of sound audible to the human ear: 20–20,000 Hz. But which of these resonances are able to touch our souls? German Martin Schleske, one of the best luthiers in the world, is in hot pursuit of the answer. In this essay, he describes his unique journey into the heart of sound.

20–20,000 Hz

## ESSAY

There are sounds that touch the soul. Sounds that comfort, strengthen and raise us up. A good sound has charisma. Though “charis” literally means “grace,” it also means “beauty’s charm.” Finding the perfect sound has become my purpose in life – a journey that has taken me into the heart of sound. In order to set off on that journey, however, I had to leave music school and enter a school for violinmaking. To move forward, I studied physics. And to get there, I dared the impossible – to create a sound that no instrument in the world has ever produced. But my journey has not yet come to an end.

Others may have finished their journeys. Such as the great Italian violinmakers Antonio Stradivari and Joseph Guarneri del Gesù. The secrets they took with them to the grave are inimitable – even to this day. Their instruments are not just works of art valued at millions of dollars – they are being played to this day by the world’s greatest virtuosi.

But how is that possible? It’s a question I’ve been asking myself since I was seven years old, when I was attending a small music school in Swabia. Music is my life. We

1. The master at work: Schleske’s studio is located in a nature reserve. When he opens his window, he can hear the sound of a babbling brook.

played music at home on Sundays. I’ve played in a chamber orchestra, a hard rock band and in the pedestrian zone. We even built our own tube amp. But the rest of the time, I was at school, listening to the constant answers to questions I had never asked. That’s why I left the music school after the 10th grade and began studying to be a luthier – a violinmaker. Driving me on was a dream of building instruments with a better sound than a Stradivarius and – should I not succeed – to find out why it wasn’t possible.

Did the masters of the 18th century have some kind of secret knowledge? Or was it the wood’s aging process



1. Historical scrolls and peg boxes: Our author has been studying historical violins from the 18th century for decades. 2. Carving a violin: The inspired sound researcher hews the tonewood himself. In the laboratory, he applies varnishes he has prepared according to traditional recipes.



that gave their instruments the kind of mature sound a young instrument could never achieve? The violin originated during one of the most remarkable eras of all times. For the great masters of the Renaissance, combining art and science was just a matter

of fact. It is unfathomable to think of such artistic works being created without this special attention to detail and feel for nature. It requires an environment of gifted empiricism and holistic intuition to design such highly optimized acoustical systems. In the 19th century, however, the art of violinmaking fell prey to the trade of the industrial revolution.

The guild had sold its soul. But how would I manage to reconnect to the art of sound? I first began by trying out countless of the different recipes used to make traditional varnishes. However, it soon became clear to me that the old masters would have combined science without forfeiting art – just as acoustician Helmut Müller taught me. A physics teacher at my violinmaking school, he operated a research laboratory at his acoustic consulting firm Müller-BBM. It was in his laboratory that I was able to pursue the answers to all the unresolved questions I had tortured him with for so many years.

And then, a revelation: modal analysis. A method used in aerospace technology. I was the first one to apply it to the violin. At last, it was possible to actually see how the violin vibrates. The bulbous breathing in the lowest natural frequency – the Helmholtz resonance around 260 to 280 Hz. The strong distortion of the lower corpus resonances, the extensive motion of the plates and their two main resonances 440 and 550 Hz, and their wide deviations around



ESSAY



↑1. *Corpus delicti*: In the heart of the violin, Schleske is conducting research into the right resonances. →2. Work accomplished: “An individual acoustic and visual sculpture”



the bass bar. The vocal formants from 700 up to 1,000 Hz, which give the violin its open sound. And, finally, all the islands of vibration that give the violin its brilliance swimming in the frequencies between 2,000 and 3,000 Hz. Finally, what was hidden had been revealed.

The longer I worked along these lines, the more I realized I didn’t really understand the theoretical background. Left with no other choice, I completed a baccalaureate and studied physics. My only purpose: to continue my pursuit of the mystery behind a good, healing sound. It’s what drives me.

After I received a master of physics, I had my first opportunity to experience a Stradivarius, one of the most famous violins of all times, first-hand in the intimate acoustics of my new studio. As soon as the bow struck the string, the room was filled with a warmth, a breath, a volume and radiance palpable even to an untrained ear. The Stradivarius is like a prayer dipped in the colors of sound. It’s like being in a cloud of sound, a combination of gentleness and strength that is downright addictive. It was this violin that made me decide to become a teacher during my first years as a master violinmaker.

The violins of Guarneri del Gesù are completely different from a Stradivarius. Basically, its two main resonances are further apart. You can feel how the tones are kneaded and formed under the arch, positively sucking it in. The sounds are like freshly fallen snow that has been tamped underfoot – especially on the G string. It is a rich, crisp, satisfying feeling. Dense, dark and compact. And lower down

on the E-string, these violins have a reddish tone covered in a silvery iridescence. They can be almost archaic, hissing and large.

I’d been studying these violins for decades when, about a year ago, I had the feeling I had reached some kind of destination. When master violinist Ingolf Turban visited me at my studio, he fell head over heels in love with my youngest “child”: the Violin Opus 130. Despite owning his own Stradivarius, he now performs all his solo concerts using my violin. “This violin is X-rated,” he once said, winking at me. But his thanks said it all: “You have given me my voice!”

Even so, I haven’t reached my final stop. For years now, I’ve been researching a novel type of resonance vibrato – a frequency modulation of the resonances themselves, something that to date has only been achievable by the human voice. There is no instrument in the world able to produce these types of modulations in which an oscillator, such as a vibrating string, “plays” with a sound board. The result would be monumental, producing a sound like never before.

I’m afraid one lifetime isn’t enough to achieve my goals of beauty and perfection. Even so, it’s not going to stop me from trying. ■

TUNING THE TONE

**35** Hz is how much luthier Martin Schleske was off the mark when he tried to recreate a Stradivarius violin in 1999. Germany’s most famous violin manufacturer designed an instrument whose “spectral center of gravity” of 1,276 Hz was only very slightly above that of the old masterpiece (1,241 Hz). Using physics, Schleske wants to achieve something no one else has ever been able to do: to surpass the classic Stradivarius and del Gesù. No wonder Schleske is considered the “most informed and scientifically active luthier in the world” by a few Harvard professors. Schleske began studying the violin with Hungarian Attila Balogh, a soloist at the Berlin Philharmonic. Later, he learned the art of violinmaking in the Bavarian village of Mittenwald, a center of instrument-making. Today, world-renowned soloists such as Jehi Bahk and Ingolf Turban play his instruments. Schleske has a studio and sound laboratory at Gut Grubmühl near Munich, where he uses the new, leather-covered, luxury headphones from Sennheiser – the MOMENTUM. His book “The Sound: From the Incredible Sense of Life” was published in 2010 by Kösel Verlag.

→ MOMENTUM

With the finest leather and a powerful sound even on the go – the new luxury headphones from Sennheiser make quality tangible

Sennheiser MOMENTUM A work of art from the Style Selection	
Frequency response	16–22,000 Hz (-3 dB)
Transducer principle	dynamic, closed
Total harmonic distortion	1 kHz ≤ 0.5%
Weight	190 g



# THE THROUGH-PASS SYMPHONY

German sound engineers are on the trail of a winner's rhythm. Their sound soccer experiment shows that music can improve a soccer team's game. The right acoustical input drives a faster one-two pass – from the dance floor to the winning goal.

1. Cross, header, boom! Bayern München striker Mario Gómez shows how to set up the perfect attack. Here, in front of the goal.

80 Hz

SOUND SOCCER

On a June day in 1986, the very foundations of Mexico City's Aztec Stadium were shaken. An extraordinary atmosphere, an almost religious ecstasy – like those many people feel as they are exposed to a great piece of art – was felt by the some 114,600 viewers seated under the gigantic dome. Argentina's Diego Maradona had single-handedly brought the score up to 2:0, pushing 50 meters past the opposing team – dribbling past his competitors like ninepins – to drive the ball into England's goal. Years later, his athletic feat was voted the goal of the century.

Argentine radio reporter Hugo Morales followed Maradona's magic march from the press box. He immediately knew that he would never be able to keep up with the all-out attack by reporting in complete words, let alone sentences. "Siempre Maradona ..., " is all he could get out and these syllables have become almost as famous as the goal of the century: "Genio! Genio! Genio! Ta! Ta! Ta! Goooooooool!" By translating Maradona's fast twists into short blasts of sound, without realizing it, Morales was anticipating sports

sonification, a method sports researchers such as Prof. Alfred Effenberg of the University of Hanover are using today to capture the sequence of motions of swimmers and rowers.

Using synthesizers and computers, they are able to construct an "acoustical fingerprint," a soundtrack of the motion. By employing this acoustical tool during training, athletes can correct mistakes and improve their technique.

Effenberg's latest experiment is sound soccer, in which the professor is conducting a study to establish whether or not ear training is also applicable to soccer. The Borussia Dortmund fan, who – despite having the same last name – is not related to the former FC Bayern star, sought out a competent partner. Cologne musicologist Manfred Müller had already translated soccer players' dribblings into music for a radio show during the 2010 FIFA World Cup in South Africa. Film composer Matthias Hornschuh assisted him in translating the "Ta! Ta! Ta!" into beats and notes, turning sound soccer into a truly interdisciplinary project. "Good teamwork is dependent on the players having a common

time base," explains Effenberg. "We know that synchronizing the timing of more than one person is better controlled using acoustical than visual signals, so we looked into whether a certain type of music and certain rhythm could improve a team's passing game."

It's no coincidence then that football reporters transcribe football teams into music. Dynamic soccer teams like Real Madrid and Dynamo Kyiv are known as white ballet and red orchestra. Using tiki-taka to describe the short quick passing game of the World and European Champion Spain is also pure onomatopoeia.

Effenberg and his staff have three soccer teams participating in their experiment. Not Real Madrid or FC Bayern, but the youth and men's team of FV Engers 07, and the women's team of Eintracht Wetzlar, both German association football clubs. Sennheiser provided the technology. Prof. Jürgen Peissig from the research department was immediately enthralled by sound soccer: "If the experiment succeeds, it could open up a completely new market," and sees a real potential for innovation. The project requires high standards of quality because "ultimately, the complete musical spectrum from 20 to 20,000 Hz has to be transmitted wirelessly to the players' ears – the perfect situation for our in-ear monitor systems."

In sound soccer, directional antennas are installed on the sidelines and each player wears a Sennheiser in-ear sports headphone designed especially for joggers. Its silicone earclips ensure a secure fit. In addition to soccer shoes and shin guards, each test subject also wears a receiver on his or her body. The mobile-phone-sized EK 300 IEM G3 is attached to a belt around the hips. The trainers caution the players not to battle too hard. Effenberg and his staff then give the athletes instructions, but none of them know what it is all about nor whether the other players are also listening to music. Five teams are randomly picked. At first, they play against each other without listening to music, and then with music. Müller and Hornschuh's composition is a sonification of the dribbling of South African national player Teko Modise set to the rhythm of 140 bpm. Ball and ground con-

BEATS PER MINUTE

**160** That's the minimum beats per minute (bpm) of a drum or bass track – and the beat of Maradona-successor Lionel Messi's dribble. Whereas rowing eights might find 40 bpm too fast, in classical music it's considered slow (*lento*). Sound soccer researchers play 140 bpm in players' ears – and improve their passing games.



SOUND SOCCER



tacts begin to take on Modise’s exact beat. The techno trance-like sounds would be just as likely to be heard on a disco dance floor.

The women gripe a little, but the men like the music. One time, the players listen to time-synchronized music and they literally move at the same rate. The next time, the music is on a slight time delay. After 22 training sessions full of tackles, passes, shots and goals, the researchers’ assumption is confirmed. The manager was able to observe how the team listening to synchronous acoustics was better able to carry through long-pass sequences. Passes were also quicker and more direct – just the right sprinkling and they even shot more goals.

The amazing results quickly generate interest in the upper leagues. Football has continued to evolve since Maradona’s time – it’s gotten faster and more athletic. A tremendously talented player has less to do with success than the performance of a perfectly tuned team. The top international clubs have been using scientific training methods for a long time now. For instance, AC Milan operates the MilanLab and its soundproof Mind Room, where players go to improve their concentration using visual mental training. The Bundesliga has also caught up in recent years, but visual methods still predominate. The acoustical approach of sound soccer is something totally new for most teams. Prof. Effenberg maintains acoustical training is significant and forward-looking.

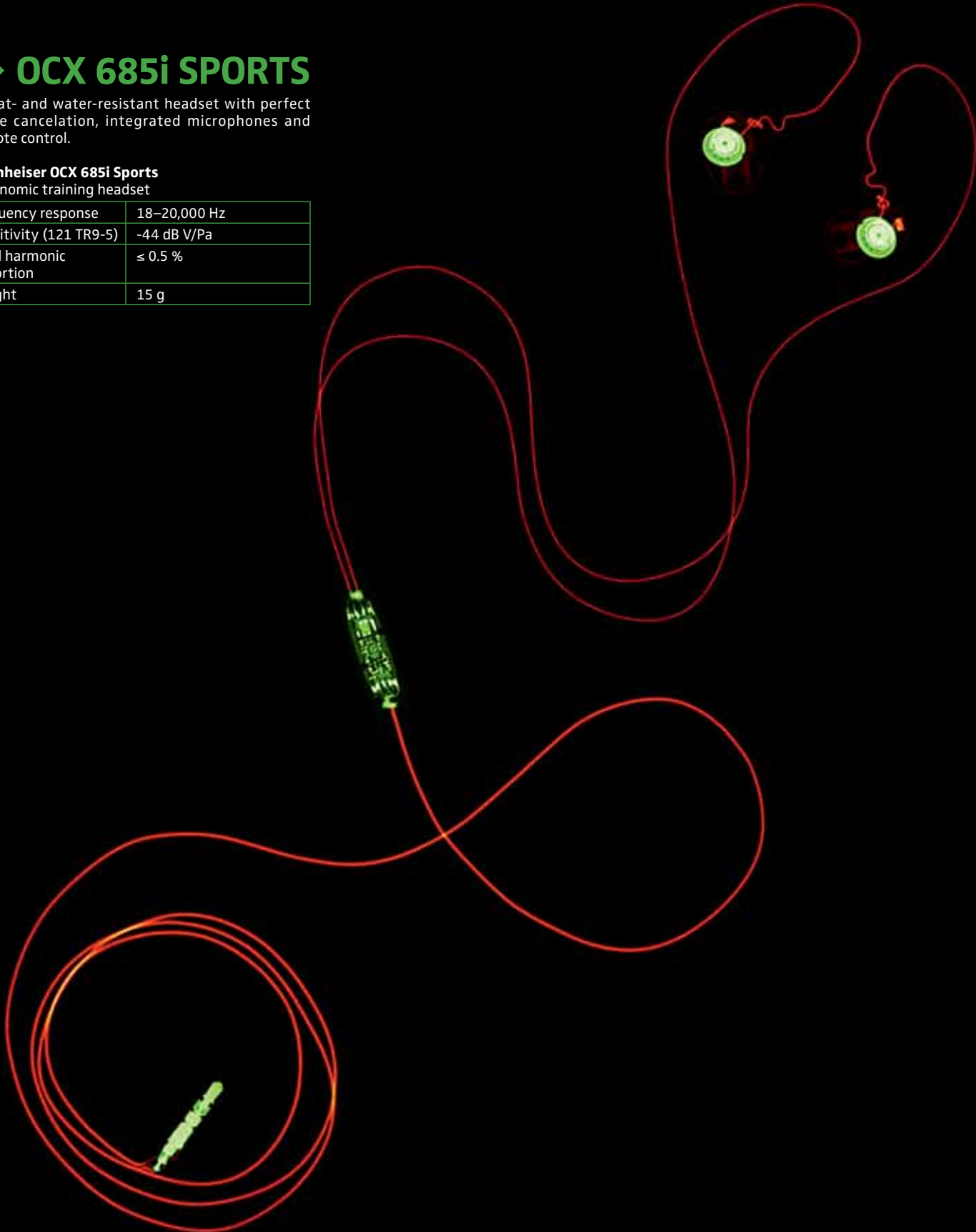
↑1. “Ta! Ta! Ta! Gooooooooo!” – Maradona’s goal of the century during the 1986 World Cup. 2. “Rudders, long!” – sonification improves the motion sequences of scullers as well.

In the future, he wants to use high-tech insoles to more accurately measure the football players’ step sequences and ground contacts in order to gain information on the players’ dribbling and tackles. Using this method, it was even able to decipher the magic formula of FC Barcelona’s brilliant game. In 2007, its prodigy and superstar Lionel Messi recreated Maradona’s goal of the century in a game against a local football association. When Manfred Müller sonified this celebrated dribbling, he found something miraculous. “Messi is one of a kind,” marvels Müller. “He moves in three different, overlapping rhythms and is the only one able to achieve a sequence of ground and ball contacts of over 160 bpm.” But even a genius like Messi can only excel with the help of a functioning team. Messi’s performances with the Argentine national team are proof of that. Without glistening teamwork, Messi won’t shine, either. Maybe Argentina should give sound soccer a try sometime.

→ OCX 685i SPORTS

Sweat- and water-resistant headset with perfect noise cancelation, integrated microphones and remote control.

