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Feature Story

Resound

RION CO., LTD.

Suzanne Ciani

Composer and musician

Leading the way to unknown sound
～Challenge of a woman composer

Text by Michinari Okazaki / Photo by Megumi Yoshitake

Synthesizer. The synthesizer of today takes many forms, but in the early days when Suzanne played the Buchla, a modular instrument played without a conventional keyboard, people often didn't understand the potential of this new kind of instrument.
As a female composer, Suzanne Ciani sought her musical expression through the synthesizer.
Her music caught on here in Japan. We interviewed her as a pioneer, during her first visit to Japan since her debut album.
(Interview : October in 2015)

Suzanne Ciani

Suzanne Ciani is an Italian-American who was born in 1946 and grew up near Boston. She started playing the piano from the age of five. While studying composition at graduate school, she met Don Buchla, the developer of one of the first synthesizers. In 1974, she founded Ciani / Musica, Inc., a music production company, in New York City. She wrote music for commercials and created sound logos for well-known companies such as Coca-Cola, AT&T and General Electric. In 1982, she released her first album, "Seven Waves," in Japan, which was well regarded around the world. She has released 15 albums so far, and five of them were nominated for Grammy Awards. She has a studio overlooking the Pacific Ocean outside of San Francisco, where she works with electronic music instruments, piano, orchestras and instrumental ensembles. She is currently performing live Buchla concerts, piano concerts, and composing her new album. In 2015, she returned to Japan for the first time since the early eighties to perform solo piano concerts.

Her first album was released first in Japan

Suzanne was making music for commercials and sound logos, making full of use of electronic instruments, and knocking on the door of record companies in the early 70's. She wanted to let people listen to the music that she was creating.
" I need a studio for a week, with a multi-track tape recorder."
In those days it was hard to professionally record electronic music. Record companies had the facilities for recording and she needed recordings to show people this new style of music.
But the record company staff did not understand what she needed.
"We will give you three hours, with a guitar, bass and drums".
"No it is not that kind of music, this is something else."
"You're a girl. Why don't you sing as well ?"
She visited a number of record companies in the United States, but couldn't get them interested. Then she went to Europe because electronic music was more popular there, for example there was a German electronic music group, Tangerine Dream. But even in Europe things did not go well because she was not well known. Then she decided to produce the music on her own by earning money during the week and renting a studio on the weekends, taking all the necessary electronic instruments with her to start making the recordings. At the point when she had several songs recorded, she heard that Japan was the second largest music market in the world. A week later, she was in Tokyo. And she met with record companies, played them her demo tape, and got offered deals by all of them. She got her first recording contract, and thus her first album "Seven Waves," which made full use of the synthesizer, was released to the world from Japan.
Why was she first published in Japan?
"It was because they listened to my music. The situation was different until then. In the United States and Europe, when I played my demo, people would go in and out, the phone would ring, and someone would be smoking a cigar. In Japan, I went into a quiet room with no telephones, no people interrupting. Just two people sitting in a room who played the music and listened to the whole thing. I had never seen anybody just listen to the music before. This is why I believe I was first accepted in Japan. Also there were already some successful people in electronic music, like Isao Tomita. The Japanese had a sense that accepting electronic music might be something that would work."

Encountering electronic music

Suzanne's first encounter with music was when she was 5 years old. She danced to a record called the "Tennessee Waltz" in the living room. Then, she started playing the family Steinway piano.
She auditioned for The Longy School of Music in Cambridge, near Boston, while still in high school. After hearing her play Rachmaninoff and Grieg, the teacher said, "Can you play a scale?" She replied, "What is a scale?" Since she had been playing without a teacher for ten years, she didn't know what a scale was, or even a quarter note. So she then started studying these basic things. But she never had to audition for a music school ever again.
"My friends who were in conservatory were threatened, because they were very competitive and insecure. They said things like, 'Oh, he missed that b flat.' I never wanted music to be about that kind of competition. So I decided to study music in a liberal arts school called Wellesley college, and not in the conservatory. I was offered a composition prize to go study with some classical composers. But I didn't go. I protected my independent connection to my music. And I think that's very important for me."
Suzanne studied music at Wellesley

College, and then during her senior year, her music class had a special evening at its brother school, the Massachusetts Institute of Technology (M.I.T.). That was in 1967. When she heard sound come out of a computer, something in her just took off. To be a composer, she went to the University of California at Berkeley for her master's degree in music composition. There she met Don Buchla (1937-2016), who had invented a groundbreaking synthesizer. And that changed everything.

"The classical music world where I was being trained, my professor outright said, 'Women have no right to conduct.' It was the beginning of women's liberation in the late 60s. It was just starting. And composing was a sad career because you couldn't hear your music unless you could get people to play it. But with the electronic instrument I would have complete control. I didn't need to depend on anybody else. I wanted to have that personal independent relationship with my music. So electronic music was perfect for that. You were in the sound as you composed."

The synthesizer, a musical instrument

Buchla's synthesizer had no conventional keyboard, but used a "touch plate," and different modules were connected by patch cords (connection cables). It was a giant and complex "machine" that was controlled with lots of knobs and switches.

"It was a modular analog system where the modules could be connected in various ways. It had oscillators to make the sound, filters to change the color of the sound, and envelope generators to change the volume of the sound. The old analog machine was amazing; however, the Buchla synthesizer of that style, the model 200, is no longer being manufactured, and we couldn't get the parts to fix my original machine."

It looked very complicated. Did Suzanne recognize what all the knobs did, and where the cables went?

"It could be very messy [laughing]. When there was no memory on the machine, it took a while - and mental power - to make that instrument perform. Do this, do this, how do you get from here to here? Sometimes I needed to practice for a month. Nowadays, because there is memory, in the model 200e, I can jump from one setting to another. But even now it's tricky. When using the memory, I have all these things patched and you have to get familiar with the patch. Sometimes I have to follow the wires like, 'Where is this? Where is that?'

Music generated through an electronic musical instrument

A modular synthesizer is such a complex machine, and might seem artificial, mechanical and inorganic. But Suzanne's music is natural, gentle and romantic. How is this possible using a synthesizer?

"I always attribute this a little bit to gender differences. A man gets a machine and he likes that it can pound strongly, make noise, be loud, and do noisy things. But the reason that I was attracted to the machine is it is dependable, secure and comforting. It's hard for a human to play a very slow tempo, but not for a machine. 'Seven Waves' was at least half the speed of any normal music. It could go very, very slow. My mission was really to make it sensual."

Since then, Suzanne performs not only on the synthesizer but also the solo piano, with an ensemble of acoustic instruments, and in recent years, she has done collaborations with a variety of musical instruments such as composing orchestral music. What does she want to express through music?

"I think the important thing with any music is that you have something to say. For me it is 'emotional.' I create music in order to feel something. It does not matter what the style of music is. When there's something communicated, you feel it and you connect. It doesn't matter whether it's rock 'n' roll, opera, or electronic. So it's not about a style or a kind of music, it's about whatever it is that you want to say."

Operating the early Buchla synthesizer
©sevwave.com

At a piano concert in 2006
©sevwave.com

About the stream of returning to an analog machine

Suzanne is currently performing using the Buchla 200e analog/digital synthesizer. Is there any meaning behind going back to the synthesizer from acoustic instruments?

