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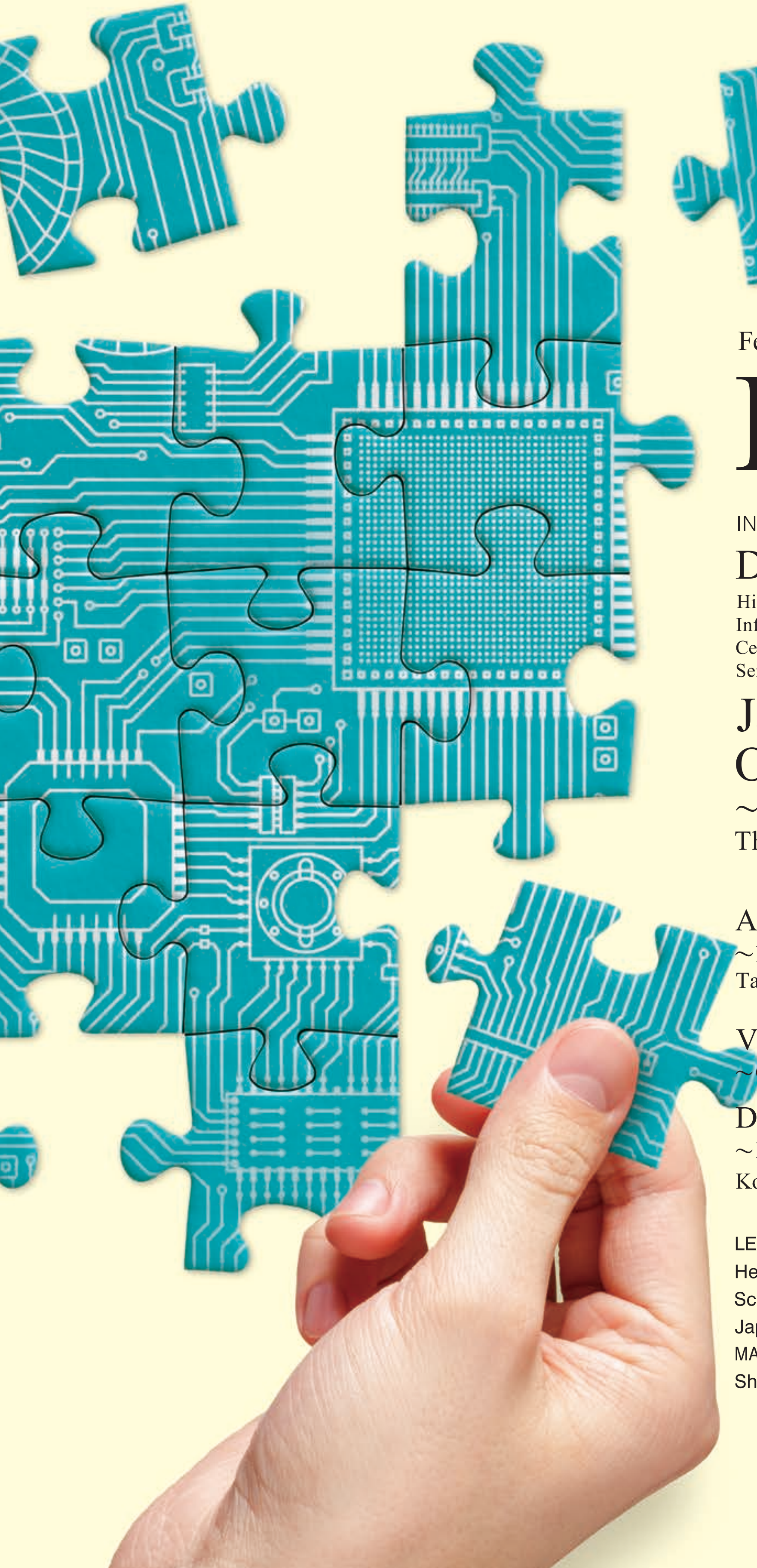

Feature Story

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INNER **VIEW**

Dr. Masanao Yamaoka

Hitachi, Ltd. Research and Development Group
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Center for Technology Innovation - Electronics
Senior Researcher

Japan's Specialty, Once Again

～Defying Conventions, a Machine That Took the Semiconductor Industry by Surprise

Annealing, the Process That Resets Metals

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Kobayasi Institute of Physical Research

RION CO., LTD.

Masanao Yamaoka

PhD (Informatics). Born in Hiroshima Prefecture in 1973, Dr. Masanao Yamaoka earned a master's degree in 1998 at the Graduate School of Engineering, Kyoto University. In the same year, he joined Hitachi, Ltd. and began working on research and development related to low power consumption memory circuits. In 2007, he completed the doctorate course at the Graduate School of Informatics, Kyoto University. From 2013 to the present, he has led research and development on CMOS annealing machines.

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Dr. Masanao Yamaoka

Senior Researcher Hitachi Research & Development Group
Information Electronics Research Department Center for Technology Innovation – Electronics

Japan's Specialty, Once Again

~Defying Conventions, a Machine That Took the Semiconductor Industry by Surprise

Photo by Megumi Yoshitake

With its spacious premises in Kokubunji City, the Hitachi Central Research Laboratory is a neighbor, located within walking distance of Rion's headquarters. There we paid a visit to a central figure in the development of next-generation computers.

"But there's nothing quantum about that!"

Anyone with an interest in computers has heard of quantum computers. In contrast to ordinary computers, which harness semiconductors like LSIs and read and execute programs sequentially, quantum computers obtain solutions by observing the unique behavior of quantum particles in a superconducting state created when cooled to temperatures close to absolute zero. Natural computing is the term for computer technologies like this based on natural or physical phenomena. Natural computing has the potential to solve extremely quickly complex problems we wouldn't expect ordinary computers to solve in a reasonable timeframe. Natural computing, which relies on new principles diverging significantly from conventional computing methods, is expected to become the next-generation computer technology supporting a future IT society.

In 2015, Hitachi surprised the world with its announcement, made at the ISSCC*1, an international meeting known as the Olympics of semiconductors, of a CMOS annealing machine (Fig.1). Using semiconductors to implement a new operating principle intended to transcend the limitations of semiconductors, this machine defied conventions. Dr.Yamaoka, who gave the presentation, recounts those days.

"We got strong responses from two groups. One was the semiconductor industry. We seemed to be approaching the limits of semiconductor performance, and many in the industry believed we were in dire need of a breakthrough. So, our machine was hailed as the new semiconductor technology. The other group, in contrast, consisted of people involved with quantum computing. Their criticism was that there was nothing quantum about our machine. [laughs] Since then, I've had the opportunity to speak with those in the latter group, and I've persuaded them to come to the understanding that an approach like ours is also vital."

*1 ISSCC: International Solid-State Circuits Conference

Annealing — specialized to solve combinatorial optimization problems

The term annealing here was originally a metalworking term. In quantum computing, as the observation target transitions from a state of high energy to low energy, phenomena can be observed that resemble those that occur while heated metal gradually cools during the annealing process. The quantum computers currently operating in the world realize this principle using quantum particles in a superconducting state. The problems that can be solved by annealing are known as combinatorial optimization problems.

"Combinational optimization problems involve finding the optimal combination of multiple parameters that satisfy the given conditions. One such prominent problem is the travelling salesman problem, where the objective is to find the shortest route a salesman can take that passes through all of the specified cities before finally taking him back to where he started. With this problem, the number of routes that can be taken increases explosively as the number of cities increases. Finding a solution to the problem using conventional computers can take astronomical lengths of time."

Current computers attempt to solve this problem by sequentially calculating the distance for each and every possible combination of parameters. In contrast, the annealing machine will at once read the parameters that give a stable state of energy lowered from the higher energy state, thereby obtaining a solution to the problem with incredible speed (Fig.2).

The real world presents many potential applications for the combinatorial optimization problem, says Dr.Yamaoka (Table 1).

"One real-world application of the travelling salesman problem would be determining how the matches between

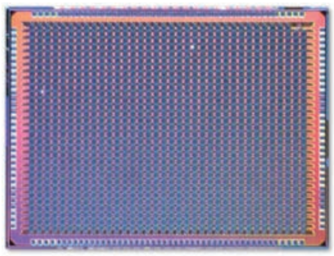


Fig.1. Semiconductor chip for CMOS annealing machine (4 mm wide × 3 mm high) ©Hitachi, Ltd.