Sennheiser OCX 685i Sports Ergonomic training headset	
Frequency response	18–20,000 Hz
Sensitivity (121 TR9-5)	-44 dB V/Pa
Total harmonic distortion	≤ 0.5 %
Weight	15 g

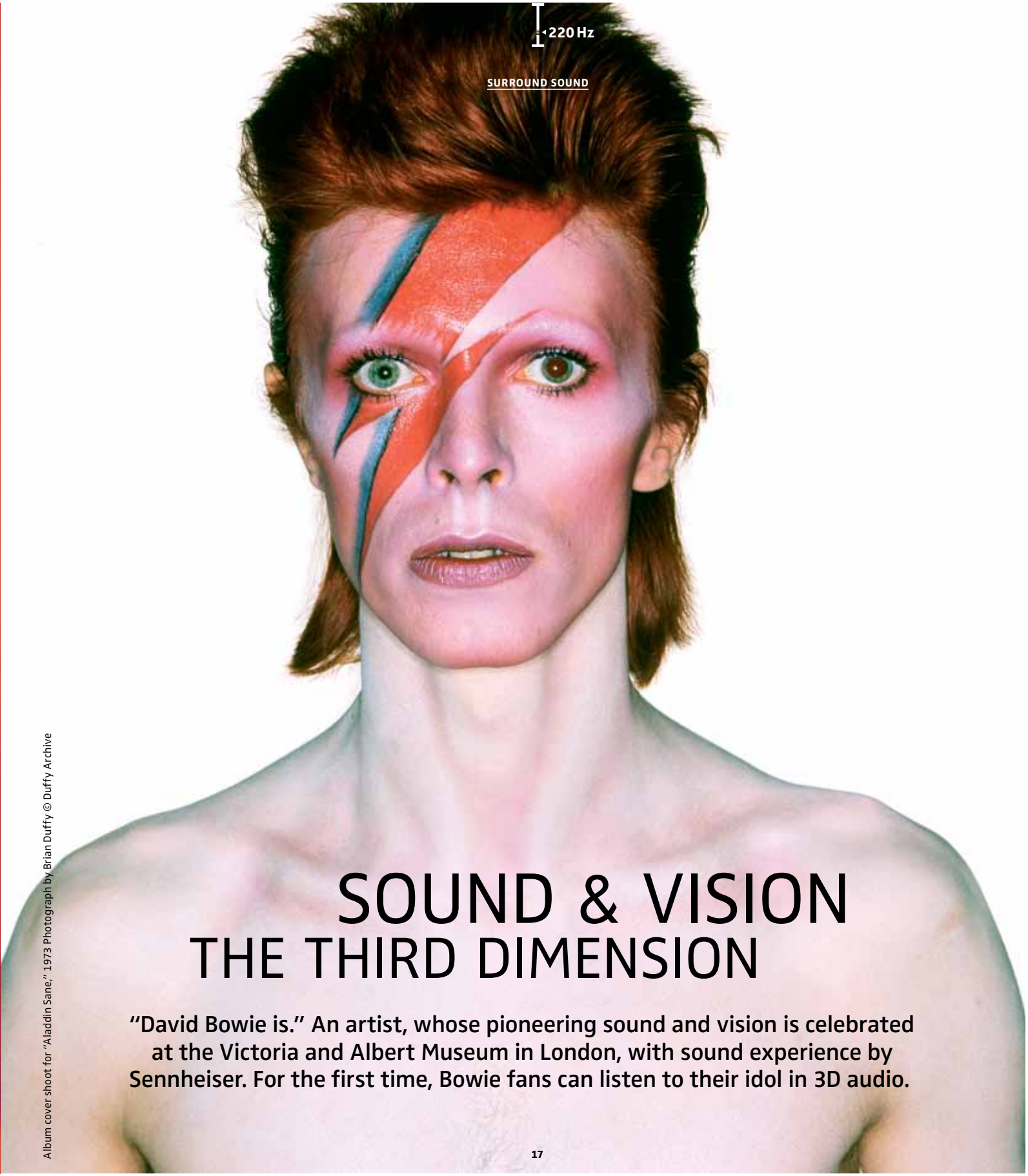






➤1. Avant-garde artist for over four decades: For the *Aladdin Sane* album cover (1973), Bowie used make-up to symbolize a split personality ➤2. Clothed in Kansai Yamamoto.

Striped bodysuit for "Aladdin Sane" tour, 1973 Design by Kansai Yamamoto Photograph by Masayoshi Sukita - © Sukita The David Bowie Archive 2012



220 Hz

SURROUND SOUND

# SOUND & VISION THE THIRD DIMENSION

"David Bowie is." An artist, whose pioneering sound and vision is celebrated at the Victoria and Albert Museum in London, with sound experience by Sennheiser. For the first time, Bowie fans can listen to their idol in 3D audio.

Album cover shoot for "Aladdin Sane," 1973 Photograph by Brian Duffy © Duffy Archive



His fingers slide along the controller one last time and then you hear “The Voice of God.” As the audio engineer swipes the equalizer on his iPad, David Bowie begins to sing. And how! Live performances are projected on gauze screens from floor to ceiling while 10 hidden speakers envelop the visitor in sound, creating a concert atmosphere: *The Jean Genie lives on his back, The Jean Genie loves chimney stacks, He’s outrageous, he screams and he bawls, Jean Genie, let yourself go!*

Gregor Zielinsky gives a contented smile. In just a few days, the ground-breaking and acclaimed “David Bowie is” exhibition is scheduled to open at the Victoria and Albert (V&A) Museum in London. There’s a feeling of heightened excitement in the air as technicians thread the last cables and the audio engineer makes his final sound check. Zielinsky is a sound perfectionist and wizard at music reproduction. Using the Sennheiser 3D Audio surround sound system, he has conjured up the “Voice of God” on the ceiling of this, the world’s greatest museum of art and design. “David Bowie is” has become the best-selling exhibition in the museum’s history.

That said, when audiophiles speak of “God,” they are not referring to the superstar who was launched into the stratosphere of pop music as “Ziggy Stardust” – despite the fact that this exhibition is



1. Who is Bowie? The exhibition offers many possible answers.  
2. What does Bowie sound like? Sennheiser audio engineer Gregor Zielinsky has given the artist’s sound a new dimension.

bursting with his memorabilia. Rather, they are referring to the sound installation’s hidden height channels, which are strategically placed to evoke an almost religious shudder from its visitors. “In the past, many hi-fi gurus didn’t think you needed more than six surround channels to create a surround sound effect,” comments Zielinsky. He motions toward the exhibition hall’s high walls where he has hidden a handful of Neumann

speakers that deliver one height channel for each of the five base channels: “That’s the secret behind our ability to create a third dimension of sound.” Cinema applications use a similar additional height channel, which audio engineers at Hollywood studios christened “The Voice of God” – the voice from above. “The name may sound a bit dramatic,” says Zielinsky, “but what better way to describe an acoustical signal that emanates from above?”

“Sound and Vision” is the title of a successful Bowie single first released in 1977. Appropriately, sound and vision interact throughout the exhibition. Its designers, Fifty Nine Productions, in collaboration with Real Studios, have transformed the galleries into theatrical spaces where visitors are immersed in music and images from across David Bowie’s phenomenal career.

On the one hand, there are the visual curiosities taken from the artist’s private collection, which he made available to curators without ever having communicated with them personally. More than 50 mannequins dressed



“IN THE PAST, MANY HI-FI GURUS DIDN’T THINK YOU NEEDED MORE THAN SIX SURROUND CHANNELS TO CREATE A SURROUND SOUND EFFECT. I USE 10.”

## GROUND CONTROL TO MAJOR TOM ...

**220** times per second – that’s how often the oscillator swung in 1969 when David Bowie turned on his Stylophone. Shortly after the mini analog synthesizer was switched on, it played back an A3 (220 Hz). He could then use the tiny metal keyboard’s stylus to draw out tones ranging from A2 (11 Hz) to E4 (329.6 Hz). Similar to the original sample-playback keyboard, the Mellotron, the Stylophone belongs to Bowie’s curious collection of instruments.



SURROUND SOUND



1. Equalizer: Zielinsky makes final adjustments. 2. Mobility: The guidePORT system beams the Bowie sound into listener's ears. 3. Popular: No exhibition at the V&A was more enthusiastically received.

on board: "We used Sennheiser's guidePORT system to deliver huge amounts of audio content without creating a cacophony of sound in the galleries." As the portable

wireless headphones take visitors on a journey spanning several decades, they never lose track of where they are or at what point in time. As they stand in front of the young man who would become known as "Bowie," for instance, they are surrounded by one of his early songs, 'When I Live My Dream.' The audio guide doesn't just play music, but also plays excerpts from interviews and provides additional information. With the guidePORT, visitors can tour the exhibition at their own pace and plot their own course. Says Norbert Hilbich of Sennheiser Application Engineering: "Even though the tour is completely automated, it is very individual."

Shortly after Zielinsky has the Sennheiser systems go live, more than 600 international journalists begin filing their stories on the multimedia event. "The most striking thing about the show is that it is brought to life by technology and united in sound and vision in a way rarely seen in a museum," raves *The New York Times*. Sennheiser technology and expertise has been fundamental to the "immersing audio experience" created by the exhibit designers. Walking round the galleries, one has the feeling that "Ziggy Stardust and the Diamond Dogs" have been brought back to life.



in phantasmagoric Bowie costumes. Outfits such as Japanese designer Kansai Yamamoto's Tokyo Pop and other costumes inspired by Japanese samurai armor and Kabuki theatre. Or the Union Jack frock coat created for Bowie by Alexander McQueen. The star comes to life on the exhibition's walls, cubes, old TVs and monitors. There are also records, drawings, oil paintings, design sketches, a key to Bowie's apartment in Berlin and – doodled on graph paper – his then unfinished text for "Heroes": *and we kissed as though nothing could fall ...*

The V&A has created an absolutely unique sound experience. "From the start, we knew that sound and video were going to be extremely important," says exhibit coordinator Tom Grosvenor. That's why Sennheiser was brought



1. English earthling: For his 1997 album "Earthling," Bowie posed in a Union Jack coat designed by Alexander McQueen.





1. Spontaneous goose bumps: Zielinsky during a sound check of a musical collage composed especially for the show.

Zielinsky’s algorithm automatically transforms images into 3D simulations. Though there aren’t any stereo systems available right now that could transport these sounds to the car or living room of users, Sennheiser 3D audio technology will become available to consumers in the future. Until then, a first impression of the sound effect can be found in London.

The new surround sound is also celebrated in the second gallery with its larger-than-life video triptych. In a long-lost recording, Bowie rocks the BBC show *Top of the Pops* with ‘The Jean Genie,’ while the music video directed by Mick Rock and concert film *Ziggy Stardust and the Spiders from Mars* by D.A. Pennebaker plays in tandem. Since some of these recordings date back to the early 1970s, Zielinsky had to fall back on the mono recordings. However, by making a few adjustments to his algorithm, Zielinsky has been able to come up with an impressive reproduction in surround sound. “I was able to give the instrumental passage the maximum bang while keeping the major vocal passages more mono-dominant, which I preferred because I didn’t want to veer too far away from the original,”

says the audio engineer of his work. “These adjustments take the old material and turn it into a treat for the ears of today’s listeners.”

No wonder the Sennheiser sound experience, created by Zielinsky, will tour with the exhibition when it travels to international venues. As of spring 2014, “David Bowie is” will be on loan in São Paulo. The German sound wizard will also be on hand in Brazil to adapt the surround sound system to the space. “I know exactly how to create this effect,” says Zielinsky and stows away his iPad. By the time he’s completed his last sound check, Zielinsky knows every nook and cranny of this immense room: “I didn’t want to believe it at first, but I was completely bowled over by David Bowie’s music in this amazing setting.” ■

The feeling at the exhibition is at its strongest in the two locations where the 3D installations resound. In the first room is a 14-minute mash-up of songs from across Bowie’s career, created by legendary Bowie producer Tony Visconti. “When I first heard this remix, I immediately got goose bumps,” remembers Zielinsky. To help museum visitors share in his experience, Zielinsky readied the work using a formula he developed for Sennheiser’s surround sound system. “Tony’s mix was so open and so beautiful that his piece could be sent directly and unfiltered through my algorithm,” he says. When Visconti heard the remastered recording adapted to the premises for the first time, he responded enthusiastically: “I don’t know how Gregor does it, but – to me – it seems like magic!”

## → SENNHEISER MKH 800 TWIN

The separate, two-channel dual capsule makes it possible to make adjustments to pick-up patterns later on – the ideal microphone for surround sound and 3D images.

Sennheiser MKH 800 TWIN studio condenser microphone	
Frequency response	30 to 50,000 Hz
Pick-up patterns	omni-directional, cardioid, figure-8
Nominal impedance	100 ohms
Weight	172 g



300 Hz

ARCHAEOACOUSTICS

# 300 THE MUSIC OF THE MYSTERIOUS MONOLITH

Miriam Kolar and her Stanford team analyze sound to help reveal the purpose of an ancient "lost city" in the Peruvian Andes.

←1. Half a day's trip north of Lima, at an altitude of 10,430 feet, lies the temple complex of Chavín de Huántar. ↗2. Half man, half beast, the "lanzón" statue lurks at the center of the complex.



## ARCHAEOACOUSTICS

In the green upper reaches of the Peruvian Andes, more than 10,000 feet above sea level, lies a mysterious ancient gathering place called Chavín de Huántar. Its stone plazas and temples are now covered in moss, but their grand scale and detailed bas-relief carvings testify to their one-time significance. As with another famous Peruvian site, Machu Picchu, Chavín's exact purpose has long eluded historians and archaeologists because its creators left behind no written records. But while we may never experience Chavín exactly the way the ancients did, archaeoacoustics researcher Miriam Kolar and other sound detectives from Stanford's Center for Computer Research in Music and Acoustics (CCRMA) have shed light on some possible reasons for its existence. Using state-of-the-art technical equipment, they have been able to demonstrate how an engraved stone monolith at the site could have served as a hidden oracle that "spoke" to people listening outside in a sunken plaza.

"A person who had access to it would be in the company of a small number of people," says Kolar. When Kolar had the opportunity to conduct sound experiments at Chavín, once a center of spirituality for ancient peoples all over the region, she jumped at the chance. Formerly a sound designer and recording engineer in Los Angeles, Kolar is familiar with how the layout of interior spaces can affect the quality of sound transmission and how a space's acoustics can shape a listener's experience. "Archaeology offers the perfect opportunity to study the human effects of acoustics," she says. "We're interested in the whole ancient landscape of human experience." How might it have been to visit Chavín 3,000 years ago – what might listeners have heard there and what psychological effects might the sound have produced? Kolar's cultural acoustics research seeks to answer these questions.

While structures at other noted archaeological sites are often crumbling, the buildings at Chavín still have many interior rooms and corridors intact. Some of the passageways are so narrow and labyrinthine, they make the

outside world seem light-years away. "Since these galleries are so deep within the buildings, in many places no light can come in from the outside," says Kolar, as she explains her undertaking.

Before Kolar made her first trip to Chavín, her team equipped an archaeologist with a customized acoustics field kit. When taking his first on-site measurements, John Rick employed a compact Neumann loudspeaker to play back powerful test signals in the subterranean chambers. He then used in-ear microphones equipped with Sennheiser KE4 capsules to record the signals, which enabled the researchers to gather information on the sound-transmission qualities of the rooms and corridors. The information was then sourced to develop a digital acoustic model of the galleries.

Kolar, who formed the team together with colleague Jonathan Abel, visited Chavín for the first time in 2008. Once on site, she grew so immersed in recording and analyzing its acoustical properties that she made Peru her research base. "Until you get into the space yourself, you can't really understand it," she says. "Moment to moment, your psychological and physical states alter your perception."

As Kolar explored the space, she focused her attention on a sculpture deep inside the temple complex – a 4.5-meter-high stone monolith decorated with fangs and twisting snakes: "el lanzón" or "the lance." She noticed that the carved mouth of this stela was almost perfectly aligned with a corridor and a horizontal duct leading to a sunken circular plaza beyond the temple. Was it possible that this corridor and the two parallel ducts were able to transmit and amplify the sound like some ancient loudspeaker? The recordings made by her on site showed that "there's a direct line of sound from the mouth of the carved monolith all the way to the world outside." Kolar continues, "The question is whether it can be heard there."

1. The corridors and ducts are disorienting and claustrophobic.  
2. Tenon-heads like these are thought to represent stages of a human-to-feline shamanic transformation.



"THERE'S A DIRECT LINE OF SOUND FROM THE MOUTH OF THE CARVED MONOLITH ALL THE WAY TO THE WORLD OUTSIDE."



ARCHAEOACOUSTICS

To find out, Kolar played test signals from locations near the monolith and in the depths of the gallery using directional loudspeakers. As she hunted throughout the ducts for specific types of sounds produced by every frequency audible to humans (20 to 20,000 Hz), evenly spaced omnidirectional microphones listened in. The results of the data they delivered were amazing: the ancient ducts must have made it possible for sounds emanating near the monolith to be heard loud and clear by listeners in the ceremonial plaza. Just what types of sounds did the ancients make? Since conch-shell horns, known as pututus, appear in much of the site iconography, Kolar's team tested replica pututus on site and also called on famous Peruvian musician Tito La Rosa to perform the instruments in museum tests. Perry Cook led the Stanford team in measuring their natural frequencies and recorded frequencies of around 300 Hz. "If you pass sound from all frequencies in the range of human hearing through the ducts," explains Kolar, "it is fascinating to hear how the sounding-tone frequencies of the Chavín pututus are amplified and high-frequency sounds are drastically suppressed." She suspects the ducts work as filters, making any tone measured at 272 to 340 Hz sound like these Chavín pututus.

Other research indicates that such low-frequency sounds – low enough so that they could be felt as vibrations as well as heard – could have provoked a sense of awe in listeners standing in the plaza. This is because the sounds produced by a conch shell are just as low as those produced by a church organ, the sounds of which believers can not only hear, but feel.

Assuming the decorated stone monolith did serve as an oracle, what was the oracle's purpose? While research is still ongoing, various findings at the site hint at an answer. Archaeologists at Chavín have found pictorial evidence of psychedelic plants like the San Pedro cactus, tools for grinding and mixing plant materials, and representations of people with mucus streaming out of their



noses – a typical side effect of using such drugs. The carvings on the oracle statue, including fangs, upturned eyes, and clawed hands and feet, are similar to other carvings found elsewhere on site and in the region, indicating that the statue featured distinctive, possibly religious iconography that had widespread influence.