"I started (recording) electronic and then very gradually transitioned to acoustic music, and I'm going back and forth. I'm surprised, I didn't think I was going to be doing electronic music again. But there is a lot of interest now in electronic music. For me, they discovered my past. People want analog, and they want the hands-on experience. 'What did we miss? Wait a minute, where was this?' I think that's a good thing."

Why is that?

"I think it's an interesting time for the resurgence of analog. Electronic music is more widespread than ever. The early modular instruments gave more of a hands-on experience, and more of a personal connection to the instrument. Back then, we started new concepts of playing an electronic instrument. But soon after people thought it was about sounding like a flute or a cello, and about playing those sounds on a traditional keyboard interface. People lost sight of the true potential of the electronic instrument. And the new generation wants to go back and experience the knobs, dials and patch cords of playing a modular interface again. It takes a long time to learn to play a sophisticated instrument. It takes years to improve one's violin skills and playing a Buchla is no different. It is not about sounding like a flute or a cello, it is about new performing techniques."

Composer or synthesizer pioneer

Asked about her view of life, Suzanne told us about her motto at the time her first album was issued.

" 'There is nothing to do, and everything will get done.' So there is nothing to do, and I am not worried. I think fear is the most destructive force that we have. And it is in us all the time. 'I'm afraid I won't get to the appointment in time, I'm afraid I won't do the... I'm afraid.' You have to develop the skill of listening for when the fear is running you, and just stop it. Fear is something that was in humans to protect them and it became an automatic system, but it's not really useful for the most part any more. Instead of thinking about failing, you should better think, 'There is nothing to do, and everything will get done.' "

Suzanne can be called a synthesizer pioneer, a composer or a performing musician. For our last question, I asked, What do you want to be remembered for?

"I think of myself as a composer. That is my inner identity. But the world thinks of me as an electronic music pioneer. And I can't shake it. When I got a TV offer, I said I would go on, but I didn't want to be on TV as just this electronic whizz-kid. 'You have to also give me time to play my music.' But as we started to play my music, they cut to commercial. There is always this brushfire of enthusiasm for the electronic thing. So maybe one's identity, you don't choose it completely for yourself. And maybe it changes. 200 years from now, someone might find my piano books and be impressed, or maybe not. Who knows?"

[Side story]
I encountered Suzanne's music on FM radio while at high school 30 years ago. I am thankful that fate has given me the chance to meet, through my work, this woman whose music I have so admired. I told her that "I have often dreamed of, by chance, sitting next to you on an airplane and talking about your music." "Yet on a train instead," she said with a smile. I was so happy.

Feature Story

Resound

As the children on the Rion factory tour enter the anechoic chamber, one can often see them looking about in wonder.
Experiencing the extraordinary anechoic chamber,
a room that is almost entirely free of sound reverberation,
gives them a true sense of just how important echoes are,
and how grateful we should be for them.
Sound from any source seems dry and uninteresting
in the absence of acoustic reverberation.
Reverberation gives life to sound, enriches it,
and can help communicate emotion.

01 Introduction to research

The Value of Vocal Tract Models

Amid the hustle and bustle of a Spring 2016 meeting of the Acoustical Society of Japan,
one could hear "ahh" and "eee" that sounded just like a human voice.
What's more, the device had an amazingly simple structure,
and was based on the vocal tract model (Fig.1) being studied by Sophia University Prof. Takayuki Arai, Ph.D.

What is the vocal tract model ?

Prof. Arai has continuously studied the vocal tract model since opening his laboratory in 1998. The vocal tract model is built to simulate the human voice. The vocal tract model for vowel sounds is a cylinder about 20 cm long. Placed atop a speaker that serves as a sound source, the cylinder makes beautiful vowels. By changing the thickness of the pipes through which air passes inside the cylinder, the vowel sounds corresponding to the Japanese letters, a, i, u, e, and o can be produced. For example, the "ah" sound is reproduced through the combination of a thin pipe (simulating the throat side) and a thick pipe (the mouth side). It's surprisingly simple.

"Its simplicity is the result of peeling away excess and leaving only the essential elements, based on an educational perspective. When our research first began, the challenge was how to explain to students in an easily understandable way how human beings produce speech. It's hard to help them understand just by drawing illustrations on the blackboard or showing slides. We wanted to use something tangible. That's why we decided to use a physical model. Simply by repositioning the sliding part with a small hole in the cylinder, we can generate the sounds "ahh" "eee" and "ooh" The educational potential of the vocal tract model when used in the classroom comes from the way it helps students intuitively understand the mechanisms of speech production."

Fig. 1 shows the vocal tract models for producing the five vowel sounds by using pipes of various different diameters.

The starting point for research on speech sounds

A vowel sound is a relatively stationary speech sound formed by vocal-fold vibrations creating the sound source, and the vocal tract (including the oral and nasal cavities) acting as a resonator. The first sound made by a newborn baby is a vowel sound, characterized physically by its fundamental frequency and its resonant frequencies. The fundamental frequency is the frequency of the speech vibrations, corresponding to voice pitch, while the resonant frequencies are the various frequencies that determine the quality of the vowel as the harmonic components are amplified in the vocal tract. Although we now know that a vowel sound is a human being's most fundamental speech sound, a wide range of propositions were made after serious speech research began in the 19th century, and there has been a good deal of confusion.

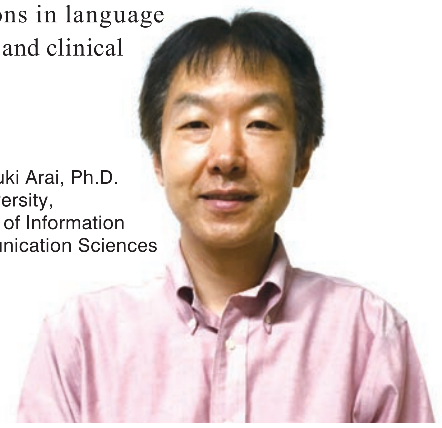
The dispute concerning vowels was brought to a stop by "The Vowel" [1], 1 authored by linguist Tsutomu Chiba and physicist Masato Kajiyama in 1942. In that work, Chiba and Kajiyama elucidated the relationships between the shape of the vocal tract and the acoustic properties of a vowel sound and between an equivalent resonator and the resulting resonant frequencies. Their work was revolutionary in that it confirmed that an artificial vowel sound generated from a vocal tract model had the same distinguishing features as an actual spoken vowel sound. Just as Newton's Principia was the starting point of modern science, so was this work the starting point of contemporary speech research.

Chiba published this book based on the studies at the Tokyo School of Foreign Studies; he later continued his studies at Sophia University.