Table 1. Example of fields with optimization applications

Field	Transportation systems	Supply chains	Power grids
Issue	Resolving traffic congestion	Minimizing logistics costs	Achieving stable energy supply
Target of optimization	Volume of traffic, travel costs	Total cost of transportation	Amount of stored energy, etc.
Input parameters	Traffic conditions, destination of each vehicle	Cost of transportation between supply bases	Power generating capacity, power consumption, transmission capacity of each line
Control parameters	Traffic signals, vehicles	Transportation routes	Power generating capacity, paths
Optimization problem	Maximum flow, shortest path	Travelling salesman	Maximum flow

Materials courtesy of Hitachi, Ltd.

the professional soccer teams can be scheduled to minimize the distance that the teams have to travel. Others include finding the combination of financial stocks that will offer the greatest returns with the lowest risk (a portfolio) or creating a work shift table for a factory. Conventional computers can handle this problem if the conditions for scheduling the shifts are simple, like securing a specified number of workers needed for each work day. But in practice, there's always a great number of constraints—a worker not being able to take the early shift following a late shift on the previous day or workers being required to have a day off after a specified number of consecutive work days. These constraints present significant obstacles for conventional computers."

Using semiconductors, the CMOS annealing machine realized a specialized method of annealing to solve such combinatorial optimization problems.

"When quantum computers first appeared, we were discussing what exactly they were. And we started to ask ourselves if the principle could be realized using semiconductors.We were approaching the limits of semiconductors in terms of enhancing performance, but there was an ample stock of established technologies for semiconductors. Our team had been developing semiconductors for quite some time, and we had the technologies in hand. So we decided to give it a try and embarked on our development efforts."

What are the advantages of developing a machine based on semiconductors, given that quantum computers are being realized?

"Quantum computers offer extremely high precision, so they' ll be suitable for problems that require such precision. On the other hand, our semiconductor chips are easy to handle and produce on a large scale. So, I expect they' ll each be applied to the problems that suit them and that their areas of application will be distinct."

From electronic circuits and human-powered gliders to semiconductors

Dr.Yamaoka says his father may have influenced him in choosing this life path.

"My father was an electronic circuit engineer. I got interested in electronic circuits, too, and used to make model cars and wireless microphones using electronic circuits, and also toys using LEDs. One day, my father gave me a used oscilloscope, which I used to observe circuit waveforms to create more sophisticated designs. Then I really got hooked."

But ever since he was in elementary school, Dr.Yamaoka also loved to run around outdoors. He never narrowed his horizons, instead expanding his activities to include soccer in junior high school and swimming in senior high school. When the time came to choose a university, he chose the Faculty of Engineering at Kyoto University, a university with a well-known reputation for eccentrics and freedom of activities. There, Dr. Yamamoto joined a club whose goal was to compete in the Japan International Birdman Rally.

"Up through junior year, I made human-powered gliders. They're aircraft powered[*2] by a pilot pedaling to turn the propellers, like bicycles. We weren't one of the top teams, but we had a brilliant student majoring in aeronautics on our team. In my junior year, we succeeded in building a glider that flew 310 meters. We ended up winning 4th place on the national stage."

This experience acquainted Dr.Yamaoka with the difficulties and rigors of *monozukuri* (manufacturing).

"We made the aircraft by ourselves, so we were aware that any lapses in commitment could cause the craft to fall, and even

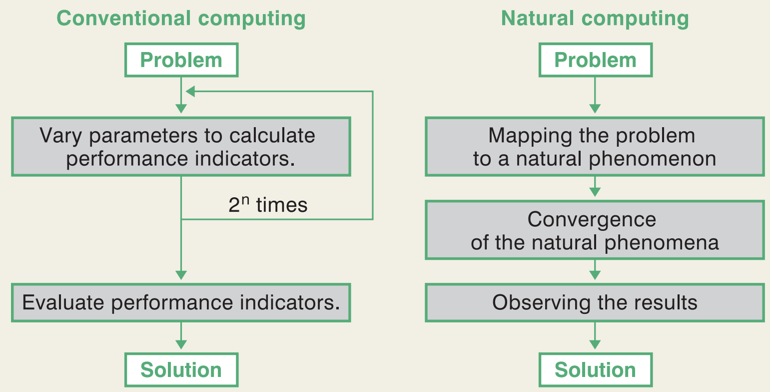


Fig. 2. The process of solving an optimization problem

In conventional computing, all performance indicators are repeatedly calculated to reach an evaluation of the indicators. To reduce the number of calculations required, natural computing relies on the tendency of natural phenomena to converge.b

Materials courtesy of Hitachi, Ltd.

endanger the pilot's life. Precision was essential. A difference of just 0.1 of a millimeter could change the flight distance by some 10 meters. We reveled in the satisfaction of finishing in 4th place."

In his senior year, Dr.Yamaoka joined a laboratory specializing in LSI development, where he learned how to design semiconductors. He says this choice was significantly influenced by his father.

"I've always made electronic circuits as a hobby, but my father said, 'The future lies in ICs, not electronic circuits. A single IC chip will be able to do everything. You won't make a career specializing in electronic circuits.' So I decided to study ICs. I was amazed a small semiconductor chip could perform all the functions of my handmade electronic circuits."

After graduate school at Kyoto University, Dr. Yamaoka joined Hitachi, Ltd. The days in which semiconductors were widely regarded as Japan's forte were waning. Nevertheless, for the next ten years, he pursued research and development at the Hitachi Central Research Laboratory, seeking to reduce semiconductor power consumption.

"Those were the days when we were trying to implement every possible function into cell phones. More functions required more power, which is why we tried to make LSIs that would require less power."

Working at a laboratory, Dr. Yamaoka welcomed a work environment that allowed him to test newly-developed technologies in the process of *monozukuri* (manufacturing).

"There were many ways to reduce power consumption, but the one I selected was controlling the voltage of the memory element to minimize the power memory consumed while not in operation. The memory stores data, which has to be safely retained. So, the conventional idea was that you couldn't fiddle with voltage. But you couldn't reduce power consumption without doing so. The results of our first challenge were good, and the approach is now a standard technology."

*2 Japan International Birdman Rally: A competition sponsored by the Yomiuri Telecasting Corporation in which participating teams compete for the distance and time a human-powered glider can fly

Collaborative creation to explore technologies for the "beyond"

Flouting the conventional wisdom that voltage for memory couldn't vary, and applying semiconductors, a mature technology, to new principles—such flexible thinking appears to emerge from Dr.Yamaoka's active efforts to interact with people from fields outside his own.

"When you're involved in memory R&D, you tend to end up talking only within a certain circle of specialists in the same field. But I like to talk to people from different areas, like the people who make other components, or people who are users of LSIs, or even those who make the materials for LSIs. The exchanges are stimulating. And sometimes they inspire ideas about what I can do."

Given this outlook, Dr.Yamaoka has great expectations for a new facility called the *Kyōsō-tō* (collaborative creation wing) that opened this year on the premises of the Central Research Laboratory. As the name suggests, the purpose of the facility is to provide initiatives for technological innovation through open collaboration between people both within and outside Hitachi.

"We can't expect to maintain an ongoing renewal of initiatives by keeping to ourselves. The question is: How do we connect to people on the outside? How do we come across new information and assimilate it into what we're doing? Conversely, how do we communicate what we have so others can make use of that ? Cycles of give and take like this are essential. That's why I'm fully on board with the *Kyōsō-tō* concept. Our group has one space allocated to us in the facility. I think it will be important to invite people from various fields to this space to engage in discussions, share knowledge, and exchange ideas."

Dr. Yamaoka regards himself as an optimist. He's found new paths for semiconductors that defy convention, even with his firsthand understanding of the limits of semiconductors. Last but not least, we asked Dr. Yamaoka what he foresees.

"I think our world will become ever more convenient in the future, not just in terms of computers. I expect the emergence of various technologies—technologies that will become commonplace in our lives. Research on AI has been quite active in the past several years. I consider what the AI currently available can't do, and what comes after this AI. People say computers will surpass humans by the year 2045. Will they ? If so, then what ? I'm interested in what might happen next in our world. That's what I think about constantly."