Since Chavín's acoustic environment includes disorienting, sound-distorting corridors as well as ducts that amplify low-frequency tones, it may have served as the setting for a ritual or ceremony during which people experienced plant-fueled hallucinations. Such visitors may also have heard the haunting low moans of voices or pututus emanating from the oracle where the monolith is concealed. Kolar raves, "We know there's something extremely special about this site. This is a place where people came to have an extraordinary experience." Her team believes priests or other high-ranking officials may have used the oracle to convey messages to visitors outside.

Kolar hopes to continue her work at Chavín, but she also aims to go to other locations to conduct research into other unexplained acoustical phenomena. In the past, she has investigated the sound of Istanbul's Hagia Sophia, the largest and grandest church of sixth-century Byzantium. For the future, sites such as Hopi kiva buildings in the southwestern United States are on her list. Because, just as the oracle of Chavín softly hums its riddles, the effects of acoustics on human beings still hold plenty of mystery. ■

←1. Horn of the netherworld: 20 decorated conch shells have been found at Chavín. Carved mouthpieces transform them into deep-sounding trumpets.



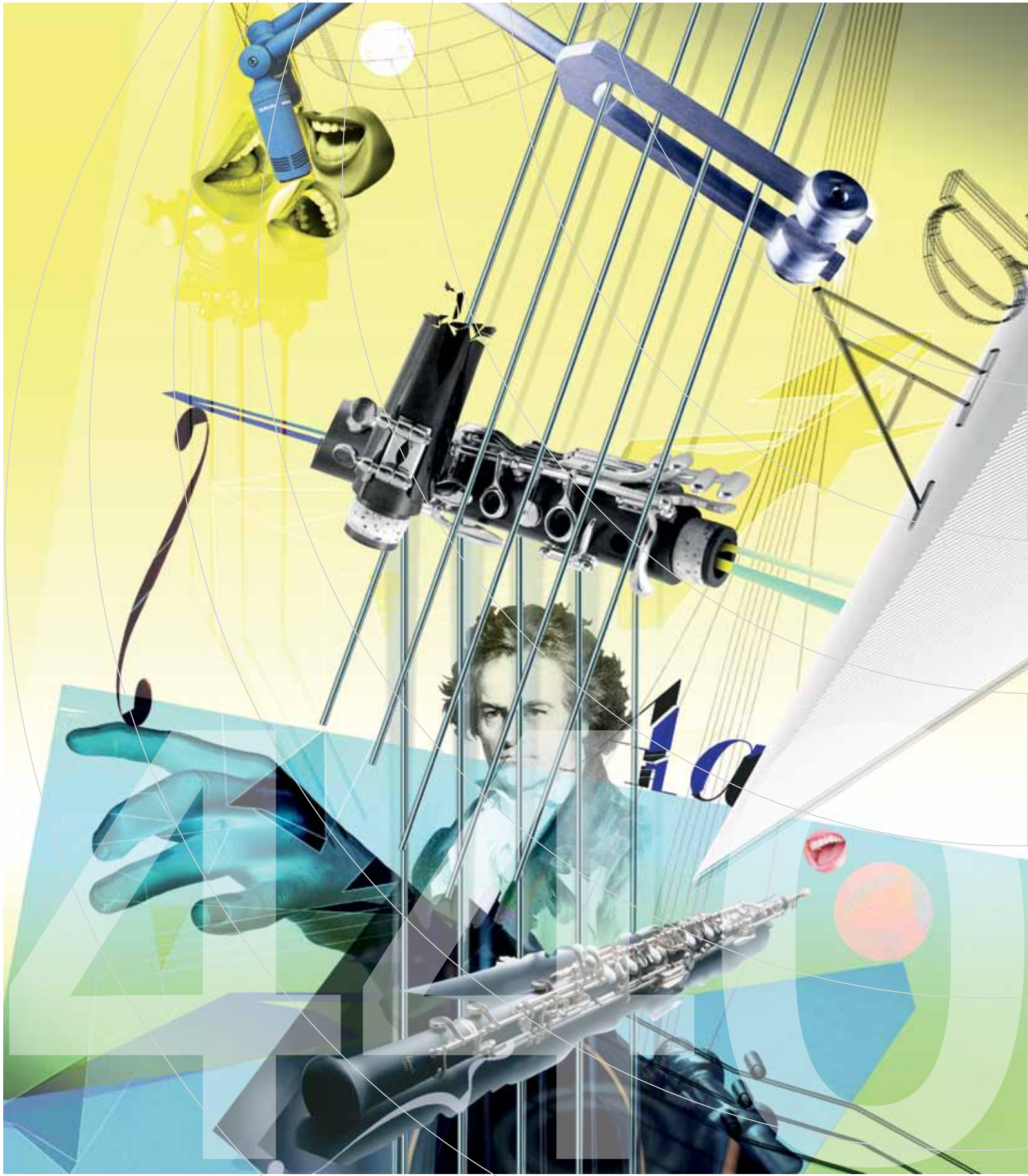
**ARCHAEOACOUSTICS**  
3 millennia – using a computer, speakers and microphones, archaeoacoustician Miriam Kolar bridges a vast gap in time. The doctoral candidate still doesn't know which deity was worshipped at Chavín, nor exactly by whom. But at least she has found out what the ancients used to come closer to their god: drugs, architecture – and the right sound.

# → KH 120 A

A near-field loudspeaker that employs the latest acoustical and electronic simulation and measurement technology to ensure the most accurate sound.

Neumann KH 120 A G 5.5+1 Active Studio Monitor	
Free field frequency response	52–21,000 Hz, ± 3 dB
Total harmonic distortion	> 100 Hz (< 0.5% at 95 dB SPL in 1 m)
Impedance electrically balanced	XLR, > 10k ohms
Weight	6.4 kg (14.1 lbs)





# THE GREAT PITCH INFLATION

Every orchestra is tuned to one single pitch. The higher it is, the brighter and more brilliant the instruments sound – and the more difficult it makes it for the singers. The history of a centuries-long struggle to establish the frequency of a single tone: “A.”

There is an air of excitement and expectation when you enter an opera house. People scurrying to arrive on time while others enjoy a glass of champagne or wait outside in the hopes of getting a ticket to an already sold-out performance. And as they begin to take their seats, the audience is greeted by a wild cacophony of sound as up to 100 orchestra members warm up for the performance by playing scales or taking one last opportunity to practice a particularly difficult passage. The theater pulsates with the expectation of the evening to come and heightened adrenaline as – behind the stage – soloists and choir, conductor and orchestra, prompter, technicians and stage managers prepare for the curtain to go up on an evening that will take on a life of its own.

And then – suddenly – absolute silence. That is, until the first oboist of the evening puts his lips to reed and begins to play. Like a snake charmer, the oboist’s clear, haunting tone seems to cast a spell on the other orchestra members who, without word, take up their own instruments to join in the master’s one-note song – “A.”

It is a ritual that has taken place since the 16th century, when early masters of the Baroque Giovanni Gabrieli and Claudio Monteverdi began laying the groundwork for the modern orchestra and opera. And yet, in a musical era marked by the orderly progression of tonal harmony, a striking dissonance soon began to resonate between the singers and instrumentalists: at what frequency should the pitch “A” be tuned?

Pitch is an auditory sensation that employs a cycle of vibrations per second (hertz) to assign notes on the musical scale. However, unlike frequency in physics, which is a pragmatic science based on the characteristics of wavelengths, pitch is the result of what we hear and, as such, can be extremely subjective. Like economic inflation, it tends to rise and fall according to demand.

During periods in which instrumental music rises in prominence relative to the voice, the tendency is for the concert pitch, the pitch used to tune the orchestra, to rise as well. That’s because, when tuned at a higher frequency, the increased tension of the strings gives string instruments a brighter, more brilliant sound. The singer’s dilemma is that the physiological function of the vocal cords is better suited to a lower concert pitch. In the Baroque period, for instance, the tuning of A fluctuated wildly between 392 cycles per second (A392) and 440 cycles per second (A440), a difference of almost one whole tone, leading German composer and leading music academic of his time Michael Praetorius to report how “pitch levels had become so high that singers were experiencing severe throat strain.”

The classical period is particularly noteworthy for its lack of pitch inflation. Looking to emulate the aesthetics of classical antiquity, the concert pitch was generally calculated

A GOOD VIBE  
**256** According to legend, passing blacksmiths at work, Pythagoras stopped to enjoy the beauty of the anvils as they were being struck. In doing so, he discovered a simple and uniform mathematical relationship between the frequencies. Later efforts to set the concert pitch according to the purity of the Pythagorean method failed.





using the Pythagorean method, in which the frequency relationship between all intervals is based on the perfect fifth. With its emphasis on mathematical purity, tuning was set at  $C = 256$  (A432), a binary system in which C remains a whole number all the way down to 1 Hz. The lower tuning marked the rise of the singer as composers such as Wolfgang Amadeus Mozart and Ludwig van Beethoven were able to better leverage the colors and nuances of the different natural vocal registers.

However, as classicism gave way to Romanticism, pitch inflation took a turn for the worse. During the Congress of Vienna in 1815, Czar Alexander I set off a pitch inflation alarm by calling for a brighter sound. Possibly as a means to placate a man with some 450,000 troops located near disputed territories and who claimed “I shall be King of Poland, King of Prussia and King of Saxony,” the crowned heads of Europe were immediately on board. While classical musicians resisted, the new Romantic school led by Friedrich Liszt and his son-in-law Richard Wagner began to drive pitch inflation until, by 1850, pitches among the major European theaters ranged from A420 to A460.

The issue seems to have become so heated among singers that a committee of composers championed by Giacomo Rossini called for the first standardization of pitch in modern times. Passed by the French government on February 16, 1859, the diaposan normal was set at A435. Within 20 years, however, pitch inflation had skyrocketed back up to A460, leading Giuseppe Verdi to complain that “what we call an A in Rome is a B-flat in Paris.” In an effort to address rampant pitch inflation, the Italian Parliament passed a bill to return to its classical roots of  $C = 256$ . Though Verdi’s tuning never became an international standard, pitch remained relatively constant (A432–435) until World War II.

Classical music of the 20th century mirrors an era marked by immense change. The balance of world power had shifted, and the sudden emergence and rapid pace of technology that took humans off the horse and to the moon brought words like “holocaust” and “nuclear war” into common usage. Life became an experiment and so did music, as

composers broke away from traditional tonality to create new innovations in musical forms and styles. Possibly in reaction to a world gone mad, efforts made in 1939, 1953 and as recently as 1971 to standardize concert pitch to A440 have been so compelling that many believe it to be the international standard it is not.

The jet age has put particular demands on the singer. No longer traveling by ship between the United States, Europe and South America accompanied by their own pianists and with their own costumes packed away in steamer trucks, these vocal nomads fly around the world, singing in Berlin one day and New York the next. A full stage rehearsal may mean nothing more than arriving at the theater before the performance and being walked through their paces. And whereas Rodolfo’s high C in “La Bohème” may have been tuned at A440 in Chicago, at A444 and above, the same high C would be even higher in Germany, causing some opera houses to transpose the aria down by a half-step.

As dramatic as innovations in musical form and styles were in 20th-century music, so was the rapid change in recording technology. What began as a mechanical device that used a horn to capture the now-famous words “Mary had a little lamb” was thrust forward by electricity and digitalization to create state-of-the-art technologies that have given sound engineers new digital tools to help dispel the specter of pitch hyper-inflation and possibly even resolve the pitch debate. For instance, the new Sennheiser MKH 8090, a wide cardioid condenser microphone with a sound that seems to “shine,” giving an orchestra the brilliance it demands at a pitch the singer longs for. ■

“WITH THE RIGHT MICROPHONE, THE SPECTER OF PITCH INFLATION CAN BE DISPELLED.”



## → MKH 8090

The high-quality microphone with a wide cardioid pick-up pattern is analog- and digital-compatible. It is particularly suitable for orchestral recordings.

Sennheiser MKH 8090 studio condenser microphone	
Frequency response	10–60,000 Hz
Pick-up pattern	wide-cardioid
Nominal impedance	25 ohms
Weight	25 g





1. A Ferrari pit stop: In amongst the roaring engine noise, double World Champion Fernando Alonso relies on Sennheiser technology.

1,000 Hz  
RACING GAME

# ... AND SUDDENLY IT WENT VROOOOOOOM!

Nowhere else are virtual reality and the real world more closely related than in motor racing. The lines are often blurred between racing simulation and the circuit, but one element is always constant: the right sound can make the difference between victory and defeat.

Someday, André Böttcher will get around to getting his driver's license. Maybe in a few months, once he's become Formula 1 World Champion. But to say it isn't exactly a top priority for the 20-year-old would be an understatement. After all, until he does get his license he's got the network of buses and trains to transport him comfortably around his home region – the Ruhr Valley in Germany. André's mission right now is to get his hands on the coveted FIA F1 trophy – in the virtual world, of course. While Vettel, Alonso and Räikkönen burn fuel and rubber on the F1 circuit, all Böttcher uses is a little electricity powering his simulator, but instead of competing against 20 other F1 professionals, he has to prevail against 40,000 competitors from all over the world in the online racing simulator iRacing. There's simply not enough time for something as run-of-the-mill as a driver's license.

The media and IT student from Herne, Germany is one of countless motor racing fans around the world who have immersed themselves in the world of racing simulation. No other simulation games are so real, nowhere else are the similarities between gaming and reality so strong. In fact, one iRacer has already made the jump to Formula 1. Finnish driver Valtteri Bottas now races for Williams.

André Böttcher is one of only 45 racers worldwide to have qualified for iRacing Formula 1. In order to maximize his chances, Böttcher has built himself an impressive simulator in his bedroom consisting of an aluminum frame housing a racing seat, three monitors, a Formula 1 steering wheel and robust pedals. Böttcher drives for

my3id-Gaming, a virtual racing team. He meets his team director, "mechanics" and fellow drivers from Finland, the UK and Brazil in a chat room, where circuits, engines and setups are discussed via headsets. Böttcher wears his headset while racing too, as the sound really makes the racing experience. Where are his closest competitors? Are they behind him to the left, or alongside on the right? Should he put his foot down or only lightly touch the gas pedal? Should he be braking? Böttcher absorbs all of this information through his headset, and is able to pinpoint the locations of the other cars on the circuit.

Thomas Jung is one step further than André Böttcher. He not only is a fervent online gamer, but also programs and "drives" racing sims at racing simulator producer Van Hese in Papenburg, Germany. When he's not trying out his skills in painstakingly developed Grand Prix cars or full-motion simulators, Jung is putting in the laps on online racing sim rFactor. Jung was a huge fan of the Sennheiser PC 151 for a long time, but then he discovered the benefits of the brand-new Sennheiser U320: "The ear pads adjust automatically to my head, and the headphones are light and very versatile," says Jung. "I can also adjust the in-game audio volume and the volume of fellow gamers separately."

Just like Böttcher, whose grandfather used to race around the famous AVUS circuit in Berlin, motorsport is in Jung's blood. He

**SINGING ENGINES**  
**1,000** Hz – that's music to any motor racing fan's ears. This is the frequency produced by a Formula 1 engine. At 15,000 rpm, the ten-cylinder monster screams out at 1,000 Hz. A regular four-cylinder, four-stroke engine runs at around 3,000 rpm and produces a mere 100 Hz.





grew up only a few miles away from the Nürburgring and often accompanied his father, who worked there as a medic, to the track.

Thomas Jung is the technical director of the Black Falcon racing team and oversees world-class racing drivers at 24-hour races. The team uses racing sims to save money, as on-track training is an expensive business. “These days drivers will learn new circuits in the simulator, especially young drivers,” explains Jung. “Once they get a chance on the real-life circuit, they practically know every single turn already.” The rFactor racing sim, open-source software that programmers are free to adapt and refine, is much more than simply a game for Jung. “The game’s physics even make it interesting to top-class motor racing teams.” One thing Jung needs is reliable headphones: “I have to be able to trust the headset 100 percent,” he says. “If something is wrong in that area, then the race is lost.”

In Formula 1 – real-world F1 this time – the legendary Scuderia Ferrari use Sennheiser headsets for pit team communications. “Headsets are absolutely vital in a sport such as motor racing,” says one Ferrari team member. Whereas such importance is attached to a detailed depiction of the racing environment in racing sims, the opposite is true when it comes to communications in the pits. However, top-

quality headsets are still an absolute necessity. “When the driver is talking to us, it’s vital that the sound is clear and not distorted,” says Thomas Jung from the Black Falcon.

Chris Dymond is another person who blurs the lines between simulation and real-life racing. He races in the Porsche Carrera Cup Great Britain and the FIA GT3 European Championship, but is also a star on iRacing online simulation. For Dymond, the sounds of his racing car on iRacing are even more important than when he is racing in the real world. “On iRacing there’s no way to experience the car’s physics,” he says. “There are no vibrations through your seat or the pedals. The absence of these sensations is what makes the sound so important.” That is why a high-quality headset is a must. “If the sound is poor, I make more mistakes,” he says.

However, despite the progress made in virtual racing simulation, Dymond still believes that it’s a world away from the true experience. Even if it becomes possible to simulate everything perfectly in future, from the weather to the penetrating smell of fuel and sweat in the driving seat, one aspect of real-life racing will never be able to be simulated: “The fear of something going wrong; something that even the top professionals cannot turn off.” ■

➤1. Almost like training for a space shuttle: Sim racer Thomas Jung in a full-motion simulator.

## ➔ U 320

There are two volume controls – one for the game audio and one for other players – and the microphone communicates your messages clearly and distinctly.

Sennheiser U 320 Multi-Platform Gaming Headset	
Frequency response (headphones)	15 – 23,000 Hz
Impedance	32 Ohm
Sensitivity	-38dV/Pa
Weight	284 g







1. Under a wall of gold and platinum: Anderson's grand piano is in Miami, but his students are everywhere. Here, he instructs Alicia Keys via Skype.