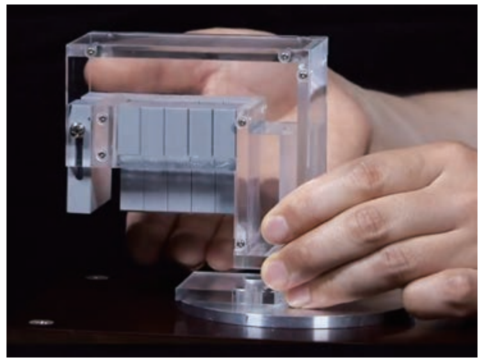
"My studies of the vocal tract model expand on the studies of Prof. Chiba, who was the first anywhere in the world to systematize vowel science. The vocal tract model makes it possible to conduct repeated speech production experiments by partially simulating the human speech organs. Sound changes as a result of a combination of movements such as the closing of the lips, the opening or closing of the valve that controls the flow of air to the nose, and raising or lowering the tongue. These can be tested repeatedly through trial and error. Aside from the goal of simplicity for educational purposes, the vocal tract model has research potential for further investigations of the mechanisms of speech production clarified by Prof. Chiba."

The vocal tract model for research use (Fig.2) is curved in the middle at right angles, just like a human throat. It includes structures for simulating the movements of the lips and tongue. One version even models the tongue using a flexible material that simulates an actual human tongue, generating the sound "ahh" when the throat side is narrowed and the mouth side widened. The "eee" or "eh" sounds can be generated through precise control of the elevation of the flexible tongue. The "bah" sound can be generated by releasing the lips after completely closing them once with the mouth shaped as when making the "ah" sound. The "bah" sound becomes "mah" when the air flow escapes through the nose. Another version can generate even the "r" and "l" sounds that Japanese people tend to have difficulty pronouncing.

"Another model for the "r" sound also can be used to differentiate the subtle differences in pronouncing "tense/lax" versions of "i" or "e" in English.To train people who have trouble pronouncing these sounds, we ask them to pronounce them while repositioning the tongue in increments of just a few millimeters, using their hands. Using one's own fingers in pronunciation training helps improve pronunciation, as people learn to use their tongues like fingers. In addition, using this model to explain pronunciation to patients who face pronunciation difficulties can help them understand the principles of phonation and articulation, which makes language learning easier. In this way, we learned that the vocal tract model also has applications in language education and clinical settings."



Prof. Takayuki Arai, Ph.D.
Sophia University,
Department of Information
and Communication Sciences



(Left) Fig.1.
Vocal tract models using pipes
(Right) Fig.2.
An example of a research vocal tract model (from YouTube)
https://www.youtube.com/watch?v=BKbbQC0WKvQ

The significance of the vocal tract model

The ongoing progress in computer speech technology is remarkable. The words spoken by car navigation systems and artificial intelligence applications employ speech synthesized by computers. So why pursue an analog approach by generating speech sounds as a result of the resonance in the vocal tract model, whose input is vocal-fold vibration? This model has successfully generated the truly human-like "ah" sound of a sigh by exciting it with a lung model (Fig.3) that uses a balloon as a lung and a rubber membrane as a diaphragm.
"Of course, we recognize that there's great value in using computers. In fact, we're working on research on communication support systems and other computer-related studies. But while people today are no longer surprised to hear speech come from a computer speaker, when they hear speech sounds from a model like this, their eyes light up with surprise. Why this difference? A head-shaped model that can only make the "ah" sound sounds just like what real humans produce. There's an essential difference here. Even if the sound produced by a vocal tract model is the same as one from a speaker, it still creates a different impression and has a different effect on people. In this sense, I think it includes some of the essence of human speech communication."

Achievements through speech research

Prof. Arai says that the simple vocal tract model is the result of eliminating the individuality of a human speech, however, this paradoxically makes it easier to explore the individuality of each person's speech sounds.
"The individuality of a human speech comes from various elements. This includes not just differences in resonance due to minute variances in the shape of the vocal tract, but the pitch of the voice, the degree of admixture of breath, accent, and intonation. For example, when police identify a criminal by his or her voice, they bring to light distinguishing features by analyzing these elements. One of the most important policies of our laboratory is:"Do it for people." Rather than pursuing a subject just because it's interesting, we ask ourselves constantly, "Can this help or support people?" At the same time, when pursuing the individuality of human speech, we return to the fundamental question of what differentiates human speech from other sounds. By returning in this way to the starting point and looking anew at the essentials of humanity, we might be able to make some breakthroughs. This is the context of the vocal tract model."
Prof.Arai says he grew up watching his father, a pulmonary surgeon. Although he did not become a doctor himself, he has committed himself to helping people through his speech research. Unmistakably, the ultimate targets of his studies through the vocal tract model are human beings.

The vocal tract model that Prof. Arai has developed is on display around the world. Table1 shows some of its major exhibitions.

Reported by : N.Okamoto

Table 1. Main sites of vocal tract model exhibitions (as of November 2016)

Venue	Location	Notes
Swiss Science Center Technorama	Zurich, Switzerland	Ended
Shizuoka Science Museum Rukuru	Shizuoka,Shizuoka Prefecture	Permanent exhibition
Hitachi Civic Center	Hitachi,Ibaraki Prefecture	Permanent exhibition
Wonder Museum,Okinawa Zoo & Museum	Okinawa,Okinawa Prefecture	Permanent exhibition
Handel House	Halle, Germany	Permanent exhibition
Estonian National Museum	Tartu, Estonia	Permanent exhibition Nine Estonian vowels
Dresden University of Technology	Dresden, Germany	Now under preparation

(References)
[1] T.Chiba and M.Kajiyama : " The Vowel : Its Nature and Structure", Tokyo Kaiseikan, 1942

Fig.3.
Prof. Arai demonstrating a lung model with a head-shaped model (from YouTube)
https://www.youtube.com/watch?v=fG151ztS968

02 Case study

Acoustic Measurements for a Chapel

A unique design resolves conflicting acoustic requirements

Tokyo Bible Church (Meguro Ward, Tokyo)

The church stands on the corner of a busy intersection, but stepping into the main chapel, one enters a peaceful, hushed space that makes the hustle and bustle outside seem unreal.
Rion's instruments were used to make various acoustic measurements (outdoor noise, sound insulation, and reverberation time) for this chapel, which was completed in March 2016.

Acoustic challenges

Since its foundation by a husband-and-wife team of American missionaries, Tokyo Bible Church[1] has inhabited its original building for more than 60 years. The biggest challenge during its long-looked-for reconstruction involved acoustics. Tranquility is essential for the religious practice of prayer. Situated in a location where noise levels exceed 70 dB —a corner of the intersection between Meguro Street (with two lanes in each direction) and Jiyu Street (with one lane in each direction) — the project demanded a high level of sound insulation. While it would be possible to achieve some noise cancellation using thick walls if the structure had been steel-reinforced concrete, the church was to be built of wood for various reasons. Additionally, in its services, this Protestant church stresses the pastor's sermons and the singing of hymns by the congregation. Brief reverberation times are ideal for audio clarity during sermons, while long reverberation times enhance the voice quality of the choir. The design of the church resolved these mutually conflicting acoustic performance needs.

Design and construction efforts

Design work proceeded based on the following policies, focusing on the elements of worship stressed by the church:

- Sound insulation : Blocking out outdoor noise by positioning cloisters with noise-absorbing walls around the chapel.
- Reverberation : Avoiding noise absorption as much as possible inside the chapel by applying plates all over exposed surfaces to help sound waves carry throughout the space.
- Clarity : Installing planewave speakers with remarkable capabilities in projecting sound in straight lines to carry the speaker's voice.
- Design : Adopting an octagonal design for the chapel itself and placing the pulpit, communion table, and baptismal font along the three walls in the front.

