TOTAL MOTION CONTROL

Harmonic Drive Systems Inc. Corporate Guide

Harmonic Drive Systems Inc.

ISO14001
Hotaka Plant
ISO9001

The World of Motion Control Transformed

The innovative concept and unique principles underlying the HarmonicDrive® were first developed by the brilliant American inventor, C.W. Musser. His invention, which uses the flexibility inherent in metal to transmit motive power, was a revolutionary advancement that surpassed conventional theory and gained the avid attention of the entire world. Two companies were willing to commit to the commercialization of Mr. Musser's invention: United Shoe Machinery of the US, and the predecessor to our own company, Hasegawa Gear Works, Ltd. Thanks to their vision, Harmonic Drive Systems Inc. now offers the benefits of this unique motion-control method to the world market.

C.W. Musser, inventor of the HarmonicDrive®

by a Single Invention

Musser Memorial Room (Opened in October 2006.)

Musser's wave-motion gearing mechanism was originally called "Strain-wave gearing" and was patented under that name. Subsequently, Harmonic Drive Systems Inc. succeeded in commercializing the technology. The technology today is generally referred to as a "wave-motion gearing mechanism," while the term HarmonicDrive® is a registered trademark that applies exclusively to the products manufactured by Harmonic Drive Systems Inc. This trademark is registered not only in Japan but also Taiwan and South Korea.

1964: The Year the HarmonicDrive® Became a Practical Reality in Japan

In 1964, the HD Division of the predecessor of our company, Hasegawa Gear Works, Ltd., entered into a technical agreement with USM Co., Ltd. and succeeded in creating a practical Harmonic Drive system for the first time in Japan. In 1970, the two companies established a joint-venture company which, in 1979, became Harmonic Drive Systems Inc.

Through the commercialization of Musser's remarkable invention, we can meet the needs of clients working in a wide range of fields who require highly precise positioning in their motion-control systems.

Throughout our development, we have pursued our goals with the firm belief that the ultimate mandate of our engineers is to earn and keep the trust of our customers. We will continue our efforts to develop new means of motion control that will further improve the working environments of our clients.

Original members of the HD Division (Technology and Production Departments) [1967]

The first HarmonicDrive® was delivered to Hitachi, Ltd. by Hasegawa Gear Works vice president Kiichiro Hasegawa [1965]

The Harmonic Drive Systems Inc. booth at an early International Industrial Robot Exhibition [1965]

The Matsumoto Plant, nestled in the Japan Alps [1970]

A Constant Search for Total Motion Control

Using the high-precision machining and control technologies we have acquired over many years of operation, we continue our efforts to achieve ever higher levels of total motion control.

While manufacturing HarmonicDrive® that is smaller, lighter, stronger, and more accurate than ever before, we are also refining peripheral technologies to maximize performance.

To optimize the total motion-control system, we are developing motors and drivers that move more accurately, as well as controllers that make better positioning possible, and sensors that further enhance performance, all in a complete, integrated system that appeals to our customers.

Our work is a fusion of advanced technologies in both mechanics and electronics, helping us to become a comprehensive engineering company that specializes in process control.