## "YOU NEVER ALLOW THE MUSIC TO TAKE YOU AWAY"

Ron Anderson is a vocal coach to the stars. In an interview with Sennheiser, he discusses working with Seal, Björk, Axl Rose and Pink – and lets us in on the secret of his technique.



VOICE TRAINING

On Anderson's house in South Miami is a repository of pop and rock history, walls lined top to bottom with gold and platinum albums, signed posters and photographs of seemingly every major artist in the world – Alicia Keys, Selena Gomez, Maroon 5, Red Hot Chili Peppers, Avril Lavigne, Seal, Pink and the Iglesias family. They have all stood by Anderson's nine-foot Knabe grand piano and received help from the erstwhile operatic tenor-turned-vocal-coach, whose fabled technique and persuasive manner can improve even the most damaged of vocals.

A tall, impeccable man with kingly bearing, Anderson spends as much time touring with acts as he does teaching from his studio, often via video. He can give as many as 12 one-hour lessons in one day. This Friday morning found him at 8 a.m. teaching young Russian tenor Alexander Kogan, who was preparing to tour with Julio Iglesias. Later came remote video lessons with Janet Jackson and with Alicia Keys, who was preparing for her national anthem performance during the Super Bowl. How does Anderson know what to do with such a vast array of voices and styles? Read on for the secrets behind one of the world's most noted vocal coaches.

*So many singers are successful and don't have great voices. And so many singers have beautiful voices and never become successful. What makes the difference?*

The entire package. You have to have the personality, you have to have the mentality and you have to have the talent. But the main thing is, you have to be you and nobody else. Once you have that, and you have that package, it's unstoppable.

*Let's say I have a great voice. Why do I need to come to you?*

You come to me because I can guide you. Each person has their own thing, and I bring out the best in them. Pop artists come to me because they don't have the training. And once they start to achieve the training, the registers open up, the voice's range goes to where it should go. Now, in the classical world, we've already got that kind of training. So we have to have another discipline. We have to take care of our bodies, and I bring that back into the pop world. They do a lot of things that they shouldn't be doing.

*How do you approach your lessons?*

The new ones I approach in person. I think it's very important, because you have to study the anatomy. You study the coordinations, you have to know the sounds and you have to see where the resonances are placed. After that, half of my business is online.

*What advice do you give all your singers?*

First of all, sleep. Sleep is the only thing that truly rejuvenates the voice. Watch your diet. Stay away from a lot of things that cause acid reflux. What time you eat. Don't go to bed for at least three hours after you've eaten. Watch your medication. Drugs. If I run into that, I'm off the tour. And I've gone off a couple. The real enemy is the cold.

*Technically speaking, what is the biggest mistake singers make?*

They over-sing. They think power is everything. You never sacrifice beauty for power; you always stay in control. You never allow the music to take you away. That's a big problem, and we all have that because we get involved in a performance. You start to get hoarse, the voice starts to get dry and immediately you have to start backing off. If you don't, you'll never make it through the concert.

*You were with the show choir Young Americans as a teen, and at 17 you had your first record deal with a boy group. But then, you hurt your voice and ...*

... I couldn't even talk for eight months! It was like, your life's over. Literally. That's the way I looked at it and I was really angry, because we had studied. But I found out that most of these teachers had no clue what they were doing, because many voice teachers are choir singers. They've never had to carry a show. Ever.

*You then went to two renowned voice teachers – Fritz Zweig and Lotte Lehmann – to get your voice fixed. You took lots*

BRILLIANCE & RADIANCE

2,800

Hz: this is the approximate frequency range where the singing formant of trained opera tenors lies. It is an effect that gives their voices a light metallic ringing. Enrico Caruso and Plácido Domingo had this formant, and Ron Anderson developed it in himself with hard work. With this type of powerful projection, a practiced "Heldentenor" can belt out his songs over the orchestra pit – without the sound getting stuck in the thicket of instrumentation. If laypeople try this, they will fail – even if they sing in a choir every week.



1. "Power isn't everything" – Anderson prepares Russian tenor Alexander Kogan (right) for his tour with Julio Iglesias.



2,800 Hz

VOICE TRAINING



of lessons and started studying opera. Were those studies the basis of your technique?

Yes. I was going through a vocal transition, becoming a Heldentenor [“heroic tenor”: the term given to the few voices that can sing the great tenor roles of German opera, especially Wagner]. But it took me 11 years because I could not find the teacher to move my voice up. Until I found the great British tenor Benvenuto Finelli in London. And in 10 minutes he did what none of the other teachers in 11 years could do. He had me singing an F above high C. It was unbelievable.

So what exactly is the Ron Anderson technique?

It’s the combination of several technical skills. There’s the German skill, there is the Italian skill and there’s also the French skill. They all have their own individual placements, and each person has their own, which is what I find in the very first three to five minutes of working with a singer.

You’re also known for fixing voices on stage ...

True. Take Björk: She was having problems. She also had a nodule, which I ended up getting rid of on the road with her. Seal, too, when he came to me, he had a nodule, and in three weeks I got rid of it, and then he said, “I need you to come on the road with me, I leave tomorrow.”

Seal, in fact, uses Sennheiser microphones. What’s special about the Sennheiser?

The Sennheiser is one of the top mikes in the market. They are very clear, they give a full-bodied sound, they don’t fade during the middle register and going into the top part of the voice – the upper registers – so the singers who use them really sing, and sing well.



←1. Anderson worked with US star Pink early on in her career.  
↻2. The voice coach also likes to sing – he is a trained Heldentenor.

An average human can hear between 20 and 20,000 Hz. Does the Sennheiser pick up this whole range?

Yes. There is a chip in that microphone, the Neumann Sennheiser Solution D, that goes from analog to digital immediately. So that makes everything much more even through register changes, right up to the higher part of the voice, where it can withstand all the power and softness. It has both ends, the light and the heavy.

Pink was your student, and is a Sennheiser artist. What was it like working with her?

I worked with Pink many years ago. She was very strong-willed, very opinionated of what she was and how she was and how to get there.

When laypeople hear a rock star seemingly scream for two hours – what don’t they know that you know?

I’ll give you an example. With Axl Rose from Guns N’ Roses, it took us six years to really develop his sound. Axl actually was a bass. He literally could go to a low B-flat below a C without a problem. It was a really deep, rich sound. But when we stretched the voice in the top he found the pharyngeal voice very quickly, which forms inside of the larynx and gives a very piercing sound. It worked for all the material.

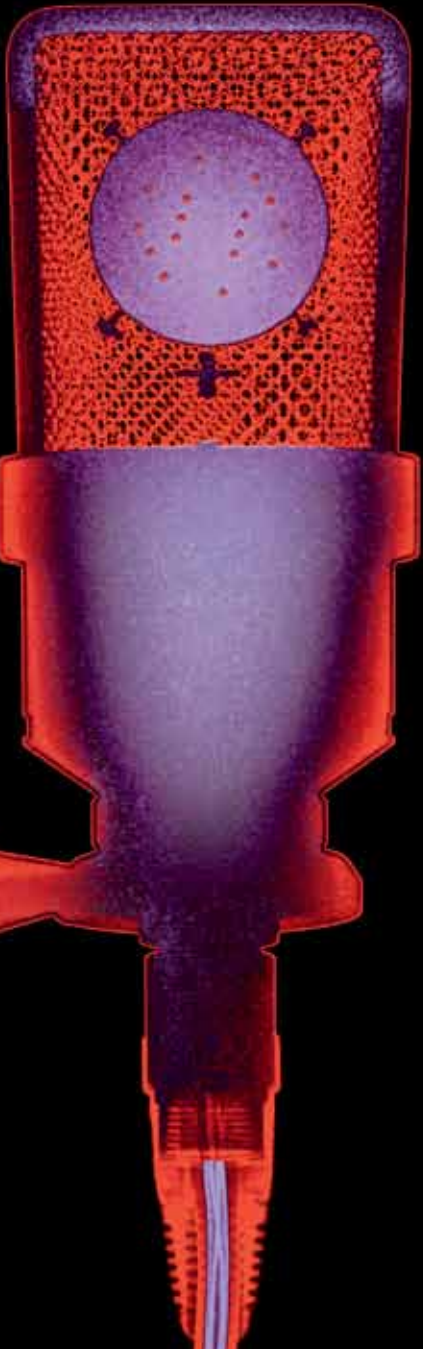
Clearly, the human voice is a fascinating thing to work with. What does it have that no other instrument has?

The flexibility to say words and the flexibility to sing those words with a great deal of feeling and a great deal of passion. Because without the feeling and the passion, you only have a voice. ■

→ NEUMANN TLM103D

Pure Neumann sound on the digital level. Because signal conversion happens directly in the capsule, A/D converters and pre-amps are no longer needed.

Neumann TLM103D digital studio microphone	
Frequency response	20 Hz – 20,000 Hz
Pick-up pattern	cardioid
Nominal impedance	50 Ohm
Weight	460 g (1 lb)





# TRIAL BY FIRE BEHIND THE SCENES

HD for the ears. With the Digital 9000 digital wireless system, uncompressed audio signals can be transmitted for the first time ever. The new technology made its debut during the television competition "The Voice of Switzerland."

8,000 Hz

BROADCASTING

The tension was unbearable in the Bodensee Arena in Kreuzlingen, Switzerland. So much so, that you could almost hear a pin drop. In a venue typically populated by ice hockey players chasing after pucks, four young singing talents were awaiting their fate. It seemed like an eternity before moderator Sven Epiney finally put the candidates, audience and people watching on TV out of their misery: "The Voice of Switzerland is Nicole Bernegger from Bern." There was no stopping it now. Suddenly, the hall turned into a madhouse of frenetic cheers, ear-piercing shrieks and thunderous applause. Yellow confetti rained down on the stage as the finalists threw themselves into each other's arms. And in the background, Bono Vox of U2 reminded us that it's a "Beautiful Day."

Just meters away, however, there was no time to take it easy. Behind the scenes of Swiss television SRF1, the team in the control room responsible for the program's perfect sound was under the gun. The next piece up was the beaming winner's musical acceptance speech and it should give the audience goose bumps. "A big sound for the big picture" was demanded, and the effort was enormous. On the central, all-digital mixing console alone, there were more than 160 channels to control the volume of the band's 60 microphones, and the 12 atmospheric and 36 additional mics used by the vocalists and presenters. It all came down to the audio engineers, who had to mix the sound before sending it on its long journey into people's living rooms.

Peter Flückiger of tpc – technology and production center switzerland ag, the production company in charge of the program – was on board. The sound expert, who has

"audio specialist" written on his business card, is simply thrilled by the sound of the show: "I can't think of many TV productions that have such a great sound." With more than 40 years of experience,

Flückiger is all too familiar with the television industry and the complex technology used behind the scenes. Even so, the singing competition's last season was a premiere of sorts for the Swiss. Following more than 10 years of devel-

opment work, it was the first time that Sennheiser's new digital wireless system Digital 9000 was on stage.

Digital audio systems are typically more difficult to handle and more susceptible to interference than analog systems. Yet, Flückiger wasn't a bit nervous about the Digital 9000's premiere. "I had nothing to fear," says the audio technician with a smile – a lot of problems can be taken care of with the right know-how and a good team. In preparing for "The Voice of Switzerland," one of the problems turned out to be the many LED walls on stage. However, by changing the positioning of the wireless Sennheiser microphones, they were able to achieve the desired results and produce a signal that was about 10 decibels stronger.

"I was immediately excited with the Digital 9000's sound quality," says Flückiger. The handling noises typical of earlier generations of wireless microphones have disappeared and, acoustically, it shows no difference from a wired mic. "Singers don't have to use a filter, it's got an awful lot of brilliance, and the sound isn't distorted," raves the technical manager. "Having the perfect acoustics gives singers a confidence boost." It's one of the ways in which technology can improve emotions. The audience can immediately sense whether a performer feels comfortable and is enjoying his or her performance, and Flückiger knows this. Swiss Sennheiser professional audio expert Rolf Jauch agrees: "Being able to fully rely on our technology makes it possible for singers to concentrate on their singing."

That's how candidates Nicole Bernegger, Angie Ott, Iris Moné and Sarah Quartetto were able to use their impressive vocal performances to make it to the final round of the competition. The frequency response of the human voice, which ranges from about 80 to 16,000 Hz, was exploited to the greatest extent possible – from the female's fundamental frequency (up to 250 Hz), to the typical voice range

**"ACOUSTICALLY, THE DIGITAL 9000 SHOWS NO DIFFERENCE FROM A WIRED MICROPHONE."**

←1. The control center. From here, sound technicians operate more than 100 microphones used for the Swiss television SRF1 program "The Voice of Switzerland."



**PAINFUL PROGRAM**  
**110** decibels is the volume required to recreate the atmosphere in a concert hall for television viewers when listening to a music program. Yet Peter Flückiger must chuckle at his own tongue-in-cheek recommendation, as these noise levels reach the output equivalent of a jackhammer. At this rate, it wouldn't take long to reach the threshold of acute discomfort.

(up to 2,000 Hz) to the highest, most brilliant tones at 2,800 Hz.

If the 10 audio technicians from tpc had made a mistake, even a singer's most beautiful overtones would have gotten lost. After all, the "The Voice of Switzerland" transmits live. Explaining the tremendous responsibility that rests on the shoulders of his colleagues, Flückiger says, "Viewers at home hear everything instantaneously." Both the 5.1 and stereo signals were mixed on site at the Bodensee Arena before being transmitted. "Sadly, it's not possible to convey the power felt in the arena on television ... no matter how good the microphones are," says the audio expert regretfully. As he says with a wink, "You would probably have to listen to the broadcast at 110 decibels in your living room."

It took Flückiger's audio team seven days to trans-



↑1. More than 160 channels in the control room. Together, they make up the sound of the Digital 9000. ↗2. Swiss audio specialist Peter Flückiger is thrilled by the sound of the Sennheiser microphones.



form the Kreuzlingen hockey arena into one huge, perfectly tuned acoustic TV studio – and a decade for Sennheiser engineers to achieve the Digital 9000's high standards. "We had to push the limits of the physically possible to develop a wireless microphone system with digital transmission and truly outstanding audio performance. And, at these physical limits, the technical complexity explodes," says Gerrit Buhe, Head of Development Electronics & Signal Processing at Sennheiser, as he describes the long road to the finished product.

With painstaking detective work, a tremendous attention to detail and working step by step, the sound engineers at Sennheiser were able to realize an even higher data rate, which resulted in the high-definition mode used during the Swiss talent competition. Unlike other wireless microphones, the Digital 9000 doesn't compress sound. Sennheiser is the only manufacturer that has been able to bring this type of technology to production. "There's no such thing as a perfect digital wireless microphone – but we're pretty close," says Buhe.

TV visionary Peter Flückiger already has an eye on the future. Should the 4K Ultra HDTV, which has four times as much full HD image resolution as HDTV, eventually push its way onto the market, Flückiger also wants to achieve a better sound. Not by using more channels, but through better quality and a more sophisticated spatial representation: "We haven't reached our limits." An attitude that is music to the ears of engineers at Sennheiser. ■



→ **SKM 9000**

The first digital wireless microphone comparable to analog devices, it provides artifact-free, uncompressed digital sound.

<b>Sennheiser SKM 9000 A5-A8</b> World-class digital transmitter	
Frequency response	18–20,000 Hz
Bandwidth	88 MHz
Operating time	5.5 hours (with BA 60 battery pack)
Weight	350 g





**OLIVIER HESS** His parents weren't particularly pleased with the Bowie poster hanging in his childhood room. When an older neighbor first brought Olivier's attention to the androgynous superstar, the son of German-French parents was immediately hooked. For our photographer, it was a particularly festive occasion to make a solitary pilgrimage through the sacred halls of the Victoria and Albert Museum five minutes before the opening of the exhibition "David Bowie is." Not that it's a first for Olivier, who has lived in London for more than 20 years. Olivier has worked as a photographer in more than 50 countries – from Japan to Cuba, and from Iceland to South Africa. For our last issue, he boarded a whale researcher's ship. That said, getting so unexpectedly close to his childhood idol was a very special experience for Olivier – despite the fact that his old posters have long since been taken down.



**MARILEE WILLIAMS** As a cellist, French hornist and lyric dramatic soprano, Marilee has been on both sides of the tone inflation debate. With a bachelor's from the Manhattan School of Music and two master's degrees from the University of Vienna (Austria), Marilee has performed such roles as the Countess in *The Marriage of Figaro* at the Bregezz Festival House, Hanna Glawari in *The Merry Widow* at the Royal Opera Houses of Antwerp and Ghent, and the title role of *Ariadne* in Italy and Hamburg. Today a journalist, she continues to give voice recitals. Apart from her own writing, Marilee also adapts the German texts written for this publication into English, including the 2010 English edition, which won Grand Prize for "Best Writing" at the 2012 Mercury Awards.



**JAMES DAWE** James Dawe, our illustrator for the story on pitch inflation, takes in and transforms elements from the everyday into something surreal and fantastical. He is an artist and commercial illustrator born and based in London, working predominantly in photo-collage and digital manipulation. The bright open studio space he shares with other like-minded creatives sometimes sees extra-curricular activities as far-fetched as the home-brewing of beer. Apart from that, James strives for a balance between his editorial and advertising commissions, which include the likes of Nike, Network Rail, *Bloomberg* and *Der Spiegel*, and developing his own personal works. A reoccurring theme in this side of James' work is the distortion of portraits, which are re-appropriated to form a new and abstract beauty.