The result was a uniquely shaped chapel of two overlapping squares positioned at a 45° angle. (Fig.1-3).

Measuring outdoor noise

An NL-52 sound level meter was set up at the boundary of the church site (M0 in Fig. 4) to measure outside noise.
The equivalent continuous sound level (Leq) over 10 minutes at the intersection outside the church was 71.2 dB. While this fluctuated somewhat due to the effects of traffic signals, the location was subject to constant noise.

Measuring sound insulation

The noise measured inside the chapel was at a level of NC-20.* This level of sound suppression represented sufficient sound suppression required for a space envisioned as a multipurpose hall.
* NC values are explained in an article on p.16.
Next, we measured the sound insulation performance of the chapel in accordance with JIS A 1430.[2] Since this chapel has cloisters separating the innermost space from the perimeter walls, we measured the effectiveness of the sound insulation between the outside and the cloisters and between the cloisters and the chapel

Fig.1.The church exterior

Fig.2.Inside the chapel

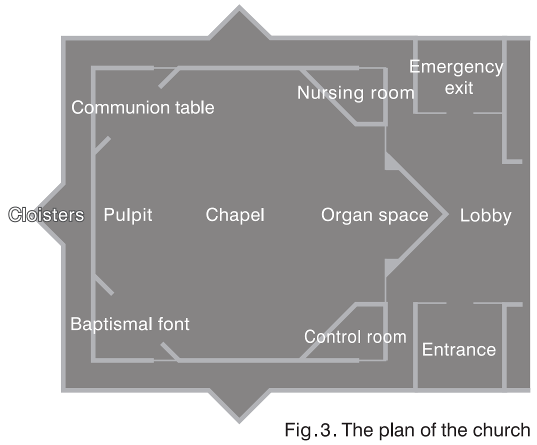


Fig.3. The plan of the church

(Fig.4). These measurements were made along the entirety of the perimeter walls. We measured the differences in sound pressure levels relative to the traffic noise as sound source between the outside and the cloisters. We set up speakers inside the chapel to measure differences in sound pressure levels between the chapel and the cloisters.

The measurement devices used included a portable RIONOTE Multi-function Measuring System, an optional SX-A1RT 1/3 octave band analysis program for the meter, UC-53A microphones, NH-22 preamps, and a SF-06 random noise generator. Measurements were made at six points: four inside the chapel (not including M3) and one inside the cloister area and one outside. Every microphone was set up at a distance of about one meter from the wall and at a height of about 1.5 m above the floor. Traffic volumes were about 350 vehicles on Meguro Street and about 90 vehicles on Jiyu Street during the 10 minutes of the measurement. A speaker was set up inside the chapel at one point, S1.

The volume of sound insulation from the exterior to the cloisters was 22.4 dB at 125 Hz and 43.6 dB at 2 kHz. At these levels, traffic noise from the intersection was only slightly audible inside the cloisters (Fig. 5).

The volume of sound insulation from the chapel to the cloisters was 23.7 dB at 125 Hz and 36.4 dB at 2 kHz (Fig. 6). A very small amount of sound from inside the chapel was audible in the cloisters, having escaped through the gaps in the doors. As shown on the two graphs, the sound-insulation effects from the exterior to the chapel were approximately 50 dB at 125 Hz and 80 dB at 2 kHz. Ultimately, the cloisters reduced traffic noise to negligible levels inside the chapel.

Measuring sound insulation (RIONOTE, SF-06)

Measurement of reverberation time

Reverberation time is defined per band as the time required for sound to decay by 60 dB from stationary levels. Using the interrupted noise method specified in ISO 3382-1 [3], we set up multiple noise sources and measurement spots and derived the average values from multiple measurements.

The equipment used consisted of an SA-02M Multi-channel Signal Analyzer and AS-20PC5 airborne/floor impact sound insulation measurement software. AS-20PC5 makes it possible to shorten measurement times by automatically calculating noise interruptions and average reverberation times following measurement. Table 1 shows the major conditions of measurement. We arranged the measurement points in the same way as when measuring sound insulation using UC-53A microphones and NH-22 preamps in five locations inside the hall.

Table 2 shows the measurement results. Figs.7 and 8 show the measurement screens.

The optimal reverberation time for a room, generally a value in the 500 Hz band, is determined by the intended usage and volume of the space. Since the chapel has a large interior, a longer reverberation time is suitable. Results of these measurements showed that for a volume of space of approximately 1,200 m³, the reverberation time at 500 Hz was 2.25 seconds. The comparison in Fig. 9 shows that this value, while on the long side, is within the range suitable for church music.

Measuring reverberation time (SA-02M, AS-20PC5)

[1] 2-9-9 Yakumo, Meguro-ku, Tokyo http://tokyobible.com/ See here for a 360º video of the interior of the chapel, viewable on smartphones and other devices. https://youtu.be/gRGENcTRno8

[2] JIS A 1430:2009: Acoustics—Field measurements of airborne sound insulation of facade elements and facades.

[3] ISO 3382-1:2009 Acoustics — Measurement of room acoustic parameters—Part1:Performance spaces.

The measurement team (from left) : T.Naito (reporter), Y.Yonemoto, C.Fujita, A.Nagai (each from the Development Division)