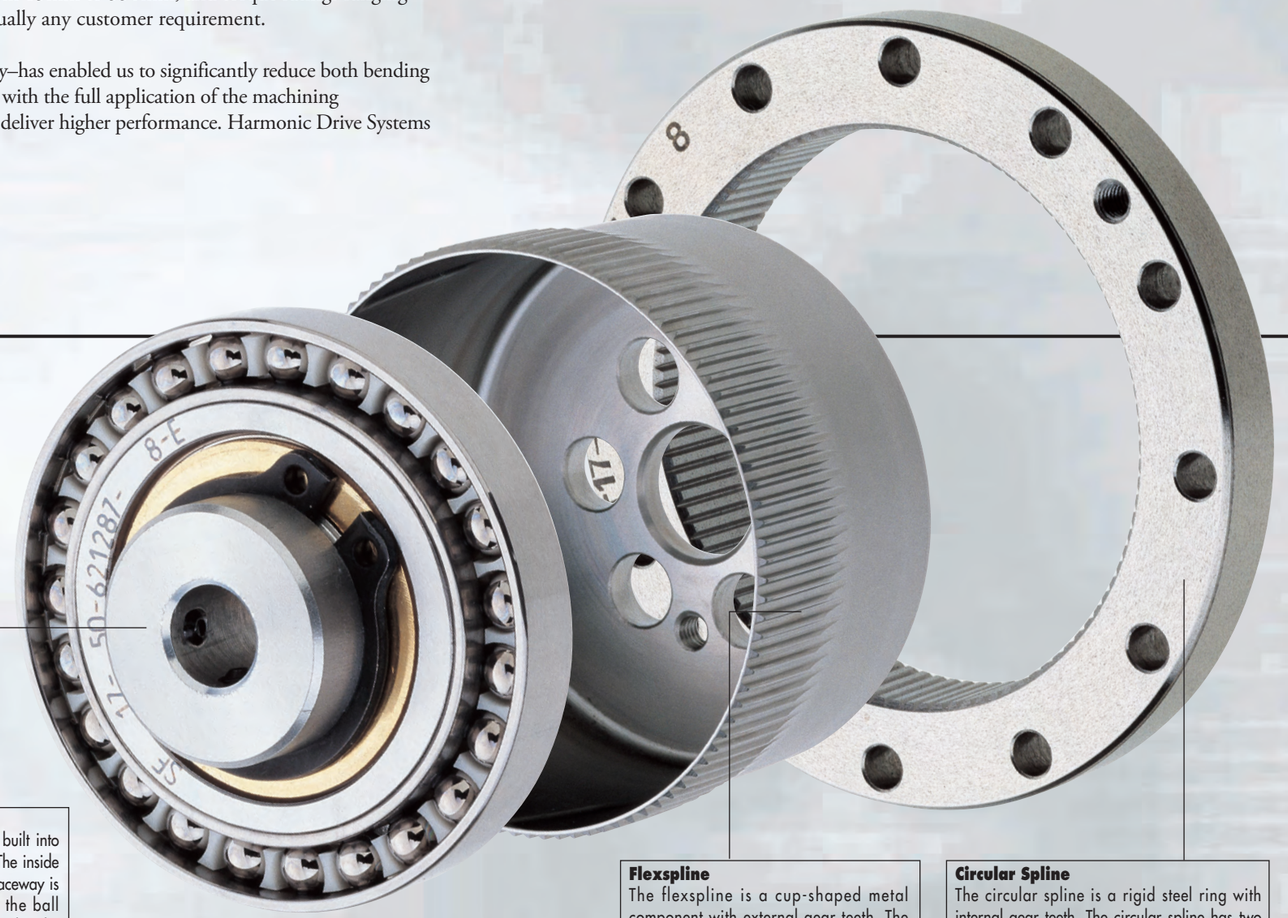
High Torque Capacity and Accurate Positioning in a Compact, Lightweight Design

Because they're comprised of just three basic components, HarmonicDrive® is amenable to a compact, lightweight design. They also feature a large area of gear tooth engagement that delivers powerful torque and extremely precise positioning. We are committed to exploiting these advantages to produce the smallest, lightest drives possible through ongoing research.

Currently, we offer HarmonicDrive® in 17 sizes with outer diameters ranging from 13mm to 330mm, and torque ratings ranging from 0.22Nm to 15500Nm (#3 to #100). This extensive line-up can satisfy virtually any customer requirement.

The IH tooth profile–which was developed through our unique tooth profile theory–has enabled us to significantly reduce both bending stress at the tooth base and contact stress at the tooth surface. This success, coupled with the full application of the machining technologies we have acquired over the years, has resulted in stronger products that deliver higher performance. Harmonic Drive Systems Inc. is committed to continuing this tradition of progressive advancement.