# THOUGHTS AND EXPERIENCES OF SOME OF OUR AUTHORS AND ARTISTS PARTICIPATING IN THIS ANNUAL REPORT



**ELIZABETH SVOBODA** Having visited ruins in Peru as a teenager, author Elizabeth Svoboda was curious to learn how acoustic analysis could illuminate the lives of ancient Peruvian peoples who left behind no written records. Researcher Miriam Kolar – who has spent years at the Chavín de Huántar site studying its former sound landscape – gave Svoboda a fascinating firsthand glimpse into a world where musicians played haunting melodies on shell trumpets and priests broadcast messages to visiting pilgrims via an elaborate network of sound-amplifying ducts. In addition to writing for magazines like *Psychology Today*, *Salon* and *Popular Science*, Svoboda recently completed her first book, titled "What Makes a Hero?: The Surprising Science of Selflessness."



**DONATA WENDERS** The artist of our essay drew photographic inspiration from people "whose inner radiance, hopes and dreams I can see just in a gesture or attitude." Thus it was that she met the violin-maker Martin Schleske, and accompanied him as he worked in the studio, laboratory and forest. From this emerged the sensitive and feeling-charged pictures that were used for the calendar diary "Klangbilder" [Sound Images] (Kösel, 2011) and for Schleske's "Der Klang. Vom unerhörten Sinn des Lebens" [Sound: The Unheard Meaning of Life] (Kösel, 2010). Other photos by Donata Wenders have appeared in *The New York Times*, *Vogue*, *Rolling Stone* and many other periodicals. She has also published books together with her husband, Wim Wenders.



**LEILA COBO** A Fulbright scholar and native of Cali, Colombia, Leila trained as a classical pianist at the Manhattan School of Music, but always dreamt of a career as a pop or Broadway star. Sadly, she met Ron Anderson too late to make a difference to her vocal chops. Instead, she published two novels, and is now the executive director of Latin content and programming for *Billboard Magazine*. Although Leila's own focus has shifted away from singing, she covers just about every Latin pop singer on the scene, featuring in-depth interviews with artists like Juanes, Maná, Juan Luis Guerra and Gloria Estefan.



MASTHEAD

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SYMBOLS OF EXCELLENCE



To date, Sennheiser annual reports have been recognized with 31 Corporate Publishing Awards.

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# FINANCIAL REPORT 2012

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# REPORT OF THE SUPERVISORY BOARD

The Supervisory Board of Sennheiser electronic GmbH & Co. KG has examined the Consolidated Management Report and the Consolidated Financial Statements for financial year 2012, which were submitted on time by the management. In the year under review, Sennheiser Beteiligungs-GmbH was responsible for the management of Sennheiser in its capacity as general partner.

The Presidents of the general partner were Volker Bartels (Corporate Services and Speaker of the Executive Management Board), Dr. Heinrich Esser (Professional Systems),

Daniel Sennheiser (Strategy and Finance), Peter Claussen (Integrated Systems) and Dr. Andreas Sennheiser (Supply Chain). In addition to the Presidents, further members of the Executive Management Board were Peter Callan (Consumer Electronics) and Paul Whiting (Global Sales).

The members of the Supervisory Board this year were Dr. Frank Heinrich, Andreas Dornbracht and Johann Soder; Prof. Dr. Jörg Sennheiser again served as Chairman. During its regular meetings, the Supervisory Board carefully monitored the situation and development of the Sennheiser Group. Between meetings, the management kept the Supervisory Board up to date on all major projects and company events, either orally or in writing. During its four full-day Supervisory Board meetings, the management and Supervisory Board held in-depth discussions and made joint decisions on the following issues:

- The revised overall Group strategy, which focuses on the premium range in the markets and market segments we operate in, was welcomed and approved for further specification, development and implementation.
- One consequence of this revised overall strategy was the clear necessity for selective distribution. In all four Supervisory Board meetings, the further development of this adjusted sales structure was pursued, discussed in-depth and subsequently approved for implementation in the following year.
- The foundations of the strategy for the Integrated Systems Division were developed, presented and implemented step by step by those responsible within the division. The gradual development from a general concept to a specific strategy caused this issue to be on the Supervisory Board meeting agenda on several occasions. The results were welcomed by the Supervisory Board, as this precise and focused strategy lays the foundations for the future financial success of our smallest and youngest business division.
- The discussion of meaningful, highly transparent figures was a recurring topic. This level of transparency can be achieved by reducing the complexity of certain processes according to the divisional organization of our company and will enable us to gradually allocate costs that arise according to the costs-by-cause principle.

- In the middle of 2012 and after over a year of negotiations, an agreement concerning the takeover of our Swiss representative Bleuel Electronic was concluded. As a result, the integration of this subsidiary, renamed Sennheiser (Schweiz) AG, into the Sennheiser Group was completed. The Supervisory Board welcomed the successful conclusion of negotiations and would like to warmly welcome the employees of Bleuel Electronic to Sennheiser. With the completion of this takeover, this important and dynamic sales market has now been directly integrated into our sales activities.
- The Supervisory Board is kept regularly updated by the management on plans to expand the Innovation Campus at the Wennebostel facility. An effective design concept was developed by the architect assigned by the company on the basis of the newly revised spatial requirements assessment. The relocation of parking spaces necessary for the realization of the Innovation Campus has been guaranteed through the acquisition of adjacent plots of land. Working together with the municipality of Wedemark, the draft development plans were put out to tender and released for public approval.

Once again, planned turnover and profit were exceeded in financial year 2012. The Supervisory Board would like to thank the members of management and all employees for this success, which has made a significant contribution to safeguarding jobs and the necessary investments in the future.

The Consolidated Management Report and the Consolidated Financial Statements compiled by the management were audited by auditing firm Deloitte & Touche GmbH and confirmed unconditionally. The Supervisory Board has ratified the auditors' reports in full and recommends that the shareholders accept and approve them.

Wedemark, April 19, 2013

Prof. Dr. Jörg Sennheiser, Supervisory Board Chairman of Sennheiser electronic GmbH & Co. KG



# CONSOLIDATED MANAGEMENT REPORT 2012

## PRELIMINARY REMARKS

As the parent company of the Sennheiser Group, Sennheiser electronic GmbH & Co. KG prepares consolidated financial statements every year.

The company’s production sites are located in Wennebostel (Germany), Tullamore (Ireland) and Albuquerque (New Mexico, USA). While Wennebostel chiefly manufactures wireless and wired microphones and microphone capsules, monitoring systems and headsets, the plant in Albuquerque concentrates on wireless microphones and monitoring systems. The Tullamore facility manufactures headsets and headset transducers. The company has a branch office in Singapore that manages the functions of product management, marketing, purchasing and part of product development for the consumer electronics area.

Besides the parent company Sennheiser electronic GmbH & Co. KG, the Sennheiser Group includes seven subsidiaries within Germany and 19 subsidiaries abroad, as well as the joint venture Sennheiser Communications A/S based in Copenhagen, Denmark. Sennheiser Audio Labs GmbH, Wedemark, Germany, was established in the year under review. In addition, Sennheiser (Schweiz) AG, Unterengstringen, Switzerland, joined the Group following the takeover of Bleuel Electronic AG.

## ECONOMIC DEVELOPMENTS DURING FINANCIAL YEAR 2012

Overall Business Developments and Development of the Industry

### THE GLOBAL ECONOMY

[ Development ]

Overall, the global economy continued to lose ground in 2012. After a weak first half of the year, global growth stabilized in the second half of the year. However, high debt and unemployment in many industrialized nations, as well as Europe’s debt crisis and other risk factors, restrained economic growth significantly.

Together with the European Central Bank (ECB), Europe’s national governments managed to curb the risks of the debt situation. In particular, they were able to prevent the dreaded and seemingly inevitable collapse of the European Economic and Monetary Union (EMU), enabling the Eurozone to put a check on the looming impact on consumer confidence and growth and soothe global financial markets – at least for the time being. The euro was able to recover slightly as a result.

In global terms, price inflation continued to wane, even though some industrialized nations and currency unions significantly expanded the money supply. Although food prices went up in the second half of the year, the effect was not enough to fuel global price inflation. Global prices for raw materials varied greatly over the course of the year. However, apart from a few exceptions, they remained largely unchanged year on year.

The favorable outlook for inflation enabled the central banks of major industrialized nations to further expand the money supply. Most emerging markets took a less restrictive stance when it came to their monetary policy.

The emerging markets were once again the main drivers behind global growth last year, especially in Asia and South America. Growth in Africa was particularly worth noting. The continent has advanced to become the world’s fastest-growing economic region, albeit at a low level of income.

Global economic growth will continue to gain stability in 2013 and will gradually pick up steam. While it remains necessary to keep an eye on various geopolitical risks, a number of positive surprises could be in store this year. For instance, consumers and businesses have built up a considerable backlog in demand. In the wake of the global financial crisis, consumers and businesses grew very cautious about spending, instead preferring to save more and reduce debt. There are signs that this trend is now slowly reversing, especially in the USA and parts of Asia.

[ Outlook ]

As in 2012, global prices for raw materials in 2013 seem likely to remain largely stable. In some markets, prices – especially for crude oil – are under pressure on account of weak growth in demand and relatively high inventories. However, stronger growth in China and the rest of Asia could drive up prices as the year continues.

### THE EUROPEAN UNION

Economic growth has been weak in Europe since mid-2011. In 2012, economists merely recorded brief, temporary recovery at the start of the year. However, for the last quarter of the year, they estimated that the EU’s gross domestic product would shrink, especially in the Eurozone. In fact, economists expect the final figures to reveal that the EU experienced a mild recession on average over the course of 2012.

[ Development ]

The main factor behind this poor performance was the debt crisis in the Eurozone, which continued to grow in severity until the third quarter of 2012. This situation was exacerbated by a slowdown in growth in key markets, such as the USA, China and Brazil. The fiscal policies of the Southern European countries most affected by debt problems, some of them extremely restrictive, put an additional damper on pan-EU growth.

In terms of economic growth, European countries have drifted further and further apart since 2010. Germany, Austria, Finland and Luxembourg all reported continued modest growth in the year under review. In contrast, every Southern European country was clearly mired in recession – a fate that the Netherlands also shared in



2012. Unemployment reached record levels in Spain, Italy and Greece. Even Great Britain and Germany reported slower growth, although the dip in performance in these countries was far less severe.

[ Outlook ]      The crisis in the Eurozone is far from over. However, a temporary easing is apparent. The reason for this is the above-mentioned decisions made by the ECB and Europe’s national governments in the second half of 2012, which included the pronounced expansion of the money supply.

This easing of the situation in Europe comes at the same time as two additional favorable developments: the global momentum already described and a slight downward inflationary trend, which should allow the ECB to continue expanding the money supply well into 2014. As a result, uncertainty continues to wane for investors and consumers. The chances are good that this trend will result in increased demand and an associated gradual economic recovery in Europe.

Overall, we expect the economy in the Eurozone to shrink slightly on average in 2013. However, this is due to the decline in gross domestic product (GDP) that began in the course of 2012, particularly in the second half of the year.

GERMANY

[ Development ]      As in 2011, Germany’s economy significantly outperformed the European average in 2012. However, Germany was unable to completely avoid the downward spiral that increasingly worsened over the course of the year. This negative trend resulted from a weakening of global economic momentum lasting until mid-2012 and the renewed exacerbation of the European government debt crisis.

Despite the general impression, exports – not the domestic economy – were once again the greatest driver of growth. Germany remains very competitive on the international stage. As a result, resilient growth in exports to non-European countries was able to compensate for lower demand in many parts of Europe.

Although industrial production had been mired in a downturn since August 2012, exports did not post a clear decline until the fourth quarter. In contrast, consumer confidence held unusually steady at an above-average level over the course of the year, likely fueled by a resilient job market and solid wage growth. While unemployment figures started to creep up slightly in April 2012 after three years of declines, the number of people employed continued to rise.

German industry’s capacity utilization was slightly below the long-term average at the end of the year under review, even though industry had recorded a cyclical high in mid-2011. This development defied the concurrent slowdown in investments and proves the extent to which demand has fallen since mid-2011.

At the same time, German businesses reacted to this trend early with more cautious warehousing. Production should therefore increase quite rapidly as soon as demand recovers, leading to investments that have so far been postponed.

The relatively pronounced drop in GDP in the fourth quarter of 2012 will limit (seasonally adjusted) average growth in 2013 to the level seen in 2012. Barring a serious renewed deepening of the Eurozone crisis, the lower level of uncertainty should be reflected in the form of increased demand and associated economic growth. In addition, the more positive outlook for the target markets USA and China will support the German economy.

Private spending has room to grow. In the year under review, uncertainty meant that consumers did not spend as much money as expected in view of increasing employment and pay raises.

The massive improvement in public finance over the past two years has also had a positive effect. The eased fiscal position has opened up leeway for fiscal policy decisions aimed at quickly counteracting a new crisis with public spending.

THE SITUATION OF THE ELECTRICAL AND ELECTRONICS INDUSTRY IN GERMANY

The German electrical and electronics industry suffered an economic setback starting in the second quarter of 2012. Although turnover recovered quickly in 2010 and 2011, earnings had yet to reach pre-crisis levels by the end of 2011.

Capacity utilization in the electrical and electronics industry reached a low of around 70% in mid-2009. Just two years later, it had climbed to a cyclical high of 86.3%. This figure has since fallen from its peak to 81.1% in early 2013. As a result, capacity utilization was not only well under the record value of 88% (2008), but also slightly below the long-term average of 83%.

In light of the temporary escalation of the government debt crisis in the Eurozone, it is remarkable that sales outside Germany held up better than domestic sales in the year under review. The chances of demand within the Eurozone stabilizing over the course of 2013 have even increased due to a partial easing of the crisis situation at the end of 2012 on account of measures by the European Central Bank and Europe’s national governments. The economies of the USA and Asia’s emerging markets have also recently picked up steam. In comparison, the euro’s moderate recovery since August 2012 has had only a slight cushioning effect. Although the dollar exchange rate in early 2013 was slightly over \$1.30 to the euro, it is important to keep in mind that the electrical and electronics industry was dealing with an exchange rate of \$1.45 to the euro 18 months earlier. The exchange rate even climbed up to \$1.60 in the boom year 2008.

All told, we expect to see a tendency towards recovery in the electrical and electronics industry in 2013. The lower level of uncertainty over the impact of the Eurozone debt crisis and increasing global economic momentum make us cautiously optimistic. Still, incoming orders have been by no means brisk in recent times, even taking



the moderating statistical effects into account. This development is not a surprise, however, in view of the deep recession in a number of Eurozone countries. The structural changes in the crisis-stricken countries are not a purely economic phenomenon and are likely to persist.

Zentralverband Elektrotechnik- und Elektronikindustrie (ZVEI), Germany’s central association of the electrical and electronics industry, is therefore forecasting a modest growth in production of 1.5% for the industry for the current year. The Executive Management Board believes this forecast is realistic.

ASSET, FINANCIAL AND OPERATING POSITION

Asset Position

The balance sheet total came to €352.0 million in the reporting year, rising by 11.7% from €315.1 million in the previous year. The main reason for this rise is the increase in inventories and current receivables. The value of inventories was increased so as to improve supply flows in view of the rise in turnover.

Pension provisions went up by €2.7 million to €67.4 million, while other provisions rose by €0.2 million. The results for the year boosted both equity and liabilities.

Financial Position

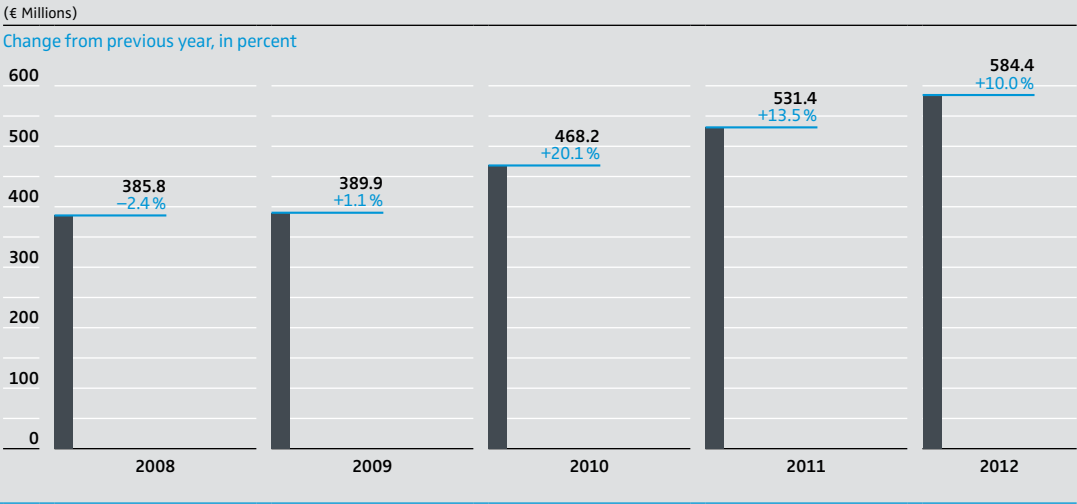
Cash flow from current business activities amounted to €37.6 million (previous year: €65.5 million). This was sufficient for the Group to cover its investments and financing.

TURNOVER AND OPERATING POSITION OF THE SENNHEISER GROUP

[ Development ]

The Sennheiser Group closed financial year 2012 with highly successful results. Total turnover grew by 10% to €584.4 million.