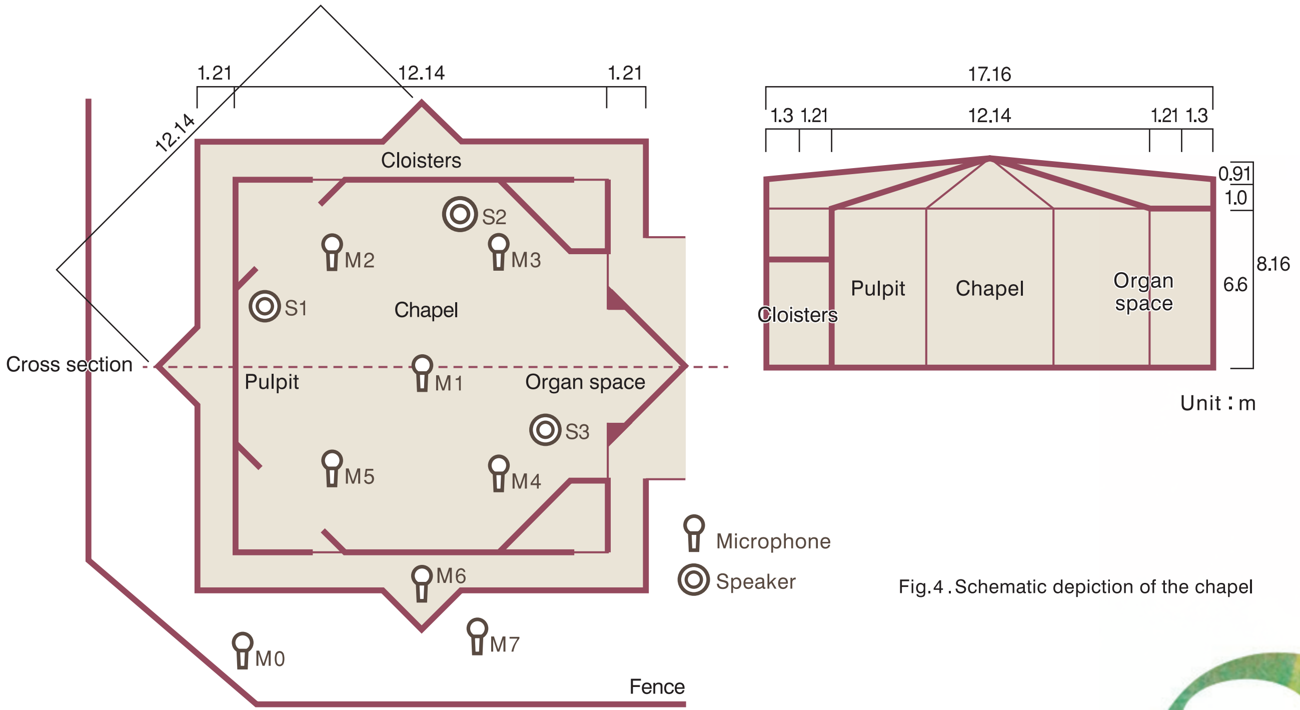


Fig.4 .Schematic depiction of the chapel

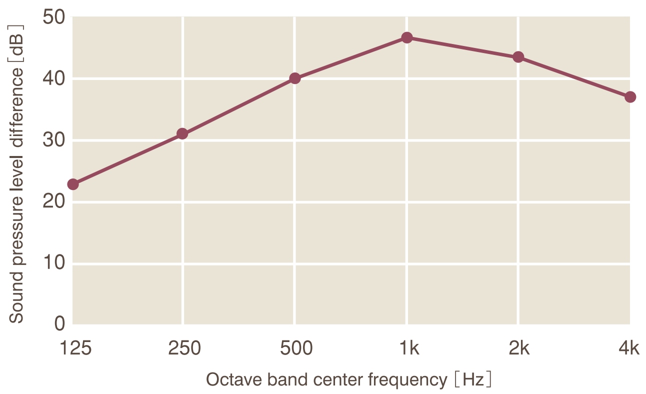


Fig.5. Sound insulation (between exterior and the cloisters)

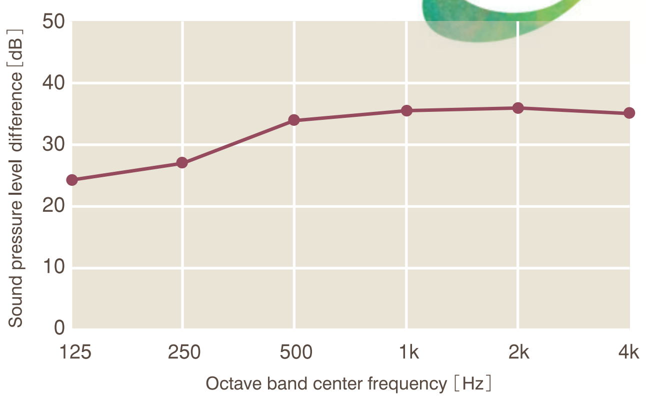


Fig.6. Sound insulation (between chapel interior and the cloisters)

Table 1. Major conditions of reverberation times measurement

Measurement method	Interrupted noise method
Quantity of measurement	Octave band
Number of sound source locations	3
Number of measurement spots	5
Number of repetitions	5
Measurement frequencies	125 Hz-4 kHz (octave)

Table 2. Results of reverberation times

Frequency band	Reverberation time (seconds)
125 Hz	2.02
250 Hz	2.34
500 Hz	2.25
1 kHz	2.27
2 kHz	2.29
4 kHz	2.16

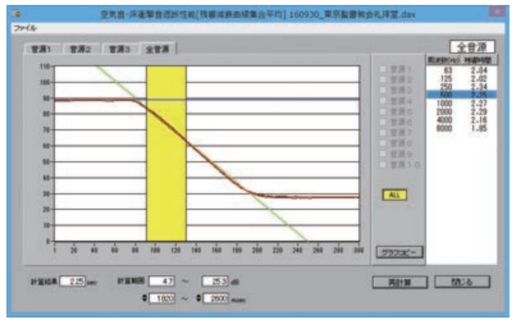


Fig.7. Graph of decay curve (AS-20PC5)

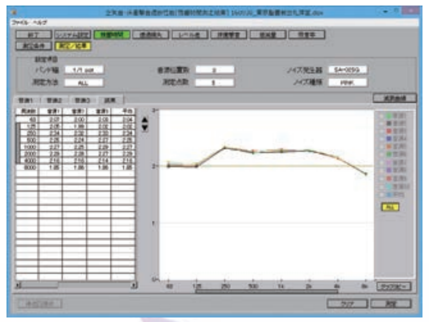


Fig.8. Results of reverberation time measurements (AS-20PC5)

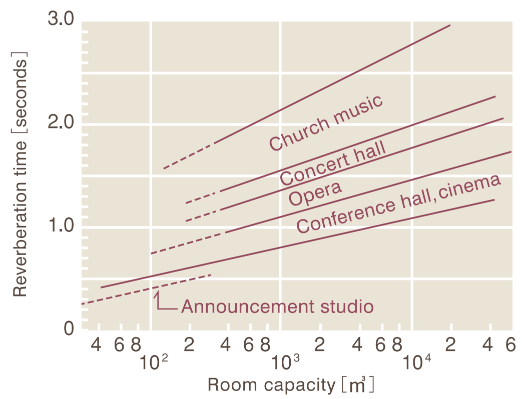


Fig.9. Scope of optimal reverberation time (500 Hz)

Understanding Measuring Instruments

We will explain a measuring instrument from various angles in a three-part series

The seismometer (Part 1 of 3)

Quantifying Earthquakes

Each time an earthquake strikes, the magnitude and seismic intensity figures are announced.
But how are these figures calculated and what purpose do they serve?
This three-part series will discuss topics related to seismometers.

Old-time seismometers

The first earthquake detection equipment for which we have detailed records was a tellurion devised by the scholar Zhang Wei in 132 CE during the Later Han Dynasty (Fig.1). It featured dragons with balls in their mouths arrayed around a cylinder facing in eight directions. In the event of an earthquake, the ball facing in the direction of the epicenter would be the first to drop, falling into the mouth of a frog positioned below it, making a loud noise in so doing. It's said that people were amazed to receive a message of an earthquake which had taken place far away a few days after a ball had dropped due to a tremor imperceptible to humans.[1]

In Japan, the book *Tensai kara Nihonshi wo yominaosu* ("Re-evaluating Japanese history through natural disasters") by the historian Michifumi Isoda contains the following interesting passage:

"When an earthquake struck in Edo, the daimyo feudal lords and others needed to send messengers to the Shogun to inquire as to his well-being after the quake. But this led to the problem of determining the degree of shaking at which a messenger would be sent. If they sent messengers after quakes of seismic intensity levels 1 or 2 they would have become a laughing stock… This led them to devise rainwater tanks. In general, the water in a rainwater tank will spill in the event of a quake with a seismic intensity of 4 or above. This is what was used by the samurai of the Edo… The rainwater tank was the seismograph for the people of Edo."[2]

Quantifying earthquakes

Quantifying earthquakes, which can cause property damage and injure people, serves the following purposes:

- It prevents damage by being useful in administering services and equipment — for example, in decisions whether or not to suspend trains.
- It helps identify the scope of the damage, which in turn makes it possible to ascertain the scope of aid needed.
- It helps in grasping correlation to the extent of the damage caused, which in turn makes it possible to establish building standards and other requirements.
- It helps prepare for the next possible disaster.