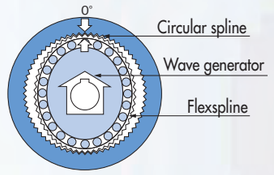
HarmonicDrive®



Wave Generator
The wave generator has small ball bearings built into the outer circumference of the elliptical cam. The inside raceway is fixed to the cam, while the outer raceway is subjected to elastic deformation through the ball bearings. The wave generator is usually attached to the input shaft.

Flexspline
The flexspline is a cup-shaped metal component with external gear teeth. The bottom of the flexspline (cup bottom) is called the diaphragm; it is usually attached to the output shaft.

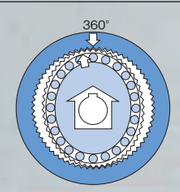
Circular Spline
The circular spline is a rigid steel ring with internal gear teeth. The circular spline has two teeth more than the flexspline and is usually employed as the fixed member.



The flexspline is deflected by the wave generator into an elliptical shape, which causes the flexspline teeth to engage with those of the circular spline at the major axis of the wave generator's ellipse, and to be completely disengaged across the minor axis of the ellipse.

When the wave generator is rotated clockwise with the circular spline fixed, the flexspline is subjected to elastic deformation and its tooth engagement position moves counterclockwise by turns relative to the circular spline.

When the wave generator rotates 180 degrees clockwise, the flexspline moves counterclockwise by one tooth relative to the circular spline.



When the wave generator rotates one revolution clockwise (360 degrees), the flexspline moves counterclockwise by two teeth relative to the circular spline because the flexspline has two fewer teeth than the circular spline. In general terms, this movement is treated as output power. This two-tooth shift in position provides a high single-stage gear ratio.

HarmonicPlanetary®

Harmonic Drive Systems Inc. has used its extensive knowledge of HarmonicDrive® gearing to develop a highly precise and rigid epicyclic speed reducer called HarmonicPlanetary®. Equipped with a unique backlash prevention mechanism, HarmonicPlanetary® delivers a high level of rotational accuracy.

This epicyclic speed reducer was made possible by using Harmonic Drive Systems Inc.'s proprietary precision manufacturing technology.

Forging the Future of Total Motion Control

HarmonicDrive® comes in many variations that is used in such applications as multi-axis articulated robots and other industrial robots; medical equipment; optical measuring equipment; communications equipment; and printing equipment—as well as in such scientifically and technologically advanced fields as deep-sea robotics and outer space development.

Technological innovation contributes to the progress and development of industry and modern civilization, and it is our technical expertise that helps make such innovation possible. In addition to the uniquely constructed HarmonicDrive® itself, we also manufacture such peripheral equipment as AC and DC servo motors and drivers; intelligent hollow-shaft actuators; optical scanners and drivers; and linear actuators.

Indeed, the key that will unlock the future potential of 21st-century technology is total motion control, the very goal that Harmonic Drive Systems Inc. is working to achieve.

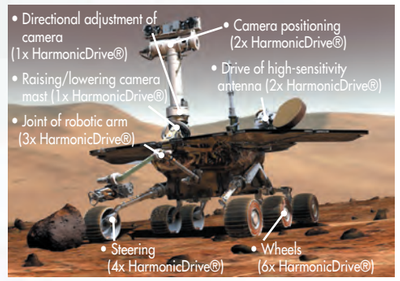
Our HarmonicDrive® technology has continued to evolve since its inception. Compared with the R-series HarmonicDrive® of 1981, today's CSF, CSG series is only three-fifths as tall, but capable of twice the power transmission. The latest of CSD series is only one-third as tall as the R series, but still maintain a high level of torque and positioning accuracy.

Innovation Supported by Total Motion Control

● Navigation System

Airbus (a merger of French, German and Spanish interests in the EADS Group and BAE Systems of Great Britain) uses HarmonicDrive® products in the navigation systems of its aircraft to help ensure flight safety (inertial navigation systems).

Photo courtesy of Airbus S.A.S.



Rover image created by Dan Maas, copyrighted to Cornell and provided courtesy of NASA/JPL-Caltech.