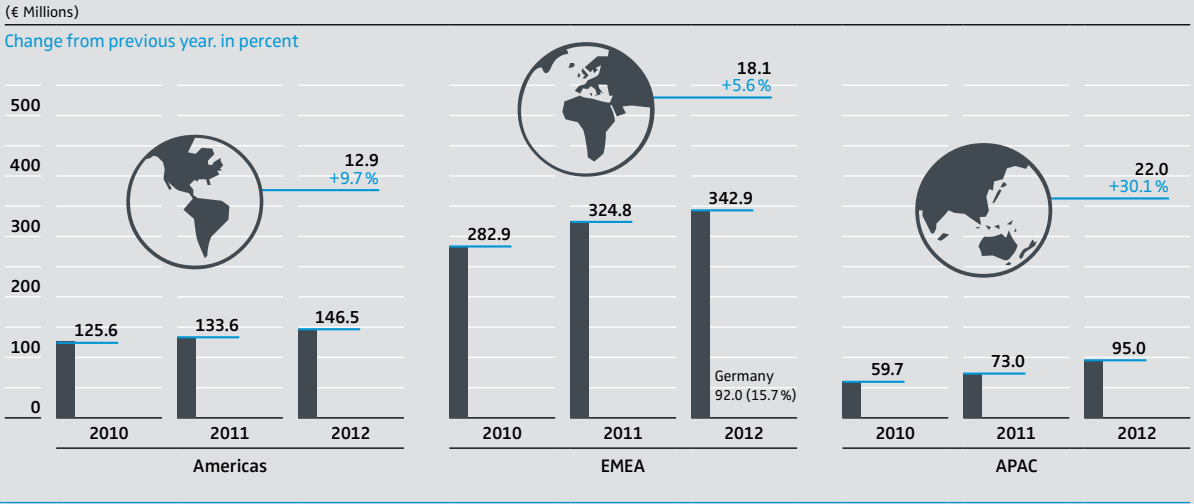
TURNOVER



Also, the USD/EUR exchange rate, which rose sharply, was one of the main growth drivers in the Americas (North, Central, and South America), boosting growth by 10% in this region. At 6% turnover growth, the EMEA region (Europe, Middle East, and Africa) was unable to quite match this performance. The above-average growth of 67% in the Eastern European sales regions contributed to this nevertheless positive development. Although at a lower level, the extraordinarily positive increase in the APAC region (Asia and Australia) of 30% growth also made a significant contribution to Sennheiser’s turnover growth.



TURNOVER BY REGION



The result from ordinary activities decreased by 11.5% year-on-year to €51.9 million. The reasons for this decline were a €47.3 million rise in material costs and an increase of €16.3 million in personnel expenses. EBT therefore amounted to 8.9% of turnover.

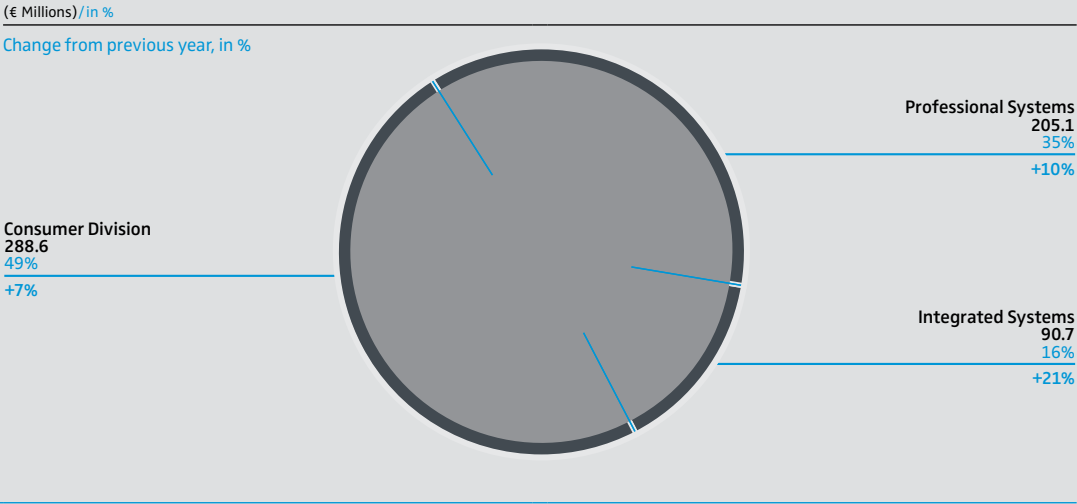
[Outlook]

We expect that the consistent implementation of the divisional reorganization of the Sennheiser Group into the Consumer Electronics, Professional Systems and Integrated Systems business divisions will continue to enhance our customer orientation.

We furthermore anticipate the Group turnover and result to continue growing in the medium term, despite the increasing uncertainty in the market.

Turnover by business division was as follows in the reporting year:

TURNOVER BY BUSINESS DIVISION





CONSUMER ELECTRONICS DIVISION

The Consumer Electronics Division generated turnover of €288.6 million in the year under review. This corresponds to a increase of 7% over 2011.

At the same time, competitive pressure increased against the backdrop of economic turbulence. Never before have the barriers to entering the mass market for headphones been so low. New competitors are coming from the fashion and automotive industries as well as other branches of consumer electronics. The result is a highly fragmented market that is today subject to greater fluctuations than ever before. In light of these developments, we have consciously decided to slow down our planned portfolio optimization. Radical changes were not realistic on account of the economic situation in certain markets. However, we intend to focus on these plans again as soon as the external circumstances permit us to do so.

The premium segment continues to be at the heart of our strategy. Increased competition in Europe requires new commitment in this market to secure market share.

Sennheiser was very successful in Asia this year as well. We intend to increase this growth further. The diversity and variety of the Asian market requires a differentiated approach.

Wide-ranging experience, strategic expertise and technical know-how are the three advantages we intend to leverage to set the Sennheiser brand apart from the competition. This strategy is particularly relevant in a difficult economic environment, as the industry clearly recognizes our technical know-how.

For instance, the European Imaging and Sound Association (EISA), comprising 50 trade publications, named our Irish-made HD 700 headphones “European Hi-Fi Headphone 2012-2013.” The product also received the TEC award at NAMM 2013.

Our IE 800 ear canal phones received the “Best of Innovations” award at the 2013 Consumer Electronics Show (CES) in Las Vegas. According to the independent panel of industrial designers, engineers and media representatives, the German-made ear canal phones “are at the top of their class, possessing the most innovations per cubic millimeter.”

The response to our new MOMENTUM headphones has been excellent. MOMENTUM is our answer to the growing popularity of lifestyle headphones. The high-quality circumaural headphones combine earcups and a headband made of brown leather with a minimalistic stainless steel earcup slider. MOMENTUM was unveiled at IFA in 2012. Building on this success story, we presented MOMENTUM Black at CES 2013, which was met with praise from industry and media representatives.

INTEGRATED SYSTEMS DIVISION

The Integrated Systems Division closed 2012 with turnover of €90.7 million. This corresponds to growth of 21% year on year. The division recorded significant turnover growth in wireless microphones and information systems.

One of the focal points in the year under review was reviewing and finalizing the strategy for the new division. The division now has a clear strategic path mapped out by the company’s strategy and Sennheiser’s values.

At the start of the year, the ADN system, our digital conference solution, was further expanded. The Sennheiser Easy Control application makes it possible to control and monitor the ADN discussion system from a remote location, especially in conjunction with our evolution wireless G3 300 and 500 series as well as the 2000 series transmitters and receivers. For example, the app can be used to monitor the battery’s state of charge, to control the equalizer or to assign names to the various devices. The ADN conference solution can be used to start recordings, to set the conference mode and to provide direct access to up to 15 discussion units so that the administrator can designate the chairperson’s unit or open microphones so that participants may speak.

At mid-year, we unveiled the world’s first AVB microphone at Infocomm in Las Vegas. The prototype received the “Best of Show” award. We firmly believe that AVB will play an important role in the AV industry in the future.

In the second half of the year, the development of LSP 500 PRO, an innovative, wireless PA system, was driven forward. Thanks to its excellent scalability, the PA system is perfect for events of any size. The system allows users to play music via a cable interface or Bluetooth and enables the use of wired and wireless microphones. Up to 20 such systems can be connected to each other via wireless link and controlled using a multifaceted app, which also functions as a mixer, among other features.

PROFESSIONAL SYSTEMS DIVISION

The Professional Systems Division generated turnover of €205.1 million in 2012. This corresponds to 10.0% growth year on year. The regions America, Asia and Australia contributed a disproportionately large share to this growth.

The new XS Wireless entry-level radio microphone was unveiled at the Prolight+Sound trade fair in Frankfurt. XS Wireless replaces the previous Freeport models. Sales of this new product family have performed very well.

For the aviation market, we unveiled the new S1 Passive headset. This high value-for-money headset followed on the heels of the S1 Digital flagship model. The new model is based on the S1 platform and is designed for private pilots and student pilots who value both excellent noise attenuation and optimum comfort.



In summer, the new fully digital Digital 9000 wireless microphone system was officially unveiled at the International Broadcast Conference (IBC) in Amsterdam. The launch was accompanied by premiere events worldwide. The technically outstanding D 9000 system provides a high-end addition to Sennheiser's portfolio of professional wireless link products. It offers uncompromising digital radio transmission with excellent sound quality and the ability to take advantage of nearby radio frequencies for particularly efficient use of the available frequency range. Our customers in broadcasting, theaters and equipment rental have welcomed D 9000 with open arms. They appreciate the system's excellent sound quality, ease of use and robustness.

We also unveiled the new MKH 8090 and MKE 600 microphones at the IBC. The MKH 8090, with its super-cardioid pick-up pattern, was designed for special applications and is perfect for orchestral recordings, expanding the range of uses of the successful MKH 8000 product family. The sound design was developed in close cooperation with experienced sound engineers and technicians. In contrast, the MKE 600 shotgun microphone was designed with freelancers and hobby filmmakers in mind. The MKE 600 offers this growing segment the right combination of excellent audio quality, simple use and robustness at an attractive price.

With the KH 310 studio monitor, Georg Neumann has provided a larger three-way model for its successful KH 120 studio monitor. In doing so, Neumann is addressing both the need for conventional stereo applications as well as the attractive segment of larger surround systems. We unveiled the KH 310 in October 2012 at the AES Convention in San Francisco, where the organizers of the event, the international Audio Engineering Society (AES), gave the studio monitor its "Best of Show Award." The monitor went into production ramp-up during the first quarter of 2013.

SUPPLY CHAIN MANAGEMENT

Turnover at our production site in Wennebostel, Germany, increased significantly in 2012. This is mainly attributable to demand for wireless microphone systems, which continued to grow, thanks in great part to the established ewG3 systems and the professional 5000 series. In the year under review, we also created high-quality jobs for the assembly of the new Digital 9000 wireless microphone systems and for the HDVA 600 and HDVD 800 headset amplifiers.

Activities at the Wennebostel site focused on increasing production stability and efficiency, which was achieved by way of closer cooperation with the development departments within the business divisions. The year 2013 will be marked by consolidation of the growth seen in recent years and by paving the way to future opportunities for growth.

The Sennheiser plant in Tullamore, Ireland, recorded significant year-on-year sales growth. Both finished headsets and acoustic transducers posted major increases. The new premium headsets played a major role in this growth. The Tullamore site operated at full capacity in the year under review. Since we expect demand to increase in 2013, we invested in the enlargement of production capacities.

The Sennheiser site in Albuquerque, USA, recorded stable turnover throughout 2012. Activities at the site focused on continuing LEAN management efforts, which resulted in improved material flow and optimized warehousing of finished goods in close cooperation with Sales.

The trend towards lower inventories at key suppliers led to longer yet overall stable delivery times in 2012. The fact that the increase in prices for so-called rare earth elements, with China as the main market behind price developments, has ended for the time being can be seen as positive. The second-source strategy, launched a few years back, has been stepped up, especially for professional microphones.



HUMAN RESOURCES

Against the backdrop of a rapidly changing future employment market, a specific strategy for human resources at the Sennheiser Group was created in 2012. The most important areas of action for Sennheiser were identified on the basis of research on the topic of “the future of work,” and the required projects were established. Aspects of globalization were considered, along with the lack of specialist staff and the demographic changes affecting society.

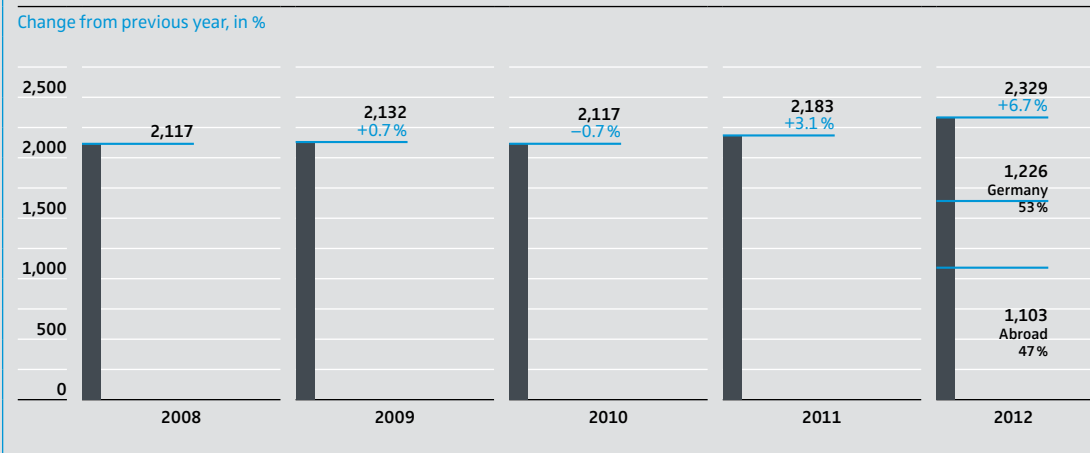
The satisfaction of Sennheiser Group employees was investigated on the basis of a survey for the first time in 2012. The analysis revealed above-average positive values for the so-called Employee Engagement Factor and pointed to further potential in the use of this high commitment. The results were considered by employees and managers in follow-up workshops in the various organizational units, allowing suitable measures to be developed.

In the future the survey will be carried out as part of an annually rotating 360 degree management feedback process. This will allow us to assess the effectiveness and sustainability of the measures taken over time.

[ Development ]

The annual average staff level at the Sennheiser Group increased by 6.7% to 2,329 in 2012, including 76 trainees (previous year: 75). At the end of the year, the number of employees at the Sennheiser Group was 2,465 (previous year: 2,248). An average of 53% of all employees were working for companies in Germany and 47% for companies abroad.

EMPLOYEES



RISK MANAGEMENT

In 2012 Sennheiser introduced a central risk management function. It was supported by the established controlling system, which monitors, manages, and supports all business processes within the Group. This allows deviations to be quickly identified and effective counteracting measures to be put in place. The Group-wide divisional reorganization continued in Controlling. The transparency of structures and processes was increased as a result. This went hand in hand with the development of strategic and operational planning and reporting tools – which will continue to be developed in the future – for analyzing and assessing medium- and long-term opportunities and risks.

In the financial year under review, Sennheiser continued its growth trend from the previous year. But the future growth of the Group will still depend on economic changes around the world. In order to disperse risks, the Sennheiser Group will continue to focus on different business areas. Increased investment in brand development, particularly in North America and Asia, as well as in Europe, will help to reduce the company’s dependence on the general economic climate.

Liquid resources, inasmuch as they are not required by subsidiaries for daily business, are concentrated in the parent company on the basis of a cash pooling program. Cash and cash equivalents are deposited with several banks and are mainly denominated in euros. Fluctuations in Sennheiser’s most important trading currencies had a significant impact on business developments in 2012. The high percentage of turnover generated in US dollars again created currency risks in 2012. These were successfully offset by concluding an increasing number of purchases in the US dollar zone, a strategy that the company has been continuously employing for years. We counteract general default risk with effective customer management. A broadly diversified customer structure also helps us in this respect.

The globally valid property, liability and transport insurance policy covers the interests of the entire Group, including all affiliated companies. A Group-wide insurance policy is also in place to protect against reciprocal risks within the Sennheiser Group and against consequential damages caused by defaulting suppliers.

The brand and product piracy risk has become a permanent threat for renowned manufacturers in the wake of globalization. Sennheiser cooperates internationally with lawyers and authorities to effectively curb this risk. The implemented measures include raids, the seizure of products by customs, shutting down trade fair stalls, and closing down websites and other online offerings. We take legal action against parties that are in breach of industrial property rights. In 2012, we continued to carry out raids in cooperation with other companies, primarily in Asia. An interdisciplinary task force with the aim of increasing product security was also founded. The result was a product security concept which will allow customers to authenticate genuine Sennheiser products online in the future.

Political decisions threaten the use of the UHF frequency range in its present form.



Significant parts of the UHF spectrum have been repurposed for new applications, for example, the LTE mobile communication standard, so-called “wireless DSL.” The EU is planning to reserve further frequencies for the use of security services, and for broadband and military applications. This creates a threat to frequency resources used by professional microphones and monitor systems.

The implementation process will take many years in Germany and across the whole of Europe. The attempts of large companies to establish so-called “White Space Devices” for the transfer of data on the UHF band pose a further risk to the uninterrupted use of this frequency range for wireless production tools. Sennheiser has been preparing for the restriction of the UHF spectrum for some years now, in order to provide its customers with disruption-free productions and therefore safe investments for the future. These measures include the development of cognitive technologies. We will also explain the negative impact of the reduction of the spectrum to decision-makers in politics and administration, thereby raising awareness to the increasing number of wireless productions and focusing our attention on quality improvements in wireless production equipment, which also require a broader spectrum (HD images – HD sound). A newly established team of Sennheiser specialists will be involved in the coordination and use of the remaining UHF spectrum.

**OUTLOOK FOR FUTURE DEVELOPMENT**

In 2013, we will work to consolidate the new structures and processes that have arisen from the successful implementation of the divisional reorganization. Sennheiser will continue to follow its current strategic path. Each year the company looks toward the coming five years in order to adjust its ambitions to the present conditions.

Overall, it should be remembered that the long-term strategic approach of the Sennheiser Group has led to a situation in which sufficient reserves were built up over recent years to avoid the increased volatility and insecurity that is affecting the market. In the coming years, this will eliminate the need for hectic reactions to short-term changes, instead allowing us to work closely with our customers to address important topics. This increases the trust customers place in the Sennheiser Group’s brands and organization.

A further important element of future success is the consistent training and qualification of our employees. This creates enough internal flexibility to allow the company to keep up with intensifying competition, despite extremely low staff turnover.