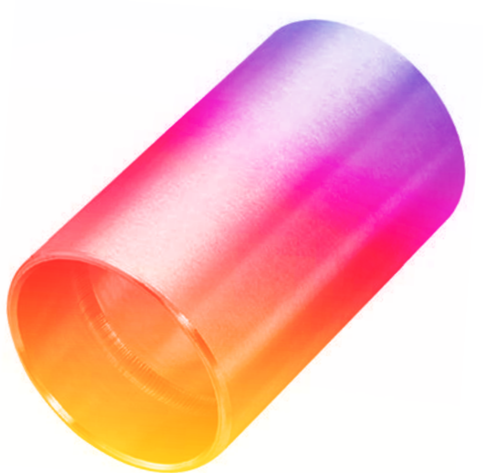
(Reference)
http://www.hitachi.com/rd/news/topics/2019/1018.html

Interview conducted with cooperation from the Research and Development Group of Hitachi, Ltd.

Our world continues to change every day.
Do we follow changes？Or do we initiate changes？
Expanding our field of view in all directions
may help uncover new possibilities.

Feature Story

Expand



01 Introduction

Annealing, the Process That Resets Metals
～From a Heat Treatment Site

Annealing is one of the operating principles of next-generation computers (see INNER VIEW on p.3 of this issue). The term comes from the term for heat treatment in metalworking. We visited Tamayakin Co., Ltd., a company that specializes in heat treatment, where we were welcomed by Mr. Shinsuke Yamada, the company's vice president, and Mr. Naohisa Saito, their senior manager/sales group leader.

Inside the vacuum furnace

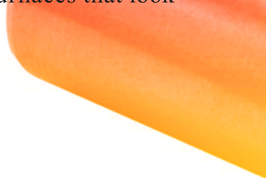
A vacuum furnace looks like a rocket frame. The panel on the side displays a graph of temperatures inside the furnace. It shows temperatures are gradually falling, in increments of 0.1 degrees.
"Annealing is the process of gradually cooling heated metal. In the case of steel, the material is heated to 850-900 °C and kept in the furnace while temperatures drop by around 2-3 °C per minute." (Mr. Saito)

Annealing, a process of resetting

Quenching, tempering, annealing, and normalizing—these are all heat treatment processes that change the hardness or durability of metals, like steel, through heating and cooling (Table 1). Mr. Yamada and Mr. Saito explained the process of annealing enthusiastically.
"In quenching and tempering processes, heated steel is instantly cooled by immersion in water or oil. The rapid cooling imparts hardness and strength to steel. But annealing has a different purpose." (Mr. Saito)
"Cutting or shaving steel generates stress in the material and gradually disrupts the structure of the metal. If you keep bending a paper clip back and forth, eventually, it breaks. That's because the bending generates internal stresses, which make the structure coarse and make the metal brittle. Annealing restores this coarsened structure to its refined state." (Mr. Yamada)
"So, annealing isn' t the final process. It's a process that resets the metal and prepares it for subsequent working. If you want to rework a steel piece that has become fatigued from use, you can anneal the piece beforehand to homogenize the structure and improve workability. Steel can be restored about three times by annealing." (Mr. Saito)

Something not visible from the outside

Within the premises of the head factory of Tamayakin are several gymnasium-like buildings. Inside, one encounters an assortment of furnaces both large and small—from baking furnaces that look



Mr. Shinsuke Yamada (left) and
Mr. Naohisa Saito (right)
The key spirit of manufacturing—sincerity

like oversized bread ovens to furnaces that apply heat while generating air and gases referred to as atmosphere and the abovementioned vacuum furnaces. All these furnaces are needed to meet the different needs of various customers.

“Heat treatment used to be a local business. There wasn’t much competition. Nowadays, with advances in distribution, we serve customers all over Japan, not just in the local Tama area.” (Mr.Yamada)

Ever since its founding in 1951, Tamayakin, as an independent heat treatment business, has responded to the needs of high-mix/low-volume production. We found the company watchword sincerity adorning walls throughout the facility. In the lounge where we met were three panels on the wall, each with one of the following words: sincerity; intuition; challenge.

“You can’t confirm whether a material was heat treated by looking at the exterior. Winning the trust of our customers is grounded in doing what we do with a sense of sincerity. That’s the spirit we see as key in our monozukuri (manufacturing) efforts.” (Mr.Yamada)

Armed with technology and reliability gained through years of experience, Tamayakin in 2012 won accreditation under Nadcap (National Aerospace and Defense Contractors Accreditation Program), an international accreditation program for aircraft parts. It has since expanded its sales into the aerospace field.

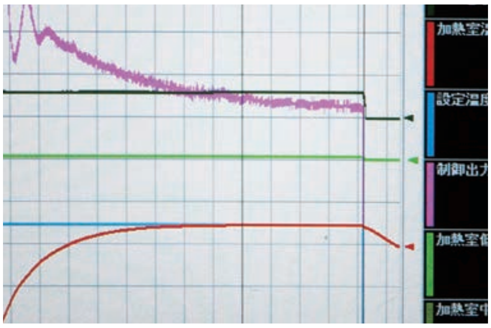
Banner raised high inside the building

Interview conducted with
cooperation from:
Tamayakin Co., Ltd.
2-77-1, Inadaira,
Musashimurayama-shi, Tokyo
http://tamayakin.co.jp

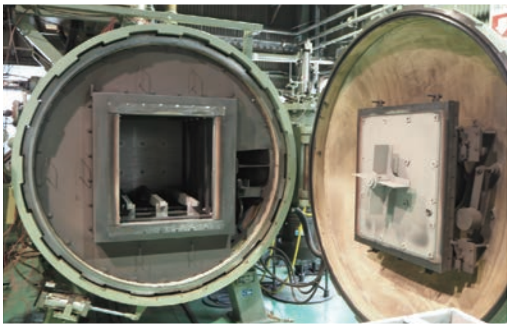
Table 1. Major heat treatment processes

Quenching	Process in which steel is hardened by rapid cooling from high temperatures. Since quenching alone results in low toughness, it’s combined with tempering.
Tempering	Process performed after quenching to impart toughness to steel and to alleviate brittleness and confer other desired characteristics
Annealing	Various annealing processes are used, depending on the purpose —for example, boosting machinability or refining the metal structure.
Normalizing	Process for eliminating the effects of the preceding processes or for improving mechanical properties by refining and homogenizing crystal grains

Materials courtesy of Tamayakin Co., Ltd.



Vacuum furnace display panel
The red line represents temperature.
We see that temperature gradually falls
from the high temperature state.



Vacuum furnace with door opened

02 Joint Research

Visualizing Things That Can't Be Seen
~Calibration Technology for Particle Counters

Particle counters measure invisible dust and other particles suspended in air or liquids. At Rion, research based on new technologies is underway to resolve various issues affecting conventional particle counters.*1

*1 Joint research with the National Institute of Advanced Industrial Science and Technology (AIST)

The environment and issues surrounding particle counters

Safety and security have emerged as major issues across all fields. The importance of cleanliness control grows year after year. As more and more industries begin to adopt particle counters, the performance demands for these devices have intensified. In addition to the development of particle counters at our Technical Development Center, Takashi Minakami is involved in joint research on calibration technologies for airborne optical particle counters (OPCs) with the National Institute of Advanced Industrial Science and Technology (AIST).

ISO 21501-4*2 and JIS B 9921*3 establish standards for calibrating the counting efficiency of airborne OPCs, which corresponds to particle counting capacity. These standards recommend annual inspections for these devices. The method stipulated in the current standards is the parallel measurement method (Fig.1): Test air with dispersed polystyrene latex spheres (PSL spheres) acting as particles for calibration is measured simultaneously with a reference instrument, whose counting capacity is confirmed before this calibration, and with an airborne OPC, the calibration target. We can evaluate counting efficiency by comparing the particle concentrations of PSL spheres observed by the devices.

But this method has two major drawbacks for large particles exceeding 1 µm in diameter, says Minakami.

"The first is the difficulty of generating particles at stable concentrations using large PSL spheres exceeding 1 µm in diameter. The second is that the particles are more likely to adhere to the walls of the distribution box and tubes due to their gravity and inertial motion in air, resulting in a nonuniform particle number concentration."

*2 ISO 21501-4:2018 Determination of particle size distribution – Single particle light interaction methods – Part 4: Light scattering airborne particle counter for clean spaces
*3 JIS B 9921:2010 Light scattering airborne particle counter for clean spaces

Takashi Minakami
(Technical Development Center)

Evaluating airborne OPCs using IAG

To resolve these issues, Rion has undertaken research on a calibration technology for airborne OPCs using inkjet aerosol generators (IAG) developed by AIST. The IAG ejects one droplet after another of a solution of a dissolved solute, and the solvent is subsequently removed by evaporation. The remaining solute is ultimately released as aerosol particles of uniform diameter (Fig.2). These aerosol particles are aspirated into the RION KC-31 for measurement (Fig.3).