● Mars Rover

Each of humanity's first Mars exploration vehicles, Opportunity and Spirit, contains 19 HarmonicDrive® actuators. They play a crucial role in the vanguard of space science, which has captured the imagination of the entire world.

● Humanoid Robot (ASIMO)

HarmonicDrive® products are used in robotic arms and legs. Next-generation robots seem destined to achieve functionality that is nearly human.

Photo courtesy of Honda Motor Co., Ltd

● Neurosurgical Operation System

Various HarmonicDrive® products are used for surgical instruments to ensure an outstanding movement tolerance.

Photo courtesy of Carl Zeiss

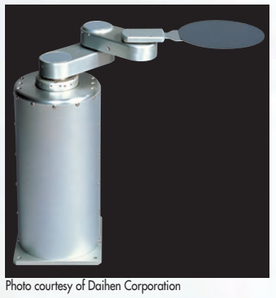


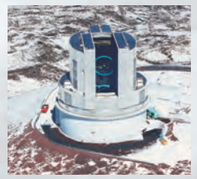
Photo courtesy of Daihen Corporation

● Semiconductor Wafer Transport Robot

AccuDrive® speed reducers are employed to operate semiconductor wafer transport robots in clean rooms because of the many advantages they offer, including compact configuration, high precision, high rigidity, smooth movement, and long service life.

● Solar Air-Conditioning Systems

Incorporating HarmonicDrive® products, this system aligns its mirrored panels with the movement of the sun to maximize the collection of solar energy.



● Subaru: A large Optical-Infrared Telescope installed on Mt. Mauna Kea in Hawaii

A total of 264 actuators which use HarmonicDrive® and AccuDrive® in combination are built into the structure of the telescope's mirror section so that the surface imperfections of the main mirror (which is 8.2 meters in effective diameter) can be kept within a tolerance of 0.1 μm. Subaru is probing deep space 15 billion light years from earth in an effort to unlock the secrets of the origin of the universe.

Photo courtesy of the National Astronomical Observatory of Japan, National Institutes of Natural Sciences

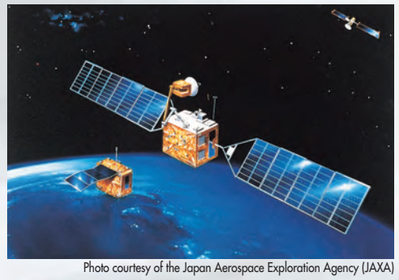


Photo courtesy of the Japan Aerospace Exploration Agency (JAXA)

● Satellites

HarmonicDrive® products are also in great demand for use in solar array drives on satellites to ensure accurate positioning and attitude control. A great deal of effort has been put into developing the materials and construction of HarmonicDrive® products used in spacecraft so that they provide a long service life under extremely harsh conditions.

Photo courtesy of Halliburton/Sperry Drilling Services

● Directed Excavation System for the Oil and Gas Industry

HarmonicDrive® products are used in steering systems of underground drilling equipment to help ensure accurate hole placement and drilling speed. These systems make it possible to accurately thread through boulders and other obstacles found in oil and gas fields, thereby improving well productivity.

● UT/HDS HAND

Equipped with an ultra-high-speed motion sensor, this robotic hand can catch a ball falling at a speed of 4m/s in less than 0.01 of a second (faster than the human eye can see). Every joint of the device is fitted with HarmonicDrive® actuators.

Photo courtesy of the University of Tokyo Graduate School Ishikawa and Namiki Laboratory

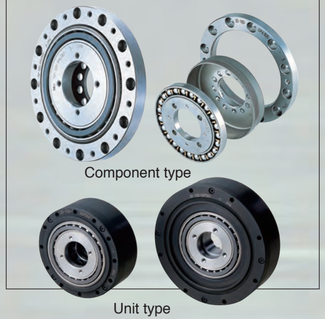
A Full Line of Products That Deliver Total Motion Control

To ensure accurate angle transmission and pinpoint positioning, we offer a full range of electronic controllers for use with AC/DC servo actuators that deliver outstanding resolution and precise rotary motion, as well as linear actuators that provide similarly excellent resolution and accurate linear motion. For optimal performance, we recommend using these controllers with our HarmonicDrive® and HarmonicPlanetary® epicycle gears. Harmonic Drive Systems Inc. is committed to the further development of peripheral mechatronic and electronic products with the aim of achieving true total motion control.