The company expects to increase its turnover further in the coming financial years. The Group result is expected to remain more or less constant.

Wennebostel, Germany, April 10, 2013  
The Executive Management Board



# CONSOLIDATED FINANCIAL STATEMENTS 2012

## CONSOLIDATED BALANCE SHEET AS OF DECEMBER 31, 2012

### ASSETS

	2012 (€)	PREVIOUS YEAR (€ IN THOUSANDS)
<b>A. Fixed assets</b>		
<b>I. Intangible Assets</b>		
1. Concessions, industrial property rights and similar rights	8,737,871.54	3,008
2. Goodwill	601,231.59	1,202
3. Down payments	190,358.66	295
	<b>9,529,461.79</b>	<b>4,505</b>
<b>II. Tangible Assets</b>		
1. Real estate, equivalent titles and buildings, including buildings on non-owned land	4,805,921.78	4,807
2. Technical equipment and machinery	14,271,818.29	14,898
3. Other plant, furniture and equipment	22,974,459.26	18,211
4. Down payments and plants under construction	955,437.53	1,873
	<b>43,007,636.86</b>	<b>39,789</b>
<b>III. Financial Assets</b>		
1. Shares in associated companies	13,250.00	13
2. Shareholdings	3,350.00	3
3. Loans	1,753.05	9
4. Indemnity claims	1,658,384.52	1,428
	<b>1,676,737.57</b>	<b>1,453</b>
	<b>54,213,836.22</b>	<b>45,747</b>
<b>B. Current assets</b>		
<b>I. Stocks</b>		
1. Raw materials and supplies	19,274,977.62	18,141
2. Work in process	13,018,544.64	13,352
3. Finished products and merchandise	66,266,884.76	48,666
4. Down payments	0	83
	<b>98,560,407.02</b>	<b>80,242</b>
<b>II. Trade and Other Receivables</b>		
1. Trade receivables	98,706,944.34	93,333
2. Other receivables	16,155,615.34	10,708
	<b>114,862,559.68</b>	<b>104,041</b>
<b>III. Trade Investments</b>		
Other securities	<b>354.95</b>	<b>0</b>
<b>IV. Cash and Cash Equivalents</b>	<b>69,109,100.94</b>	<b>70,997</b>
	<b>282,532,422.50</b>	<b>255,280</b>
<b>C. Accruals and Deferrals</b>	<b>3,703,384.16</b>	<b>3,045</b>
<b>D. Deferred Taxes</b>	<b>11,522,200.46</b>	<b>11,069</b>
	<b>351,971,843.43</b>	<b>315,141</b>

### LIABILITIES

	2012 (€)	PREVIOUS YEAR (€ IN THOUSANDS)
<b>A. Equity</b>		
<b>I. Fixed Capital</b>		
1. General partners' deposit	0.00	0
2. Limited partners' deposit	5,200,000.00	5,200
	<b>5,200,000.00</b>	<b>5,200</b>
<b>II. Retained Earnings</b>	23,931.37	24
<b>III. Expenses from Currency Translation</b>	-8,456,682.77	-8,455
<b>IV. Balance Sheet Profit</b>	69,549,662.34	70,992
<b>V. Balancing Item for Shares of Other Shareholders</b>	481,689.14	482
	<b>66,798,600.08</b>	<b>68,243</b>
<b>B. Special Items</b>	<b>166,107.00</b>	<b>172</b>
<b>C. Provisions</b>		
1. Pension provisions	67,404,102.34	64,690
2. Tax provisions	5,096,554.19	3,886
3. Other provisions	33,138,963.59	34,177
	<b>105,639,620.12</b>	<b>102,753</b>
<b>D. Liabilities</b>		
1. Liabilities to credit institutions	48,720.00	353
2. Advance payments received for orders	537,195.30	348
3. Trade payables	32,840,054.02	27,604
4. Liabilities to shareholders	130,939,117.61	101,590
5. Liabilities to associated companies	1,646.08	3
6. Other liabilities	14,575,649.60	14,056
	<b>178,942,382.61</b>	<b>143,954</b>
<b>E. Accruals and Deferrals</b>	<b>425,133.62</b>	<b>19</b>
	<b>351,971,843.43</b>	<b>315,141</b>



CONSOLIDATED PROFIT AND LOSS STATEMENT  
FOR THE FINANCIAL YEAR 2012

	2012 (€)	PREVIOUS YEAR (€ IN THOUSANDS)
1. Sales	584,357,358.12	531,441
2. Reduction (–)/increase of the inventory of finished and semi-finished products	16,861,742.31	–8,040
3. Other own work capitalized	1,105,109.79	1,332
	602,324,210.22	524,733
4. Other operating income	47,048,464.68	28,391
	649,372,674.90	553,124
5. Raw materials and consumables		
a) Expenditure on raw materials and supplies and brought-in goods	228,446,576.32	180,075
b) Expenditure on bought-in services	3,406,459.13	4,516
	231,853,035.45	184,591
6. Personnel costs		
a) Wages and salaries	134,402,325.57	120,644
b) Social charges and expenditure on pensions and assistance	26,541,518.84	24,026
	160,943,844.41	144,670
7. Amortization and depreciation on		
a) intangible assets and tangible assets	13,144,285.20	13,834
b) current assets exceeding the usual depreciation	0.00	2,585
	13,144,285.20	16,419
8. Other operating expenses	186,285,494.08	143,890
	57,146,015.76	63,554
9. Income from trade investments	24.00	0
10. Other interest and similar income	526,350.45	359
11. Interest and related expenses	5,794,702.46	5,268
	–5,268,328.01	–4,909
12. Result of ordinary activities	51,877,687.75	58,645
13. Taxes on income and profits	7,884,996.46	12,484
14. Other taxes	498,589.60	479
15. Net profit for the year	43,494,101.69	45,682
(of which attributable to minority shareholders)	3,216,478.72	3,007



NOTES ON THE CONSOLIDATED FINANCIAL STATEMENTS 2012

NOTES ON THE CONSOLIDATED FINANCIAL STATEMENTS AS OF DECEMBER 31, 2012

A. GENERAL

The Consolidated Financial Statements 2012 were prepared in accordance with the German Commercial Code (HGB).

The company is required by Section 264a of the German Commercial Code (HGB) in conjunction with Section 290 HGB to prepare consolidated financial statements and a consolidated management report.

B. REPORTING ENTITY

Included in the consolidated financial statements are the parent company Sennheiser electronic GmbH & Co. KG, Wennebostel, the seven Sennheiser Group subsidiaries in Germany (previous year: six) and 19 in other countries (previous year: 18), as well as the joint venture Sennheiser Communications A/S based in Copenhagen, Denmark.

All subsidiaries are majority owned with the exception of Sennheiser Communications A/S, where the holding is 50%. The following table provides an overview of all consolidated subsidiary companies:

CONSOLIDATION	SIZE OF HOLDING (IN %)	CUR-RENCY	SHARE CAPITAL (IN THOUSANDS)
Full Consolidation			
Sennheiser electronic GmbH & Co. KG, Wennebostel, Germany	–	EUR	5,200
Georg Neumann Gesellschaft mit beschränkter Haftung, Berlin, Germany	100.0	EUR	800 <sup>1</sup>
K + H Vertriebs- und Entwicklungsgesellschaft mbH, Wedemark, Germany	100.0	EUR	25 <sup>1</sup>
Sennheiser Audio Labs GmbH, Wedemark, Germany	100.0	EUR	25 <sup>1</sup>
Sennheiser Consumer Electronics GmbH, Wedemark, Germany	100.0	EUR	3,000 <sup>1</sup>
- Sennheiser New Mexico LLC, Albuquerque, USA	100.0	USD	5,000
- Sennheiser Manufacturing USA Corp., Albuquerque, USA	100.0	USD	<sup>2</sup>
- Sennheiser Bondholding Company LLC, Albuquerque, USA	100.0	USD	<sup>2</sup>
Sennheiser Global Operations GmbH, Wedemark, Germany	100.0	EUR	3,500
- Sennheiser Audio OOO, Moscow, Russia	100.0	RUB	3,340
- Sennheiser Belux B.V.B.A., Zellik, Belgium	100.0	EUR	150
- Sennheiser (Canada) Inc., Point Claire, Canada	100.0	CAD	230
- Sennheiser Electronic Asia Pte Ltd., Singapore	100.0	USD	338
- Sennheiser Electronic Corporation, Old Lyme, USA	100.0	USD	2
- Sennheiser Electronics (Beijing) Co. Ltd., Beijing, China	100.0	CNY	6,856
- Sennheiser Electronics India Private Limited, Haryana, India	100.0	INR	70,000
- Sennheiser France S.A.R.L., Ivry sur Seine, France	100.0	EUR	305
- Sennheiser Hong Kong Ltd., Hong Kong, China	100.0	HKD	10
- Sennheiser Japan K.K., Tokyo, Japan	100.0	JPY	90,000
- Sennheiser Mexico S.A. de C.V., Mexico City, Mexico	100.0	MXN	215
- Sennheiser Nederland B.V., Almere, Netherlands	100.0	EUR	182
- Sennheiser Nordic A/S, Copenhagen, Denmark	100.0	DKK	1,000
- Sennheiser (Schweiz) AG, Unterengstringen, Switzerland	100.0	CHF	1,000
- Sennheiser UK Ltd., High Wycombe, Great Britain	100.0	GBP	210
Sennheiser Innovation (Schweiz) AG, Zurich, Switzerland	100.0	CHF	100
Sennheiser Logistics Services GmbH, Wedemark, Germany	100.0	EUR	25 <sup>1</sup>
Sennheiser Vertrieb und Service GmbH & Co. KG, Hanover, Germany	53.0	EUR	1,000
Partial Consolidation			
Sennheiser Communications A/S, Copenhagen, Denmark	50.0	DKK	2,000

1 Profit and loss transfer agreement with Sennheiser electronic GmbH & Co. KG, Wennebostel, Germany

2 Contained in the annual accounts of Sennheiser New Mexico LLC, Albuquerque, USA

The capital share represents the share of the subscribed capital as of December 31, 2012.

In accordance with Section 296, subsection 2, HGB, the subsidiary SVS Beteiligungs GmbH, Hanover, Germany, with a holding of 53%, is recognized at acquisition cost rather than being fully consolidated, because it is of minor significance.

C. PRINCIPLES OF CONSOLIDATION

The accounting and valuation principles used throughout the Group correspond to those applied in the annual financial statements of the parent company and to the consolidating accounting standards laid down under commercial law (Section 308, subsections 1 and 2 HGB).

For the individual annual financial statements included in this report, the common balance sheet date is December 31, 2012.

The individual annual financial statements denominated in foreign currencies were translated in accordance with Section 308a HGB. With the exception of equity, items were converted at the mean exchange rate. Equity, with the exception of the results for the year, is calculated using historic exchange rates. Conversion of the profit and loss items is on the basis of weighted average exchange rates. The currency conversion differences resulting from the conversion of equity capital at historic exchange rates, the change in closing rates and the conversion of the Profit and Loss Statement at average exchange rates are shown in the equity capital as not affecting the operating results. Foreign exchange losses or gains contained in the individual financial statements included in the consolidation are recognized as affecting the net income reported for the year.

The following rates of exchange were employed for the currency conversion of the individual financial statements of foreign subsidiaries:

	CODE	RATE OF EXCHANGE	
		Average as of Dec. 31, 2012 Foreign currency/€	End of year on Dec. 31, 2012 Foreign currency/€
01. US dollar	USD	0.77755	0.75792
02. Canadian dollar	CAD	0.77878	0.76121
03. Pound sterling	GBP	1.23397	1.22534
04. Mexican peso	MXN	0.05952	0.05819
05. Hong Kong dollar	HKD	0.10025	0.09779
06. Danish krone	DKK	0.13432	0.13403
07. Russian ruble	RUB	0.02502	0.02480
08. Indian rupee	INR	0.01455	0.01378
09. Japanese yen	JPY	0.00973	0.00880
10. Chinese yuan	CNY	0.12362	0.12164
11. Swiss franc	CHF	0.82957	0.82836

The average exchange rates were determined using weighted monthly average rates on the basis of the Sennheiser Group's turnover development. Here, the monthly average exchange rates represent a monthly average based on the daily rates. This method was adopted in order to approximate the transaction-related exchange rates within the Group as closely as possible.

Capital consolidation for company acquisitions on or before December 31, 2009, was based on the book value method. Capital consolidation for company acquisitions since January 1, 2010 is based on the revaluation method. If this capital consolidation – taking into account the silent reserves – leads to a positive gain, then the amount designated as goodwill is amortized on a linear basis over a useful life of four years.

The negative difference from capital consolidation was assigned to balance sheet profit.

Offsetting was carried out on the basis of assigned values at the time of share purchase and/or at the time at which the companies become subsidiaries.

Receivables and payables involving the consolidated companies themselves are offset against each other.

Internal sales and other internal income within the Group are offset against the corresponding expenses.

Interim profits from finished goods and raw materials are charged against net income.

Interim profits relating to fixed assets are charged against net income.

D. NOTES ON THE CONSOLIDATED BALANCE SHEET

**Intangible assets** are valued at acquisition cost and are subject to scheduled linear depreciation over a useful life between three and ten years. Goodwill is generally amortized over a period of four years using the straight-line method. The valuation of tangible assets is based on acquisition and/or production costs, subject to scheduled depreciation over a useful life of two to 14 years for furniture and equipment as well as technical equipment and machinery, and 50 years for buildings. Movable fixed assets are always depreciated on a linear or declining balance basis; depending on the useful life of the assets in question, a switch will be made to the linear method when most appropriate.

For the companies in Germany, in keeping with tax regulation changes that took effect on January 1, 2008, collective items were established for minor assets as defined by Section 6, subsection 2a, of the German Income Tax Act (EStG). These collective items are written off at a rate of 20% per year in the year of acquisition and in the subsequent four financial years.

In companies outside Germany, minor assets are written off in full in the year of acquisition and are shown as disposals in the same year.

Interests in subsidiaries not fully consolidated and interests in associated companies are shown on the assets side of the balance sheet at acquisition cost. Other loans are shown at acquisition cost.



Indemnity claims from life insurance concluded for the coverage of pension obligations are recognized at the tax asset value, which equates to the acquisition cost and the fair value. Indemnity claims protected from the claims of all other creditors were offset against the corresponding pension obligations.

Fixed assets are shown in the table on the next two pages.

STATEMENT OF ASSET ADDITIONS AND DISPOSALS FOR THE FINANCIAL YEAR 2012

(€)	ACQUISITION AND PRODUCTION COSTS							ACCUMULATED DEPRECIATION					NET BOOK VALUES	
	Jan. 1, 2012	Currency- differences	Consolidation	Additions	Disposals	Transfers	Dec. 31, 2012	Jan. 1, 2012	Currency- differences	Additions	Disposals	Dec. 31, 2012	Dec. 31, 2012	Previous year (€ in thousands)
I. Intangible Assets														
1. Concessions, industrial property rights and similar rights	23,176,886.11	−87,255.11	5,730,984.74	1,555,968.64	868,594.71	294,730.03	29,802,719.70	20,168,767.55	−87,289.88	1,840,822.85	857,452.36	21,064,848.16	8,737,871.54	3,008
2. Goodwill	4,072,952.62	−1,937.29	0.00	0.00	0.00	0.00	4,071,015.33	2,870,489.45	−1,574.99	600,869.28	0.00	3,469,783.74	601,231.59	1,202
3. Down payments	294,730.03	0.00	0.00	190,358.66	0.00	−294,730.03	190,358.66	0.00	0.00	0.00	0.00	0.00	190,358.66	295
	27,544,568.76	−89,192.41	5,730,984.74	1,746,327.30	868,594.71	0.00	34,064,093.69	23,039,257.00	−88,864.87	2,441,692.13	857,452.36	24,534,631.90	9,529,461.79	4,505
II. Tangible Assets														
1. Real estate, equivalent titles and buildings, including buildings on non-owned land	6,623,402.96	−60,207.28	71,988.57	289,418.10	0.00	0.00	6,924,602.35	1,816,934.34	−35,480.72	337,226.95	0.00	2,118,680.57	4,805,921.78	4,807
2. Technical equipment and machinery	55,088,702.87	−250,850.68	82,484.15	2,659,776.03	1,348,125.38	317,498.87	56,549,485.85	40,190,691.43	−216,207.09	3,275,141.98	971,958.76	42,277,667.56	14,271,818.30	14,898
3. Other plant, furniture and equipment	76,553,615.67	−195,135.22	173,558.15	10,766,900.97	3,674,659.65	1,106,677.00	84,730,956.91	58,342,406.83	−177,706.16	7,086,654.15	3,494,857.17	61,756,497.65	22,974,459.27	18,211
4. Down payments and plants under construction	1,872,881.31	−1,584.78	0.00	823,225.72	314,908.85	−1,424,175.87	955,437.54	0.00	0.00	3,570.00	3,570.00	0.00	955,437.54	1,873
	140,138,602.81	−507,777.97	328,030.87	14,539,320.81	5,337,693.88	0.00	149,160,482.65	100,350,032.60	−429,393.96	10,702,593.08	4,470,385.93	106,152,845.78	43,007,636.88	39,789
III. Financial Assets														
1. Shares in associated companies	13,250.00	0.00	0.00	0.00	0.00	0.00	13,250.00	0.00	0.00	0.00	0.00	0.00	13,250.00	13
2. Shareholdings	3,350.00	0.00	0.00	0.00	0.00	0.00	3,350.00	0.00	0.00	0.00	0.00	0.00	3,350.00	3
3. Loans	8,801.73	0.00	0.00	0.00	7,048.68	0.00	1,753.05	0.00	0.00	0.00	0.00	0.00	1,753.05	9
4. Indemnity claims	1,427,416.85	0.00	0.00	230,967.67	0.00	0.00	1,658,384.52	0.00	0.00	0.00	0.00	0.00	1,658,384.52	1,428
	1,452,818.58	0.00	0.00	230,967.67	7,048.68	0.00	1,676,737.57	0.00	0.00	0.00	0.00	0.00	1,676,737.57	1,453
	169,135,990.15	−596,970.38	6,059,015.61	16,516,615.78	6,213,337.27	0.00	184,901,313.90	123,389,289.60	−518,258.83	13,144,285.20	5,327,838.29	130,687,477.68	54,213,836.24	45,747

**Inventories** are separately valued at acquisition cost, subject to allocated surcharges and discounts for incidental acquisition costs and acquisition cost reductions, or at production cost in accordance with Section 255, subsection 2 HGB. Production costs include individual costs as well as pro-rata allocated material overheads, production overheads and depreciation insofar as it is related to production. The lower of cost or market principle is applied. Marketability discounts, taking product releases into account, were applied as required and retrograde valuation was applied.