The best-known figures used to describe earthquakes are magnitude and seismic intensity. Seismic intensity describes the strength of ground shaking at a specific point, while magnitude describes the size of the earthquake itself at the point at which it occurred. While larger magnitudes correspond to larger earthquakes, seismic intensity will generally be higher at a point nearer the quake's epicenter and lower at greater distances from the epicenter. Other measurements include maximum acceleration, maximum velocity, and spectrum intensity (SI). Here, we will discuss three parameters used to measure earthquakes.

1. Magnitude

Magnitude expresses the size (energy) of an earthquake. It was defined by the American seismologist Charles Richter as the logarithm of the maximum amplitude value A, in micrometers, on the measurement record sheet of one component of a Wood-Anderson seismograph set up at a distance of 100 km from the epicenter.[3] For various reasons, a number of methods have been proposed for calculating magnitude. The Japan Meteorological Agency estimates magnitude (M) using the following formula in the event of an earthquake at a depth of 60 km or more (JMA Magnitude):

$M = \log A + 1.73 \cdot \log \Delta - 0.83$

Δ: Distance from epicenter (km)

A: Maximum seismic amplitude synthesized as a vector of two horizontal components (μm)

An increase of 0.1 in magnitude represents an energy increase of approximately 1.4-fold. Comparing the magnitude of the Great East Japan Earthquake on March 11, 2011 (9.0) with that of the Great Kanto Earthquake on September 1, 1923 (7.9) shows that the 2011 quake released approximately 45 times the energy of the 1923 quake.

2. Seismic intensity (*Shindo*)

For many years, seismic intensity (*Shindo*) was estimated based on physical sensations and surrounding conditions. This approach raised various issues, including subjective judgments of the people making the measurements; the time required to determine seismic intensity; and the limited number of locales for which seismic intensity is announced. One year after the 1995 Great Hanshin-Awaji Earthquake, seismic intensity was converted to a 10-level scale (Table 1) based on measured seismic intensities derived from the acceleration waveform measured by seismographs. This is done by first breaking down the periodic acceleration waveform in the directions X, Y, and Z to frequencies through Fourier transforms (Fig. 2) and returning these to periodic acceleration waveforms through inverse Fourier transforms for each of the three axial components and applying vector synthesis for the three components. Lastly, the value a is derived from the absolute value of the value obtained by vector synthesis* and plugged into the following formula to calculate measured seismic intensity I:

$I = 2 \cdot \log(a) + 0.94$

* The value "a" is the value at which the total time over which the value obtained by vector synthesis is equal to or greater than a is exactly 0.3 seconds.[4]

3. SI

Spectrum intensity (SI) values correlate strongly with the degree of damage sustained by structures. They are derived from a physical model that shows what amount of energy will shake a structure when the structure is exposed to earthquake forces. They can be used to express the extent of damage that a structure will suffer due to an earthquake. The maximum velocity Sv due to ground shaking (the velocity response spectrum) is calculated from a physical model with an attenuation constant of 20%, after which the SI value is calculated as the average value of Sv for the characteristic period bandwidth of the typical structure (0.1-2.5 seconds).

Earthquakes can occur at any time. To minimize earthquake damage, seismometers are constantly monitored. In the next issue, we will look at how a seismometer works.

(References)
[1] The Book of the Later Han
[2] Isoda, Michifumi, *Tensai kara Nihonshi wo yominaosu* ("Re-evaluating Japanese history through natural disasters"), Chuo-Koron Shinsho, p.48
[3] Richter, Charles, "An instrumental earthquake magnitude scale", BSSA Vol. 25, No.1, 1935
[4] Japan Meteorological Agency website, "How seismic intensity is calculated"

Hiroshi Nakamura,
Development Division

Fig.1. Zhang Wei's tellurion (©National Museum of Nature and Science)

Table 1. JMA seismic intensity levels

Seismic intensity level	Measured seismic intensity	Seismic intensity level	Measured seismic intensity
0	Lower than 0.5	Weak 5	4.5 or above, lower than 5.0
1	0.5 or above, lower than 1.5	Strong 5	5.0 or above, lower than 5.5
2	1.5 or above, lower than 2.5	Weak 6	5.5 or above, lower than 6.0
3	2.5 or above, lower than 3.5	Strong 6	6.0 or above, lower than 6.5
4	3.5 or above, lower than 4.5	7	6.5 or above

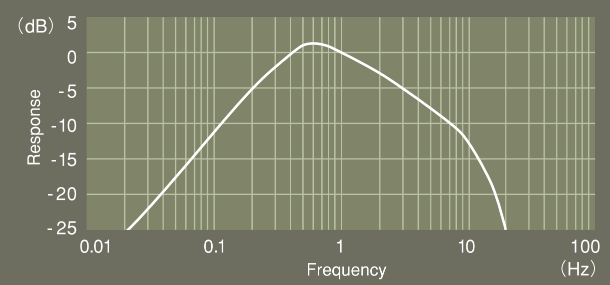


Fig. 2. Properties of the filter used to correct measured seismic intensity

Rion's History of Technology

LEARNING from our Past Products

From pure water to hydraulic fluid: Japan's first liquid-borne particle counter

KL-01

In 1977, we introduced Japan's first airborne particle counter, the KC-01. In 1981, we began tackling the next challenge: developing a liquid-borne particle counter. We spoke with Shigeru Arashiki,* who took part in this development effort.

* Currently an executive officer; he was a member of the Environmental Instrument Development Department Group 1 at the time the KL-01 was developed.

——Can you tell us about the background of the development of the liquid-borne particle counter?

The liquid-borne particle counters sold around 1980 were only made in foreign countries. It was a large-scale system with numerous components. For this reason, the goal of our development efforts was to develop an all-in-one, portable liquid-borne particle counter with exchangeable particle detection components.

——What were liquid-borne particle counters used for at the time?

They were used mainly to monitor new hydraulic fluid, as well as to manage the contamination of the hydraulic fluids used to operate aircraft flaps and rudders. This measurement applied two methods: passing a fluid specimen through a filter and measuring the size and quantity of particles with a microscope; and measuring them by running the specimen fluid through a particle counter directly.

——Where did your development efforts start?

I studied the basics of liquid-borne particle counters, including calibration fluid production, calibration, and measurement methods. Since particle counters are managed using calibration fluid, preparing this fluid is critical.

——What kind of fluid is calibration fluid?

The term calibration fluid refers to air cleaner fine test dust (ACFTD)[1] calibration fluid, a fluid produced by dispersing a certain amount of the powder used to test the clogging of air filters into aircraft hydraulic fluid. Calibration fluid is important because it's required to set the particle diameters used to evaluate the output of a liquid-borne particle counter.

——Please tell us about the principles for detecting particles in liquids.