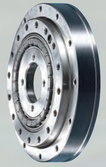
Discovering the Innovative Technologies of Tomorrow

HarmonicDrive®

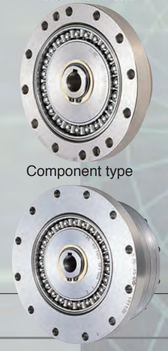
HarmonicDrive® CSD Series



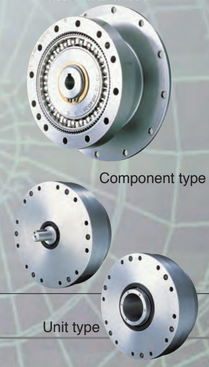
HarmonicDrive® SHD Series



HarmonicDrive® CSG-CSF Series

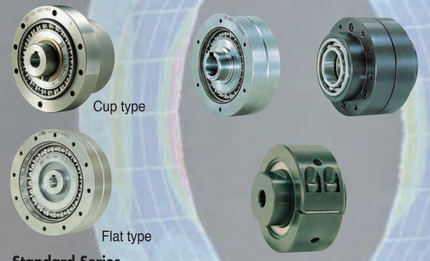


HarmonicDrive® SHG-SHF Series



HarmonicDrive® CSF-mini Series

HarmonicDrive® Standard Series/phase control units

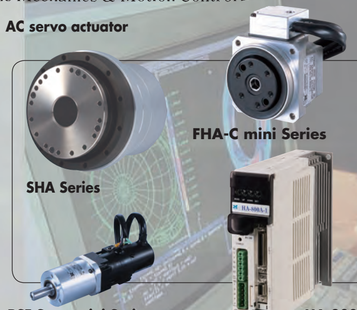


Standard Series

MECHATRONICS

Fine Mechanics & Motion Control

AC servo actuator



DC servo actuator

Linear Motion

Linear Actuator

Optical scanner

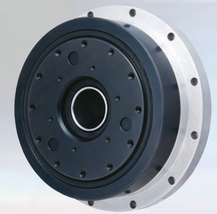
Beam Servo®
LSA Series

Rotary Motion

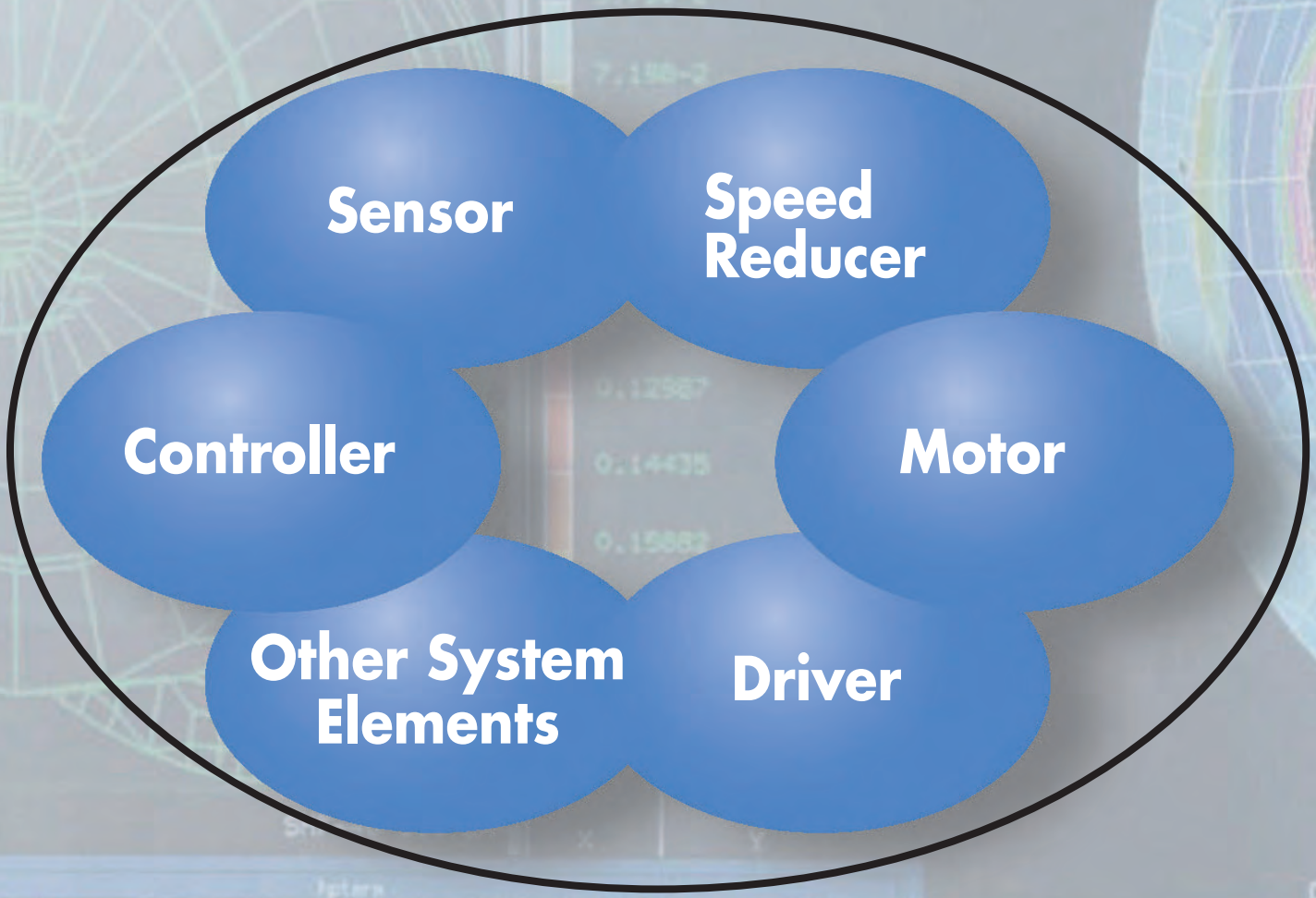
HarmonicPlanetary®

HPG Series

HPF Series



Schematic Concept of Total Motion Control



Leading the Way in All Aspects of Total Motion Control

Harmonic Drive Systems Inc. never compromises in the manufacture of its products. Our production philosophy is always faithfully adhered to at all levels of production and quality control.