**Trade and other receivables** are shown at nominal value. Any necessary itemized and general provisions are set aside for bad and doubtful debts. Receivables denominated in foreign currencies were converted at the mean exchange rate on the balance sheet date. Of the trade receivables, a total of €671,000 (previous year: €750,000) have a remaining term to maturity of more than one year. Of the other receivables, a total of €423,000 (previous year: €803,000) have a remaining term to maturity of more than one year.

**Other trade investments** are valued at acquisition cost.

**Cash and cash equivalents** are valued at nominal value.

**Accruals and deferrals** on the assets side of the balance sheet are stated in the amount of expenditure for the period following the balance sheet date.

**Deferred taxes** result from temporary differences between balance sheet items under commercial law and for tax purposes, as well as consolidation entries. In case of temporary differences arising from consolidation entries, an average tax rate of 25% (previous year: 25%) was applied. In determining deferred taxes arising from temporary differences between balance sheet items under commercial law and for tax purposes, local tax rates between approximately 7% and 41% were applied. Deferred taxes continue to be accrued on losses carried forward. On the balance sheet date, the deferred taxes on losses carried forward were €1.034 million (previous year: €1.975 million). The remaining deferred tax assets of €12.198 million result from differences in fixed assets and inventories, receivables, liabilities and provisions. Deferred tax liabilities of €1.710 million mainly relate to differences in fixed assets. In accordance with the accounting policy choice under Section 274, subsection 1, sentence 3 HGB, only the net amount of deferred taxes is reported. Offsetting results in net deferred tax assets of €11.522 million.

The **fixed capital** is shown at the nominal amount of the parent company's general and limited liability capital. The **balance sheet profit** includes a profit brought forward of €70.992 million. The consolidation operations affecting net income are shown in the profit brought forward as at the end of the previous year. The difference shown on the liabilities side of the balance sheet arising from capital consolidation has arisen through profit retention by subsidiaries prior to initial consolidation and is therefore recognized as profit brought forward. The

net profit of the parent company and the proportion of the consolidated net profit owing to minority shareholders are credited to the company clearing accounts and are thus not included in the balance sheet profit.

**Special items** contain the investment subsidies and advance payments granted to Sennheiser Consumer Electronics GmbH, Branch Ireland, Tullamore, Ireland, by the Industrial Development Agency for establishing the Irish production facility. The amortization of this special item for investment allowances on fixed assets corresponds to the scheduled depreciation on the subsidized fixed assets. Under the terms of the contract, liability for part repayment of the allowances received may arise in certain circumstances.

In accordance with the Accounting Law Modernization Act (BilMoG), **pension provisions** were generally valued according to the projected unit credit method (PUC method) at an interest rate of 5.06% (previous year: 5.14%), a pay trend of 2.5% and a pension trend of 1.5% annually. The interest rate is based on the average market interest rate for the last seven years determined by the German Central Bank, which is derived under the assumption of a remaining term of 15 years. The actuarial tables 2005 G by Klaus Heubeck were applied.

Pension provisions include provisions for obligations to previous members of the Executive Team of €3.270 million (previous year: €3.127 million).

In accordance with Section 246, subsection 2, sentence 2 HGB, the corresponding acquisition cost and fair value of the reinsurance policy (€57,000) that are protected from the claims of all other creditors and serve exclusively to meet pension obligations or similar long-term commitments were offset against said obligations.

In the financial result, income of €2,000 from fund assets (previous year: €2,000) was offset against interest expense of €2,000 resulting from imputed interest on pension obligations (previous year: €2,000).

**Tax provisions** and **other provisions** are allocated at the discharge amount in accordance with sound business judgment and take into account all recognizable risks from pending contracts and uncertain liabilities. Interest on other provisions with a term of more than one year is calculated at rates of interest as published by Deutsche Bundesbank, the German central bank. Inflation is set at 1.76%. The interest rate for 2012 applied to discounting provisions amounts to between 3.79% and 4.74% depending on the remaining term. Provisions with remaining terms of less than one year are not discounted.

**Liabilities** are valued at their repayment and/or discharge amount.



They are as follows:

(€ IN THOUSANDS)	REMAINING TERM					
	Total		Up to one year		More than five years	
	Dec. 31, 2012	Previous year	Dec. 31, 2012	Previous year	Dec. 31, 2012	Previous year
Liabilities to credit institutions	49	353	49	353	0	0
Advance payments received for orders	537	348	537	348	0	0
Trade payables	32,840	27,604	32,832	27,604	0	0
Liabilities to shareholders	130,939	101,590	130,939	101,590	0	0
Liabilities to associated companies	1	3	1	3	0	0
Other liabilities	14,576	14,056	14,558	13,678	0	0
	178,942	143,954	178,916	143,576	0	0

Other liabilities include tax liabilities in the amount of €4.808 million (previous year: €4.702 million) and social security liabilities of €1.356 million (previous year: €1.465 million). No warranties or other safeguards exist.

E. NOTES ON THE CONSOLIDATED PROFIT AND LOSS STATEMENT

Sales by division are structured as follows:

(€ MILLIONS)	2012	CHANGE OVER PREVIOUS YEAR
Consumer Division	288.6	7%
Professional Systems	205.1	10%
Integrated Systems	90.7	21%
Sales	584.4	10%

Sales broken down into geographical markets are as follows:

(€ MILLIONS)	2012	PREVIOUS YEAR
Americas	146.5	133.6
APAC	95.0	73.0
EMEA	342.9	324.8
Sales	584.4	531.4

€92.002 million (previous year: €88.696 million) of sales were generated in Germany.

**Other operating income** includes €6,000 (previous year: €6,000) from the dissolution of the special items for investment allowances on fixed assets. Other operating income also includes income not related to the accounting period amounting to €2.072 million (previous year: €2.625 million), which mainly resulted from the release of provisions and gains from the sale of items of fixed assets. Currency translation gains amounted to €39.205 million (previous year: €22.235 million).

**Personnel costs** include pension expenses in the amount of €4.999 million (previous year: €4.036 million).

On an annual average, the company had 2,329 employees (previous year: 2,183), of whom 76 (previous year: 75) were trainees.

EMPLOYEES	2012	PREVIOUS YEAR
Within Germany	1,226	1,177
Abroad	1,103	1,006
	2,329	2,183

These figures include the full 97 employees (previous year: 89) in the partially consolidated Sennheiser Communications A/S.

**Amortization of current assets**, to the extent that this exceeds the amount normal for the company, related to inventory provisions in the previous year.

**Other operating expenses** include expenses not related to the accounting period in the amount of €3.563 million (previous year: €1.709 million), which are mainly the result of reserves for bad debts. Other operating expenses also include the auditor’s fee for the audit of the consolidated financial statements for financial year 2012 in the amount of €609,000, consisting of €288,000 for the audit, €5,000 for other audit services, €189,000 in tax consultancy fees and €127,000 for other services. Currency translation losses amounted to €40.554 million (previous year: €22.066 million).

**Interest income** includes proceeds from discounting provisions in the amount of €174,000 (previous year: €50,000). **Interest expense** includes expenditures for imputed interest on provisions in the amount of €3.709 million (previous year: €3.313 million).

**Income taxes** include income from deferred taxes in the amount of €2.416 million (previous year: expenses of €3.476 million).

F. FINANCIAL OBLIGATIONS

Other financial obligations

On the balance sheet date, there were rent and leasing obligations in the amount of €30,443 million.

There were also liabilities resulting from hardware and software maintenance contracts and vehicle leasing liabilities in the amount of €4.414 million, as well as order commitments of €54.913 million.

G. OTHER STATUTORY INFORMATION

The **unlimited partner** of the parent company is Sennheiser Beteiligungsgesellschaft mit beschränkter Haftung, Wedemark, whose subscribed capital amounts to €30,000.

The **management** of Sennheiser electronic GmbH & Co. KG is the responsibility of Sennheiser Beteiligungsgesellschaft mit beschränkter Haftung, Wedemark.

The following persons were appointed as Presidents, collectively representing Sennheiser Beteiligungsgesellschaft mit beschränkter Haftung, Wedemark:

Volker Bartels, Hanover, Germany, President, Corporate Services, Speaker of the Executive Management Board (EMB)  
Peter Claussen, Burgwedel, Germany, President, Integrated Systems  
Dr. Heinrich Esser, Wedemark, Germany, President, Professional Systems  
Dr. Andreas Sennheiser, Isernhagen, Germany, President, Supply Chain  
Daniel Sennheiser, Zurich, Switzerland, President, Strategy and Finance

During the year under review, the members of the **Supervisory Board** were:

Prof. Dr. Jörg Sennheiser, Chairman, Wedemark, Germany,  
Andreas Dornbracht, Managing Director of Aloys F. Dornbracht GmbH & Co. KG Armaturenfabrik, Iserlohn, Germany,  
Dr. Frank Heinrich, Chairman of the Management of Heraeus Holding GmbH, Hanau, Germany,  
Johann Soder, Director of Technology of SEW-EURODRIVE GmbH & Co. KG, Bruchsal, Germany.

**Total remuneration** of the members of the Executive Team came to €2.044 million (previous year: €1.463 million) and that of the Supervisory Board to €348,000 (previous year: €348,000).

Regarding disclosure, the following subsidiaries in the legal form of a limited company or partnership within the meaning of Section 264a HGB have made use of relief options in accordance with Section 264, subsection 3, and Section 264b HGB:

- Georg Neumann Gesellschaft mit beschränkter Haftung, Berlin, Germany,
- K + H Vertriebs- und Entwicklungsgesellschaft mbH, Wedemark, Germany,
- Sennheiser Audio Labs GmbH, Wedemark, Germany,
- Sennheiser Consumer Electronics GmbH, Wedemark, Germany,
- Sennheiser Logistics Services GmbH, Wedemark, Germany,
- Sennheiser Vertrieb und Service GmbH & Co. KG, Hanover, Germany.

The parent company, in the form of a limited company within the meaning of Section 264a HGB, makes use of the relief options in accordance with Section 264b HGB.

Wennebostel, Germany, 10 April 2013  
The Executive Management Board

		
Volker Bartels, President, Corporate Services, Speaker of the Executive Management Board (EMB)	Peter Claussen, President, Integrated Systems	Dr. Heinrich Esser, President, Professional Systems
		
Dr. Andreas Sennheiser, President, Supply Chain	Daniel Sennheiser, President, Strategy and Finance	



CASH FLOW STATEMENT FOR THE FINANCIAL YEAR 2012

(€ IN THOUSANDS)	2012	PREVIOUS YEAR
Results of the year, including the shares of profits of minority shareholders	43,494	45,682
Depreciation on items of fixed assets	13,144	13,834
Depreciation on current assets exceeding the usual depreciation	0	2,585
Increase in medium- and long-term provisions	2,220	2,071
Increase (–)/decrease in indemnity claims	–231	100
Changes in the special items	–6	–6
Rate fluctuations (+/–) relating to fixed assets	279	–423
Cash earnings according to DVFA/SG principles	58,900	63,843
Decrease (–)/increase in short-term provisions	–231	969
Loss from the disposals of items or fixed assets	44	278
Increase in inventories, trade receivables and other assets that are not allocated to the investment or financing activities	–24,893	–45
Increase in trade payables and other liabilities that are not allocated to the investment or financing activities	3,783	417
Cash flow from current business activities	37,603	65,462

(€ IN THOUSANDS)	2012	PREVIOUS YEAR
Payment received from disposals of items of fixed assets	823	626
Investments (–) in tangible assets	–14,539	–10,616
Payment received from disposals of intangible assets	11	0
Investments (–) in intangible assets	–1,746	–1,675
Payment received from disposals of financial assets	7	0
Investments (–) in financial assets	0	–8
Payments (–) for the acquisition of consolidated companies	–5,679	0
Cash flow from investment activities	–21,123	–11,673
Other changes in shareholders’ funds excluding net profits for the year		
Cash flow from financing activities	–15,589	–7,084
Changes in cash and cash equivalents	891	46,705
Change in cash and cash equivalents resulting from foreign exchange and valuation effects	–200	407
Cash and cash equivalents at the start of the period	75,522	28,410
Cash and cash equivalents at the end of the period	76,213	75,522
COMPOSITION OF FINANCIAL FUNDS	Dec. 31, 2012	PREVIOUS YEAR
Cash and cash equivalents	69,109	70,997
Ongoing obligations (–) to credit institutions	–49	–353
Receivables from the cash pool	7,196	4,919
Obligations from the cash pool (–)	–43	–41
	76,213	75,522

STATEMENT OF SHAREHOLDERS' EQUITY FOR THE FINANCIAL YEAR 2012

(€)						PARENT COMPANY	MINORITY SHAREHOLDERS	
	Shares			Cumulative Other Group Result				
	General partners' deposit	Limited partners' deposit	Group equity capital generated	Balancing item from the foreign currency conversion	Other neutral transactions	Equity	Minority capital/equity	Group equity
Status as of Dec. 31, 2011	0.00	5,200,000.00	65,681,964.27	−8,454,752.32	5,333,327.13	67,760,539.08	481,689.14	68,242,228.22
Credit to shareholder settlement accounts	0.00	0.00	−41,719,320.66	0.00	0.00	−41,719,320.66	−3,216,478.72	−44,935,799.38
Group net profit for the year	0.00	0.00	40,277,622.97	0.00	0.00	40,277,622.97	3,216,478.72	43,494,101.69
Other Group result	0.00	0.00	0.00	−1,930.45	0.00	−1,930.45	0.00	−1,930.45
Total Group result	0.00	0.00	40,277,622.97	−1,930.45	0.00	40,275,692.52	3,216,478.72	43,492,171.24
Status as of Dec. 31, 2012	0.00	5,200,000.00	64,240,266.58	−8,456,682.77	5,333,327.13	66,316,910.94	481,689.14	66,798,600.08
Previous year								
Status as of Dec. 31, 2010	0.00	5,200,000.00	48,115,771.56	−10,218,364.00	5,333,327.13	48,430,734.69	481,689.14	48,912,423.83
Credit to shareholder settlement accounts	0.00	0.00	−25,108,963.51	0.00	0.00	−25,108,963.51	−3,006,873.61	−28,115,837.12
Group net profit for the year	0.00	0.00	42,675,156.22	0.00	0.00	42,675,156.22	3,006,873.61	45,682,029.83
Other Group result	0.00	0.00	0.00	1,763,611.68	0.00	1,763,611.68	0.00	1,763,611.68
Total Group result	0.00	0.00	42,675,156.22	1,763,611.68	0.00	44,438,767.90	3,006,873.61	47,445,641.51
Status as of Dec. 31, 2011	0.00	5,200,000.00	65,681,964.27	−8,454,752.32	5,333,327.13	67,760,539.08	481,689.14	68,242,228.22



# INDEPENDENT AUDITORS' REPORT

We have audited the consolidated financial statements – comprising the consolidated balance sheet, the consolidated profit and loss statement, the notes on the consolidated financial statements, the consolidated cash flow statement and the consolidated statement of shareholder's equity – and the consolidated management report of Sennheiser electronic GmbH & Co. KG, Wennebostel, Germany, for the financial year from January 1 to December 31, 2012. The maintenance of the books and records and the preparation of the consolidated financial statements and consolidated management report in accordance with German commercial law are the responsibility of the parent Company's management. Our responsibility is to express an opinion on the consolidated financial statements and the consolidated management report based on our audit.

We conducted our audit of the consolidated financial statements in accordance with Section 317 HGB and German generally accepted standards for the audit of financial statements promulgated by the Institut der Wirtschaftsprüfer (German Institute of Auditors). Those standards require that we plan and perform the audit such that misstatements materially affecting the presentation of the net assets, financial position and results of operations in the consolidated financial statements in accordance with German principles of proper accounting and in the consolidated management report are detected with reasonable assurance. Knowledge of the business activities and the economic and legal environment of the company and expectations as to possible misstatements are taken into account in the determination of audit procedures. The effectiveness of the accounting-related internal control system and the evidence supporting the disclosures in the books and records, the consolidated financial statements and the consolidated management report are examined primarily on a test basis within the framework of the audit. The audit includes assessing the annual financial statements included in the consolidated financial statements, the definition of the reporting entity, the accounting and consolidation principles used and significant estimates made by the management, as well as evaluating the overall presentation of the consolidated financial statements and consolidated management report. We believe that our audit provides a reasonable basis for our opinion.

Our audit has not led to any reservations.

In our opinion, based on the findings of our audit, the consolidated financial statements of Sennheiser electronic GmbH & Co. KG, Wennebostel, Germany, comply with the legal requirements and give a true and fair view of the net assets, financial position and results of operations of the company in accordance with German principles of proper accounting. The consolidated management report is consistent with the consolidated financial statements and, as a whole, provides a suitable view of the company's position and accordingly presents the opportunities and risks of future development.

Hanover, April 19, 2013  
Deloitte & Touche GmbH  
Audit Firm

Prof. Dr. Beine	Engelhardt
Wirtschaftsprüfer	Wirtschaftsprüfer
[German Public Auditor]	[German Public Auditor]