At that time, stipulations for aircraft applications were set forth in ISO 4402 (the ACFTD calibration method),[2] while stipulations for pharmaceuticals were set in the Japanese Pharmacopoeia (light extinction method). The former measures the degree to which light is extinguished (i.e., the decrease in light energy) as it's scattered when shined on particles. Back then, it took about three days for a computer to calculate theoretical values from the sensor response. Today it takes a few seconds. Semiconductor-based LEDs replaced the traditional light source of tungsten lamps, which had filaments that were susceptible to vibration.

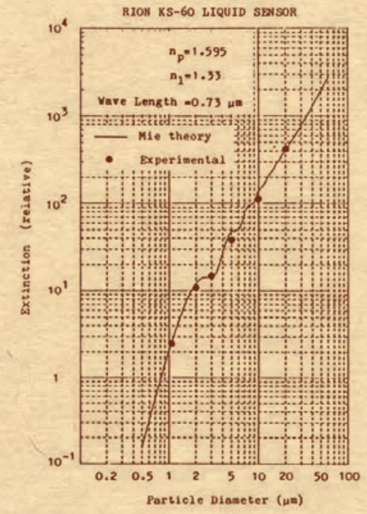
——When was the product released?

In 1984. The next year, in 1985, we gave a presentation on the KL-01 and the corresponding sensor, the KS-60, at a technical meeting. The title of our presentation was "Developing a liquid-borne particle contamination measurement device."

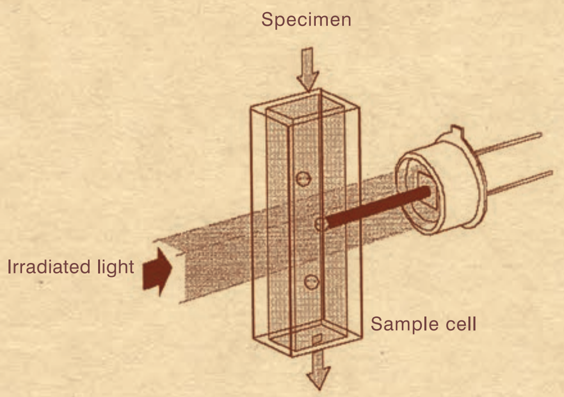
——Please tell us about the properties of the KL-01.

It's a single portable unit, with replaceable sensors. It offers good sensor response, and it's affordable. The main unit consists of the fluid system, the sensor, and electronic circuitry. After setting the specimen liquid in the fluid system, you pressurize the chamber to drive the specimen fluid to the sensor. The fluid is automatically extracted after measurement. The fluid system is made of materials selected to be easy to clean. The electronic circuitry handles adjustments of sensor levels, analysis of particle signal diameters (6ch), display, and printing. It also controls the electromagnetic valves, pressure pumps, and other components.

Shigeru Arashiki



The response properties of a sensor (KS-60), calculated over three days



Measurement principles

——What was the market reaction?

Given the background of the product's development, we began by focusing our sales activities on the hydraulics market. Later, we expanded into the pharmaceutical and semiconductor markets. We were worried about market acceptance due to its price — it cost around 4 million yen, which was high for a Rion product. I still recall vividly the moment when one customer asked me: "Can we really rely on such a low-priced product?" The liquid-borne particle counters made by overseas manufacturers were priced at 10 million yen or higher. We eventually sold more than 400 units, making product improvements, cutting costs, and adding new options along the way.

——Were there any other interesting episodes after that?

It's not used today, but CFC cleaner for precision-machined metal components was regarded at that time as a miracle cleaner due to its high permeability—it got into all the nooks and crannies of precision-machined components. It couldn't be measured using devices from overseas manufacturers due to its strong foaming properties. We then devised a method for increasing the pressure inside the sensor while suppressing foaming, which made CFC measurements possible. After that, we received overwhelming numbers of inquiries from CFC manufacturers and users. In the medical field; it caught the eye of the late Prof. Toshinobu Aoyama of the school of Pharmaceutical Sciences at Kyushu University, a pioneer in the measurement of insoluble particles in injections. He presented a paper based on use of the KL-01 in the United States and introduced the KL-01 to pharmaceuticals makers in Japan, which boosted sales.

——As one of its developers, how do you feel about the product?

In working to develop our first liquid-borne particle counter, we achieved our goal by collaborating with experts across a wide range of areas. Product requirements vary from market to market. The semiconductor devices market requires state-of-the-art measurement technologies in areas like minimum measurable diameter. The pharmaceuticals market stresses product reliability and completeness. A relatively recent requirement is ease of use. We hope to see improvements in human-machine interface technologies in the future.

Interviewed by: H.Shoji

[1] Natural sand dust from the Arizona deserts in the U.S. is used as air cleaner fine test dust.
[2] ISO 4402 Hydraulic fluid power; calibration of automatic-count instruments for particles suspended in liquids; method using classified AC fine test dust contaminant

Hello From the Office

A European Base for Sound and Vibration Measuring Instruments

Rion Co.,Ltd. Europe Representative Office

Our office opened in the Netherlands in 2002 with the goal of expanding Rion's Sound and Vibration Measuring Instruments business in Europe. After relocating to Denmark in May 2016, we operate today with a total staff of three, including one representative from Japan. Our primary duties are customer support and market research in Europe. While numerous local manufacturers of sound and vibration measuring instruments operate in Europe, many customers here are loyal users of Rion's Sound and Vibration Measuring Instruments. The regard expressed for our products for their quality and ease of use reminds us why customers choose them for highly reliable measurements, an aspect of instrument performance commonly required worldwide. In our daily activities, we deal with individual customers, based on Rion's commitment to integrity and good faith not just in product sales, but in support.In the future, the Europe Representative Office will continue to strive to contribute to the growth and progress of European society and industry based on this customer service spirit and the technologies and products accumulated by Rion over the years.
We are waiting for you with cold Carlsberg beer.

(From left) Y.Hagiwara, T.Kønigsfeldt, P.Simonsen

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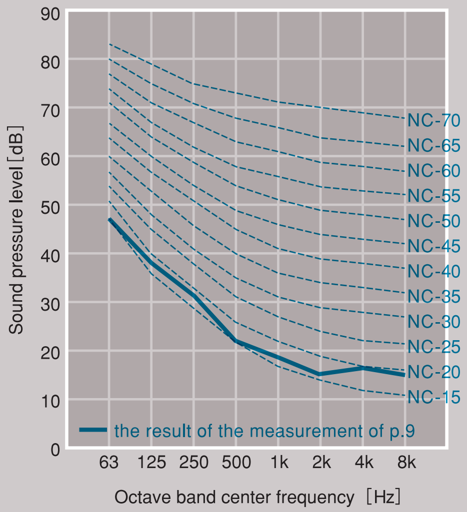
Tell Me Dr.Sojun

Q.What's an NC value？

The Noise Criterion (NC) level is one of the noise evaluation indexes for the noisiness or quietness of an indoor room.The NC level is used to evaluate continuous and broadband spectrum noise, e.g. noise from a room air-conditioning system, and is based on a rating system introduced by L.L.Beranek, an American acoustics expert.
A set of NC criteria curves drawn on a graph is used to find the NC level. At first we measure the sound pressure level of each octave band of the noise spectrum and then plot every octave band level on a graph. The NC level is the label attached to the lowest curve which is drawn under all the plotted points.The NC level is used to help set design goals that will ensure a maximum acceptable indoor noise, dependent on the purpose of the room. For example, NC-40 is the limit that workers can endure in an office, while noise lower than NC-15 is desirable in a concert hall.In Japan, the N level, which has been established by the Architectural Institute of Japan for the purpose of deciding indoor noise ranks, is the same as the NC level.