"The current ISO standard requires an evaluation of counting efficiency only for the minimum measurable particle size of the instrument. This means users have no information on counting performance for large-diameter particles. The method using IAG overcomes the two issues encountered with conventional methods. It also enables high-precision measurement of counting efficiency for large particles, something that used to be quite difficult." Through calibration, if we can "see" that the instrument is capable of accurately distinguishing and measuring large particles, those who use the instrument can be reassured regarding the accuracy of their results.

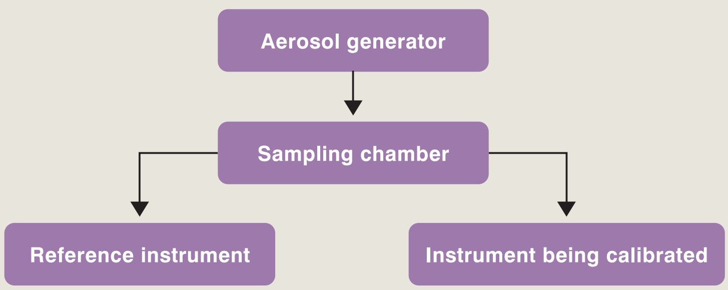


Fig. 1. Parallel measurement method

The test air inside the sampling chamber is introduced for comparison into both the reference instrument and the instrument being calibrated.

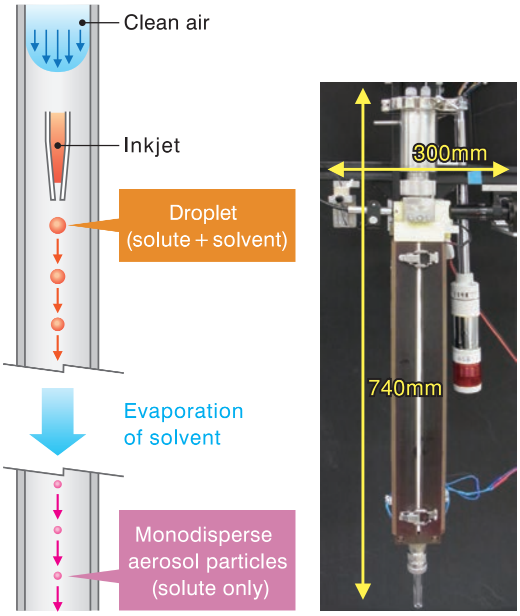


Fig.2. IAG developed by AIST
(photo courtesy of AIST)

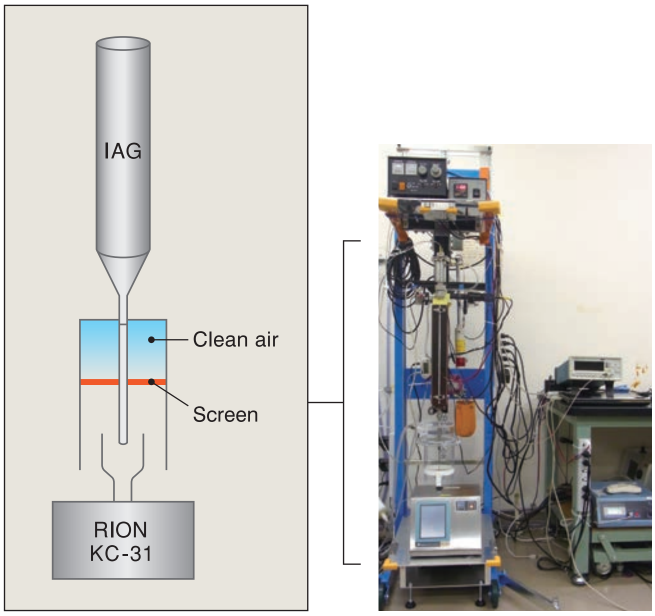


Fig.3. Calibration experiment instrument and RION KC-31
(photo courtesy of AIST)

Efforts to achieve international standardization

Minakami has taken part in activities associated with the formulation of ISO standards and is currently seeking to establish an international standard for the airborne OPC calibration technology using IAG. The official formulation of ISO standards typically has six stages, with discussions and voting occurring at each stage. Each member country is allotted a single vote; the majority must vote in favor of a standard to move it to the next stage. After publication, a standard is reviewed every five years and put to a vote.

"A representative from each member country attends the international meeting, but since all countries have differences in terms of their major industries, the performance levels each nation requires for particle counters differ. These differences have to be taken into consideration when making a proposal, and some effort has to be made to gain the support of the other countries. Certain issues remain concerning the IAG-based calibration technology, but there's no doubt that it's both simple and effective. I hope it becomes part of the standards and enters use worldwide."

The future of particle counters

Of the industries with a need for particle counters, those involved in the actual manufacture of pharmaceuticals, foods, and beverages are extremely sensitive to contamination by microorganisms like bacteria and fungi. Minakami is currently seeking to expand the use of viable particle counters, developed by Rion in 2011, for the first time anywhere in the world, taking advantage of accumulated basic technologies for particle counters. The viable particle counter instantly distinguishes between viable and nonviable particles in liquid and performs real-time measurements of viable particles.

"Research and development is an endless daily procession of challenges. We design and create prototypes, evaluate them, review what went wrong, remodel or modify the prototypes, and so on. It's gratifying when a solution to a problem seems to be just around the corner or when we finally arrive at our goal."

Making visible the particles that are invisible to the naked eye and that can't be measured using existing instruments—the tireless endeavor of these engineers continues.

Interview by: Takako Isobe (writer)

03 Research Introduction

Dreams of Talking to Elephants
～Elephants Communicate Using Low Frequency Sounds

In addition to being among the most popular animals at any zoo, elephants are said to be highly intelligent beings. Wouldn't it be great if we could talk to them? We met with a researcher with just such ambitions at the Kobayasi Institute of Physical Research.

Dogs bark. Cats meow. What do elephants do? Most of us would probably say: They trumpet.

"But an elephant's trumpeting is a lot like human shouting," explains Dr. Tetsuya Doi of the Noise and Vibration Laboratory at the Kobayasi Institute of Physical Research. "For normal communication, elephants vocalize at frequencies below 20 Hz, a range that's nearly inaudible to the human ear. Low frequency sounds travel farther than high frequency sounds, so it's reasonable for wild elephants to use low frequency sounds to communicate with another elephant far away."

Having read of a previous study concerning communication between elephants (by Irie et al.), he wanted to introduce the story as an interesting side note in his technical book on low frequency sound. While preparing the manuscript for the book, he went to interview the people at the Ichihara Elephant Kingdom (Fig. 1). To his surprise, rather than a simple confirmation, he was asked by the staff to do the research needed to determine whether this claim was actually true. Since then, he's monitored communications around the clock among the original twelve resident elephants at the Ichihara Elephant Kingdom.

Elephants chat, just like humans

"Looking at the data measured with a low-frequency sound level meter, I had no doubt they were talking. But since these frequencies are inaudible to the human ear, we can't determine which elephant is talking, or even when. So, first, I placed an array of microphones surrounding the elephants' living space to determine which elephant was talking (i.e., to determine the location of the talking elephant)." (Fig. 2)

Once the elephant that was talking could be identified, Dr. Doi's focus shifted to the frequency and nature of the exchanges. Monitoring showed communication between elephants was quite active when a baby was born or when they met for the first time. The elephants also tended to talk a lot after the elephant show, which was held twice a day. In contrast to the elephants at Ichihara Elephant Kingdom, elephants in zoos where only one or two elephants were kept were relatively quiet.

"Just like humans, elephants communicate to relay their intentions. Animals aren't likely to waste energy making meaningless noises. Studies suggest that elephants in Africa employ more than ten kinds of voice, depending on whether, for example, they're looking for a watering hole or avoiding danger. Elephants living in zoos in Japan live in an environment without a lot of hazards, and they don't have to worry about food. So, perhaps they have a less extensive vocabulary than wild elephants in Africa. If so, how many different kinds of vocalizations do elephants in Japan use? At this point, no one knows."

The pursuit to satisfy intellectual curiosity leads to an elephant voice detector

Dr. Doi is currently developing an elephant voice detector, which multiplies the

Fig. 1. Ichihara Elephant Kingdom (Ichihara-shi, Chiba; photographed by Tetsuya Doi)

Dr.Tetsuya Doi
(photographed by Yuichiro Fuse)

frequency of an elephant's vocalizations in real time by a factor of around 10. In other words, it converts an elephant's low frequency vocalizations into something humans can hear. It's a unique approach to exploring the kinds of vocalizations used by elephants based on simultaneous observations of voice and action.

What's more interesting is that this study on elephants is being carried out by a researcher who belongs to a research institution specializing in sound and vibration. Why is Dr. Doi so intent on understanding communications between elephants? Asked this question, he laughed. "It's purely to satisfy intellectual curiosity," he said. "It's more like a pastime and a break from my main duties."

During his student years, Dr. Doi majored in physics and eventually found his way to the field of acoustics. Later, he joined the Kobayasi Institute of Physical Research. He's specialized in low frequency sounds for over 20 years and is mainly involved with investigations and research on noise associated with high-speed railways. His study of elephant communications stands off to the side of his primary research. But all his studies stem from a research outlook he's cultivated throughout the years since college: to elucidate unknown phenomena through observation and measurement.

Dreams of communicating with elephants

While he refers to his endeavor as a mere pastime, the instrument for identifying the elephant responsible for a specific vocalization has potential applications in identifying low frequency sound sources humans have difficulty hearing, including the noise generated by outdoor air conditioning units. His study of elephants may also lead to new biomimetic applications.

"Sounds in low frequency bands are susceptible to contamination by wind noise, which sounds like distant foghorns," says Dr. Doi. "So, elephants' ears, which can hear such sounds, must have some mechanism for canceling out the effects of wind noise. If we can identify this mechanism, we could incorporate it into the development of acoustic measuring instruments."

Dr. Doi's dream is to one day understand what elephants talk about, and then to produce sounds using loudspeakers to allow people to talk to elephants. He says he does have one concern.

"The elephants all know me now. When I approach them to perform maintenance work on the instruments, they'll do various playful things, like throwing grass. That's how smart they are. I'm worried one day one of them will say, 'Hey, that guy is back! Let's just keep quiet today.' I'm seriously troubled by that possibility [laughs]."

Interviewer: Yuichiro Fuse
(musical technical writer)

Kobayasi Institute of Physical Research
3-20-41, Higashi-Motomachi,
Kokubunji-shi, Tokyo
http://www.kobayasi-riken.or.jp/english/english_frame_top.htm

RION NL-62 sound level meter, designed to measure low frequency sounds
Range of frequency measurement:
1 Hz–20,000 Hz

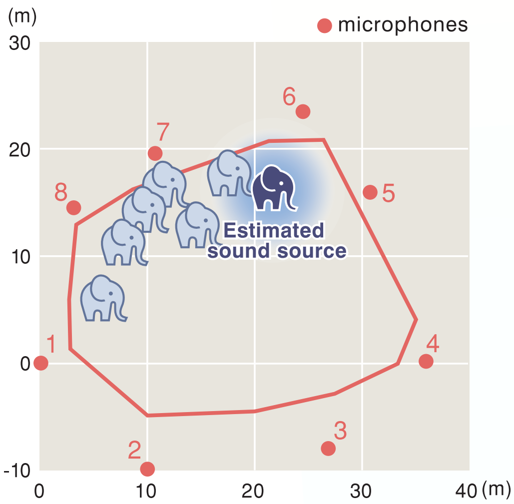
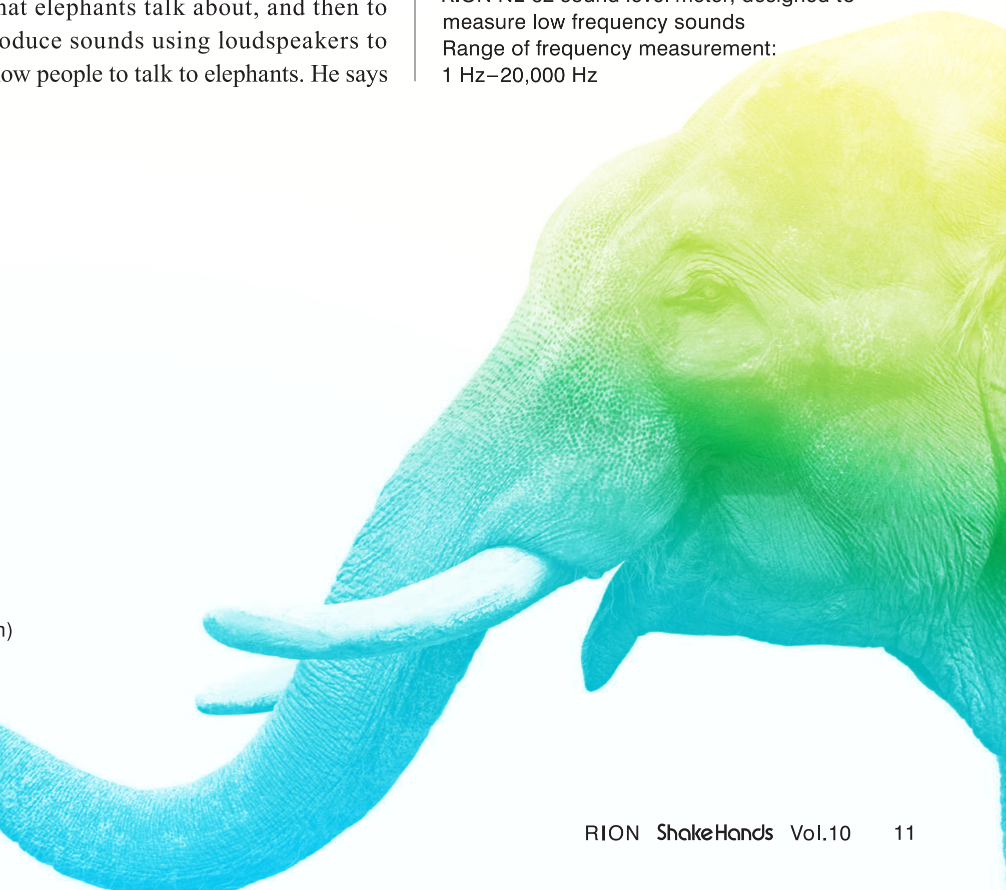


Fig. 2. Positions of microphones
for estimating the location of the sound source



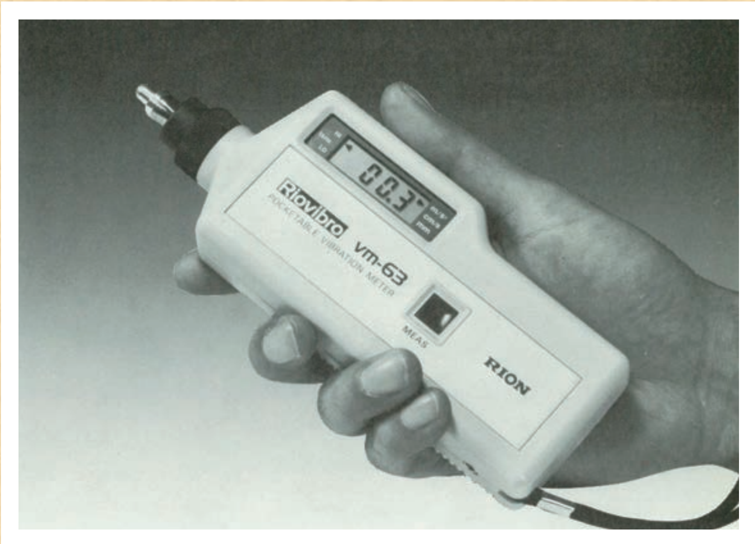
Rion's History of Technology

LEARNING from our Past Products

An Ideal Pocket-sized Design for Simple Facility Diagnostics

VM-63

(RIOVIBRO)



Commonly referred to as the RIOVIBRO, the VM-63 vibration meter has undergone some minor tweaks over the years since its development in the 1980s. It's been supporting maintenance work at facilities throughout that time. We interviewed Masahide Kohno,* who was in charge of development back then.

*Masahide Kohno joined Rion in 1974. He was assigned to the Sound Measuring Technology Department during the development of the VM-63.

——Can you give us a little background on the development of the VM-63?