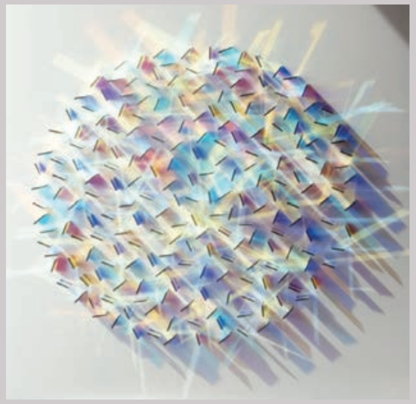
Dr. Sojun Sato, Senior Advisor, former Head of Acoustics and Vibration Metrology Division, NMIJ, National Institute of Advanced Industrial Science and Technology

SCIENCE COLUMN

Q. What color is snow?

The only sport in which (I think) I can hold my own is skiing. It's hard to describe the sense of speed from gliding along a slope and how satisfying it feels to master a bumpy slope. It's also fun to see the clean, crystal snowflakes land on my skiwear when I'm riding a lift through a powdery snowfall. It makes one wonder why snow crystals appear white in color as they fall from the sky and when they accumulate on the ground.
This leads to the question of just what color means. In the case of an object that doesn't emit light itself, the sensors that we call our eyes see the reflected light from another source as its color. For example, leaves appear green in sunlight. That's because of all the various wavelengths found in sunlight, leaves reflect only the wavelength of green, absorbing light at all other wavelengths. If an object reflects all the wavelengths of visible light, it looks white.
Let's return to the matter of snow. Snow crystals appear transparent because light passes through them without being reflected or absorbed. But why do falling snowflakes or banks of snow appear white? It's because when light shines on aggregated snow crystals, it undergoes repeated diffused reflection as a result of the complex structures of the crystals and the air in the spaces between them, so that most wavelengths get reflected. That's why snow looks white.
Incidentally, I travel to many different places to ski. My favorite snow is the glittering powder of Nagano, where temperatures are very low.

Takashi Minakami, Development Division



A glass sculpture with light reflection as a motif
"Orderd Chance" ©Chris Wood (Light artist)
http://www.chriswoodglass.co.uk/

Japanese scenery

In areas of the Tohoku region covered with (thick) snow, people build snow caves called *kamakura* and place altars inside. In the silence of the snowfall, they pray to *Suijin*, the god of water, for a rich harvest in the coming year.

Shine View!

Introducing one of Rion's shine workers, someone who shines, on and off duty.

Ms.Takayo Takada (Development Division)

What makes the horn so attractive is the ensemble

About the horn

Originally named after the horns of animals, the instrument we call the horn is described by the Guinness Book of World Records as the world's most difficult brass instrument. With a gentle, rich tone, it's a harmonious instrument positioned somewhere between brass and woodwinds.

—— How did you start playing the horn?

I was first exposed to music when I joined the marching band in elementary school. I wanted to play the trumpet, but I didn't pass the tryouts, so I was assigned the bass drum.I joined the brass band in junior high school. For some reason, this time, instead of the trumpet, I chose the horn. That's how I first began. But the horn my school loaned to me wasn't the usual French horn. It was a mellophone, a simplified version of the horn. I played it for three years.In high school, I quit the brass band after one year. I started playing the horn again in college, when I joined the orchestra. Since an orchestra combines wind music with string and percussion instruments, it was a good fit for me as a horn player.A few years after I joined Rion, a colleague introduced me to a horn ensemble.

—— What attracts you to the horn?

To play the horn, you put your right hand in the bell to support the instrument. You also use your right hand to control the key and timbre of the sound by changing the shape the hand makes. I think the horn is the only brass instrument that's performed by using the right hand in this way. I think the horn makes wonderful chords, and it's better suited to harmony than solo play. I prefer the incidental motifs that help underscore the melody, and I enjoy performing with others. It takes an ensemble to best enjoy the attractions of the horn.

—— Have you had any memorable experiences playing the horn?

Once, somebody who loved music told me, "Listen to as much music as you can while you're still young and receptive. It enriches your life and gives you the sensitivity you need to be moved by music when you get older. That's the key to happiness." Those words really struck a chord. That's why I continue listening to lots of music today, in addition to playing the horn.

—— What activities occupy you now?

I keep playing musical instruments, even if it inconveniences my children.I'm also a member of Die Kokubunji Philharmoniker, though I'm on leave right now to take care of my children.I also remain a member of a horn ensemble formed with some friends who also play the horn. We meet from time to time. Playing music with them helps me relieve stress, feel more relaxed, and get away from everyday life.I'd encourage anybody who has the interest and the time to try to play an instrument—any instrument at all. I'm certain it will enrich their lives.

Interviewed by : N.Okamoto

TOPICS Research presentations, articles, etc.

【Related to sound and vibration measuring instruments】

◎ Inter-Noise 2016 (August 21-24 Hamburg, Germany)

- Case study of application of a wireless measurement system to a moving vehicle / M.Ohya, Y.Kurosawa and Y.Nakajima
- Long-term Measurements of Sound Refraction Paths over Residential Areas using Emergency Public Address Systems / T.Ohshima, T. Naito, T. Doi*1, T.Yokota*1 and K.Makino*1
- DNN-based Environmental Sound Recognition with Real-recorded and Artificially-mixed Training Data / Y.Nakajima, M.Sunohara, T.Naito, N.Sunago, T.Ohshima and N.Ono*2

◎Fifth Joint Meeting of the Acoustical Sosiety of America and Acoustical Society of Japan (November 28-December 2, Honolulu, U.S.A.)

- INCE/J Vibration Measurement Manual for Buildings-Part 4: Measurement of ground propagation characteristic and long-term measurement in building for road traffic vibration/ R.Kazama, K.Yamashita, H.Umayahara, T.Hasumi

【Related to particle counters】

◎Sensors and Materials, Vol.28, No.6

- Development of an Automatic Sampling Module to Monitor Concentration of Liquid-Borne Nanoparticles / Y.Yeh*3, K.Kondo, and H.Weng*3

*1 Kobayasi Institute of Physical Research
*2 National Institute of Informatics
*3 Industrial Technology Research Institute

About the Front Cover

An orchestra brings various instruments together to perform a single piece of music. The breadth of its diversity is comparable to the diversity of human beings. Each plays its own individual role to form a vast symphony, creating beautiful harmonies that bring to mind a vision of the whole world. (Oana)

Editorial Postscript

This issue is the first to feature an INNER VIEW interview with a female subject. The articles also include two women from the Development Division, and the magazine was designed by a woman as well. At the same time, here in Tokyo, we've elected our first female Governor. Surely women will play even more vital roles in society in the future. Women and men will combine their individual strengths to make a better world. I think we'll need to more fully incorporate the perspectives of women into Rion's products.
(M.Okazaki)

This magazine can be downloaded from the *Shake Hands* website, where you also can take part in a reader survey: http: //rion-sv.com/shakehands/

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