All machines like motors, power generators, pumps, and various processing machinery generate different vibrations, whether they're operating normally or not. Facility diagnostics using vibrations, which seek to detect abnormal vibrations for maintenance purposes, began to attract attention in the 1970s. That generated demand for versatile vibration meters.

——So, back then, in 1983, the VM-63 was marketed as a pocketable vibration meter.

There was demand for a compact, lightweight, easy-to-use, also affordable vibration meter, and the VM-63 met all these needs. With conventional vibration meters, the accelerometer is connected to the main unit with a cable. With the VM-63, the accelerometer was integrated into the main unit. And the instrument weighed just 270 grams. We kept the number of switches to a minimum. It didn' t even have a power switch.

——How was it used?

There's a switch for switching between acceleration, velocity, and displacement and a switch for changing between Lo (low: 10 Hz–1,000 Hz) and Hi (high: 1 kHz–15 kHz) for acceleration. Pressing the MEAS button powers up the instrument and prompts it to make a measurement. The tip of the accelerometer is pressed against the measurement target. The user observes the value displayed and releases the button when the reading has stabilized to retain the measured value. To perform another measurement run, this process is simply repeated. The instrument shuts off automatically if no activity occurs for about one minute.

—— Quite simple, isn't it ?

We hoped to develop an instrument that didn' t require special training or skills, and that would allow use by a wide range of individuals. And we set the price at 98,000 yen—a bold pricing decision—to make it affordable, even for small- and mid-sized factories.

—— How did you become involved in its development?

At the time, I was the only employee in charge of designing vibration meters—so, of course, I was assigned the task of developing this new product! We had a design division specializing in accelerometers, but I was in charge of most of the preamp, electrical circuit, and case design.

—— What were some of the difficulties you encountered during development?

We had to integrate the accelerometer and the main unit into a single unit. The problem was whether such a setup could produce accurate vibration measurements. Some of the issues we faced included frequency characteristics, linearity of measurement with the amplitude of vibration, and abnormal resonance at specific frequencies or vibrations.

—— For the actual vibration measurement, is how the pickup is pressed against the target important? Or not?

The person in charge of developing the accelerometer devised a holding device by testing materials, fixation methods, and the torque for fixation and succeeded in producing a design that allowed stable measurement. I participated in device validation testing, where I had to press the accelerometer against the vibration table to take measurements at various frequencies and amplitudes again and again, seemingly for an endless number of times. I remember how strange the muscles of my right arm felt after being subjected to such powerful vibrations for so long.

Mr. Masahide Kohno (photo courtesy of himself)

Instruction manual for the VM-63.
The simplicity of its operations
—the instruction manual is printed
on a single A4 sheet—was truly innovative.

The current model, the VM-63C.
The operating procedure remains
the same as for the VM-63.

—— How did the market respond to the VM-63?

A price point below 100,000 yen was groundbreaking, and the sales department launched a project to promote the product. But, based on my impressions, initially, it didn't sell as well as we'd expected. Also, we hadn't anticipated overseas sales.

——This was followed by explosive sales in China.

Yes. It all started when a distributor in China took an interest in the quality, design, and price.

—— Can you recall memorable moments with a customer you'd like to share?

So, this happened quite some time after the product was introduced commercially. One customer came to us, bringing several vibration meters, saying he wanted us to examine his VM-63 and VM-82. One of them had a break in the accelerometer wiring, and its body had turned completely black with use. The letters on the panel were nearly illegible. It had evidently been well-used, which I found very satisfying.

——What does the VM-63 mean to you?

The idea for the instrument was based on specifications developed by a handful of people in the sales and technical development divisions. Each person was assigned responsibility for an incredibly wide range of things back then, so while I bore a significant burden of responsibility for the design, I also had considerable freedom with the specifications. I think the development of this vibration meter was my first step in producing the lineup of products that followed.

——Looking back, what are your feelings about your career?

When I first began working, I thought it would help my parents finally find relief. Later, I discovered I could make people happy by making things. I feel like I can say now, with some pride, that I've helped create products by studying hard, using my mind and body, and persisting.

An Open Space for Engineers Creating the Future

Technical Development Center

Hello, I'm Kiyokatsu Iwahashi, head of the Technical Development Center. In this issue, I'd like to introduce the Technical Development Center, or TD Center, which was inspired by Rion's commitment to looking toward the future.
Recent years have seen rapid progress in AI, IoT, and 5G technologies, as well as the ICT that supports them. These technologies affect the daily living environment of everyone around the world. Rion develops and markets hearing instruments, medical equipment, sound and vibration measuring instruments, and particle counters, but we can't just go our own way and ignore the current wave of innovations if we're to continue living up to our motto—contributing to people, society, and the world through all our activities.
Founded to create the future, the TD Center brings together engineers formerly assigned to the individual product groups mentioned above to crosslink the knowledge and skills of each and every engineer. On its founding, we prepared a free-address workplace where individuals aren't assigned to a fixed desk. The idea is that spontaneous interactions between engineers who not only come from different fields but have worked in different environments and workplaces will inspire new ideas.
Some 120 individuals currently work on the two floors. The new workplace reflects the following concepts:
(1) It's a space for open, uninhibited communication.
(2) It's a synergistic space where engineers can compete with pride and a sense of friendly rivalry.
(3) It's a relaxing space that nurtures flexible thinking.
The TD Center is just at the starting gates right now, but based on the above concepts, I anticipate this space will help generate innovative products and services with global repercussions.
Rion celebrated its 75th anniversary in 2019. We wouldn't have come this far without the support of our customers. Here in this issue, I'd like to take this opportunity to thank them. The TD Center combines 75 years of practical experience with current technological innovations with the goals of winning an even wider and stronger base of support from our customers and continuing to contribute to society. I'm confident our TD Center will help create the future to come.

Kiyokatsu Iwahashi
(Head of the Technical Development Center)


Author seated at the desk of the Head of the Technical Development Center


The Technical Development Center floor. An aquarium stands in the center of the space.


The door to the office of the Head of the Technical Development Center is always open. Employees are free to use the office for meetings or other purposes. The wall at the entrance is shown as it appeared after a brainstorming session.

SCIENCE COLUMN

Stochastic Mechanics for Drawing Electron Trajectories

In the book Learning Quantum Mechanics with Excel (in Japanese) by Kunio Yasue (Bluebacks series by Kodansha Ltd.), there's an introduction to stochastic mechanics that discusses drawing time-series trajectories of photons and electrons. When an electron passes through a double slit, a pattern of light and dark areas resembling wave interference fringes emerges on the screen behind the slit. Conventional texts explain that a single electron passes through the two slits simultaneously. Electrons are associated with a blurry image known as electron clouds. But with stochastic mechanics, the trajectory of an electron can be drawn. Based on this trajectory, although the light-and-dark pattern created remains the same, the electron passes through just one of the two slits.

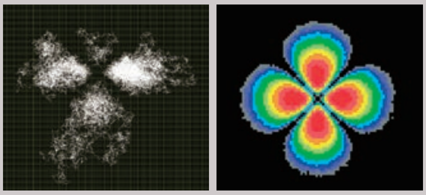
Stochastic mechanics is an interpretation of quantum mechanics presented in 1966 by Edward Nelson. The x coordinate of the trajectory of the mass point can be expressed as follows:

$$X(t+\Delta t)=X(t)+DX(t)\Delta t+A(t)\sqrt{\frac{h}{m}}\sqrt{\Delta t}$$

The rightmost term represents the quantum fluctuation indicated by the uncertainty principle. This effect can be ignored in the macroscopic world. In the microscopic world, this term is responsible for producing a zigzag, non-smooth trajectory. $A(t)$ is derived based on the assumption that quantum fluctuation is the result of the cumulative effects of multiple unknown factors and is a normal random variable having a mean value of 0 and standard deviation of 1, based on the central limit theorem. $DX(t)$ represents velocity, which Nelson derived from Newton's equations of motion by adopting the mean forward differential and the like. The author stresses that motion in the quantum world can be expressed using the same equations of motion that apply in the macroscopic world.

The figure below shows an example of the trajectory calculated by the author based on the equations for the 322 electron orbital of hydrogen obtained by stochastic mechanics. As we increase the numbers of calculations, the results gradually approach the normal electron density distribution.

Takashi Iwakura (Technical Development Center)



Japanese scenery

Photo taken in Kinchakuda (Saitama)
Photograph by Nobuhiko Hiruma
(Technical Development Center)

True to their Japanese name *higanbana* (flowers of the fall equinoctial week), the red flowers of the red spider lily bloom during the fall equinoctial week. *Manjushage*, another name by which they are known in Japan, is said to originate from the Sanskrit word "*mañjūṣaka*," translated into Japanese via phonetic representation of the word in kanji.

The three-part series to know about our measuring instruments

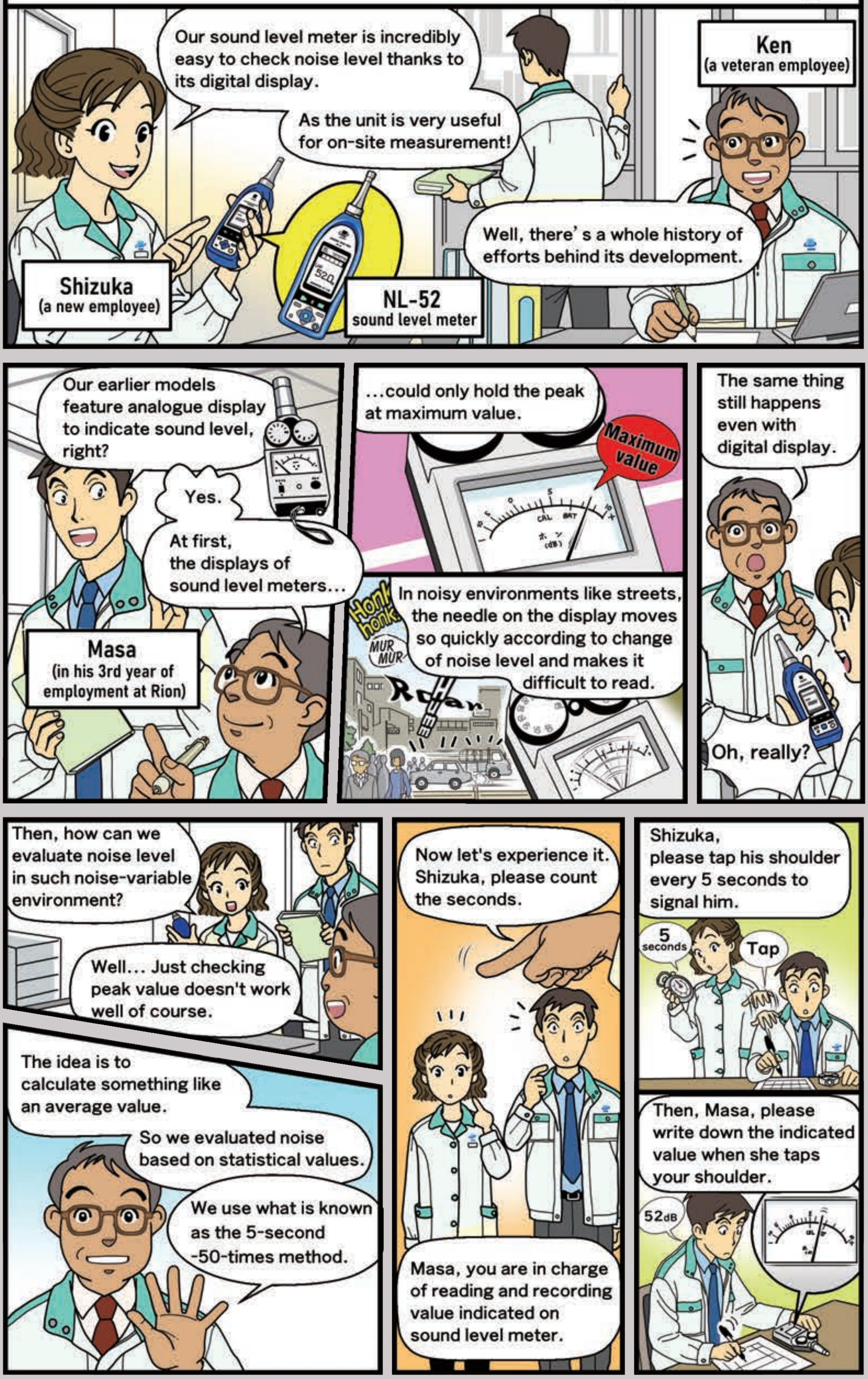
MANGA Understanding Measuring Instruments

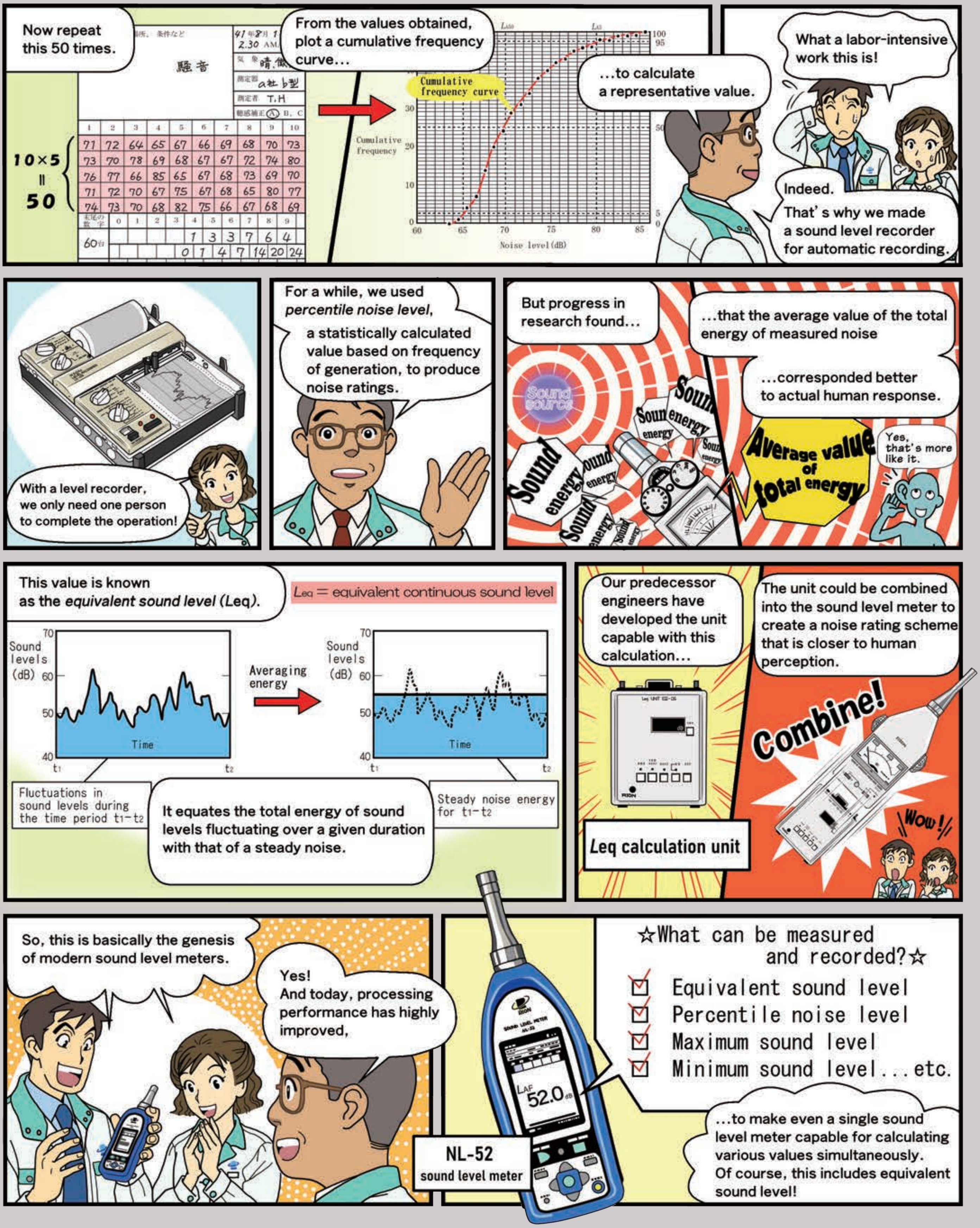
Sound Level Meter Part 2

Manga by Hisako Takagi

How Do We Determine Noise Levels?

A History of Noise Ratings




Now repeat this 50 times.
10×5 = 50
From the values obtained, plot a cumulative frequency curve…
Cumulative frequency curve
Cumulative frequency
Noise level (dB)
…to calculate a representative value.
What a labor-intensive work this is!
Indeed. That's why we made a sound level recorder for automatic recording.
With a level recorder, we only need one person to complete the operation!
For a while, we used percentile noise level,
a statistically calculated value based on frequency of generation, to produce noise ratings.
But progress in research found…
…that the average value of the total energy of measured noise
…corresponded better to actual human response.
Sound source
Sound energy
Average value of total energy
Yes, that's more like it.
This value is known as the equivalent sound level (Leq).
Leq = equivalent continuous sound level
Sound levels (dB)
Time
Averaging energy
Fluctuations in sound levels during the time period t1-t2
It equates the total energy of sound levels fluctuating over a given duration with that of a steady noise.
Steady noise energy for t1-t2
Our predecessor engineers have developed the unit capable with this calculation…
Leq calculation unit
The unit could be combined into the sound level meter to create a noise rating scheme that is closer to human perception.
Combine!
Wow!
So, this is basically the genesis of modern sound level meters.
Yes! And today, processing performance has highly improved,
NL-52 sound level meter
☆What can be measured and recorded?☆
Equivalent sound level
Percentile noise level
Maximum sound level
Minimum sound level…etc.
…to make even a single sound level meter capable for calculating various values simultaneously. Of course, this includes equivalent sound level!

Shine View!

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

Mizuki Tanaka Production & Sales Control Section

The High-Speed Racket Game of Crossminton

——Playing in International Competitions

A crossminton court consists of two squares measuring 5.5 × 5.5 meters separated by a distance of 12.8 meters. Players use a special racket to hit a shuttlecock, called a speeder, toward the other player's square.

——How did you get started with crossminton?

My badminton coach from my elementary and junior high school years invited me to play. I began playing in summer of my senior year in college. Within three years, I was Japan's top-ranked player. My highest world ranking was around 25th.

——I've heard you play in international competitions.

I came in second in singles and won the doubles title in the Japan Open, where players can earn points for their world ranking. Germany, the Czech Republic, and Hungary have the world's best crossminton players.

——What's the appeal of crossminton?

Both the racket and the speeder are heavier than in badminton. There are no nets. So the shots are more linear and a lot faster. It's also appealing that the rallies involve lots of exchanges at low heights. And it's a really easy sport to take up for anyone. When I first started, I practiced hitting for about 10 minutes before I competed in a match. That's how low the hurdle was. It's much easier than badminton. I find playing tennis a lot harder than crossminton because I keep hitting homeruns out of the court. [laughs]

——What would you say is a difficulty unique to crossminton?

I used to be a badminton player, so I'm not good with the low balls favored by players with a background in tennis. You see various types of players: those who played badminton, tennis, or squash, or even some who began with crossminton. Their style of play reflects the sport they used to play. Adjusting to the various styles is a challenge, but also makes the sport more interesting. It's something I don't think you see in other sports.

——How do you practice?

I practice up to four times a week. At most practices, I just warm up, then start to play matches. I still play badminton, which I started playing in the fourth grade. I'm in the company's badminton club. There's also practice and matches for the club, so I have to divide my time pretty judiciously to make time for crossminton.

——How has playing crossminton benefited you?

I don't get to meet foreigners with badminton, in my job, or in my life in general, so I like that I can play against people from other countries and go out to dinner with them afterwards. I wouldn't have that opportunity without crossminton.

——Can you share some memorable moments with us?

One would be when I finally got to play against this German player who had won the world championship and who I aspired to beat at the Japan Open finals. This person loves Japan and always comes to play in international competitions held in Japan. He's studying Japanese, too, and is a really good guy. I lost to him, but it felt great that I held up my own end to the very end. That game motivated me to try even harder.

At the 2019 World Championships held in Hungary (left: during the match: right : together with the Swiss pair ; Mr.Tanaka is on the far right.)
Photograph by Fumika Abe

Video of the final moments of the Japan Open championship final match, starting from the point at which the score was tied 20-20.
https://youtu.be/kQisbDC8ux4

From the interviewer

Unfortunately, Mr. Tanaka injured his hand while training a little too aggressively for the World Championships. Even so, he appears happy as he poses for the camera, racket in hand. (Kaori Sakata)

For Chemical 0.03 µm

Liquid-Borne Particle Sensor
KS-19F

- Detects particles to 0.03 µm
- User can freely select particle size
  Up to 10 channels from 0.03 µm to 0.13 µm
- Sapphire flow cell
- With abundant options, it can be used for both in-line and off-line measurement

Simultaneous PPV, VDV, Dominant Frequency & Displacement

The VM-56 is by DIN 45669-1, ISO 8041 and other national measurement standards. Like other Rion products, it is characterized by excellent build-quality and exceptional ease of use. It is suitable for a wide range of applications including attended measurements.

Tri-axial Groundborne Vibration Meter
VM-56

- Simultaneous measurement of multiple parameters including PPV and VDV.
- User definable PPV vs Frequency comparator output supports DIN 4150: Part 3 and other frequency-dependent PPV building damage criteria.
- Flexible product configuration with waveform recording function and 1/3 octave band analysis function available as optional programs.
- Suitable for use in a live-to-web system (please contact us for further details).

TOPICS Research presentations, articles, etc.

【Related to sound and vibration measuring instruments】

◎Inter-noise 2019 (June16～19 Madrid, Spain)

- Construction and measurement examples of a wireless sampling-synchronized measurement system. / Y.Nakajima, Y.Kurosawa, K.Yoshino, T.Ueta
- Study of integrated data processing method of aircraft noise data and flight path data in aircraft noise monitoring. / K.Sakoda, Y.Maruyama, K.Shinohara, K.Yazawa

【Related to particle counters】

◎PDA Sterile Product Task Force (Japan) Debriefing session of research results (June 21, Shinagawa Front Building)

- Rapid Microbial Methods -The latest information and case studies- / Y.Ikematsu[*1], S.Sugimoto[*2], T.Minakami, M.Mori[*3] (in Japanese)

◎The 36th Annual Meeting and Symposium on Aerosol Science and Technology (September 5-6, Hiroshima University)

- Calibration of Airborne Optical Particle Counter with 1 cfm Sampling Flowrate / K.Iida[*4], H.Sakurai[*4], T.Minakami, Kevin Auderset[*5], Konstantina Vasilatou[*5]

◎Ultrapure Micro 2019 (June 5-7, Arizona Biltmore, USA)

- Breaking Barriers in Traditional Light Scattering Particle Detection Technology / Joe Chen[*6], M.Shimmura

Exhibitions

S Related to sound and vibration measuring instruments
P Related to particle counters

- S Automatic Testing Expo, Novi, Michigan (October 22-24, Michigan, USA)
- S The Institute of Noise Control Engineering of Japan 2019 Autumn Meeting (November 1-2, College of Science and Technology, Nihon University Surugadai campus)
- S WIND EXPO 2020(February 26-28, Tokyo Big Sight)
- P Regenerative Medicine JAPAN 2019 (October 9-11, Pacifico Yokohama)
- P Hakodate Waterway Exhibition (November 6-8, Hakodate Arena)
- P SEMICON Europa (November 12-15, Munich, Germany)
- P SEMICON Japan 2019 (December 11-13, Tokyo Big Sight)
- P SEMICON Korea 2020(February 5-7, Seoul, Korea)
- P INTERPHEX Osaka 2020 (February 26-28, INTEX Osaka)
- P SEMICON China 2020(March 18-20, Shanghai, China)

*1 Osaka university *2 Takeda Pharmaceutical Co., Ltd. *3 Eisai Co., Ltd., *4 AIST *5 METAS *6 MGN International

Editorial Postscript

We visited Tamayakin Co., Ltd., a company whose business includes annealing, the metalworking counterpart of the subject of our INNER VIEW feature story. When one hears the term heat treatment, the first thing that comes to mind is leaping flames. We learned these flames actually result from burning oil when hot steel is immersed in oil to cool. Apparently, annealing is a process of gradual cooling—no flames are involved. We'll have to settle for the flames in the banner in the photo! (Okazaki)

About the Front Cover

The recent advances in IT remain astonishing. The story of the CMOS annealing machine introduced in this issue shows how interactions between people outside their fields of specialty can lead to innovative ideas and provides hope for infinite possibilities ahead. (Oana)

Corporate Philosophy

Contributing to people, society and the world through all our activities

Quality of Life　　Barrier-Free Society　　Eco-Management

Past issues of *Shake Hands* are available here : https://rion-sv.com/shakehands/

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