Using our proprietary precision-cutting technology, we can manufacture ultra-small gears measuring just 0.042mm in thickness, as well as cut and process sheet metal as thin as 70μm (SI units).

In 1995 we acquired ISO9001 certification to help ensure the constant maintenance and improvement of a quality-assurance system that reliably delivers products of the highest quality. Subsequently, in 1998, we obtained ISO14001 certification for our Hotaka Plant to better enable us to fulfill our corporate responsibility to protect the environment. We recognize that the global environment is an important operational issue and we are dedicated to achieving further improvement.

In addition, we are focused on a company-wide effort to improve productivity, with the aim of shortening delivery times while maintaining product quality.

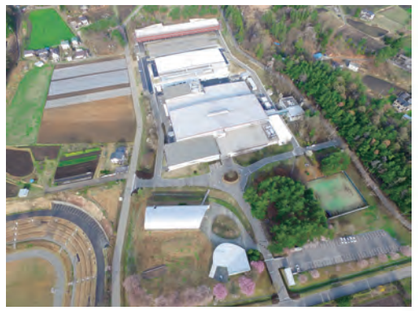
In these and many other ways, Harmonic Drive Systems Inc. continues to forge ahead in its efforts to be the world's leading corporation in the field of total motion control.

The Next Step: Precision Measured in Nanometers

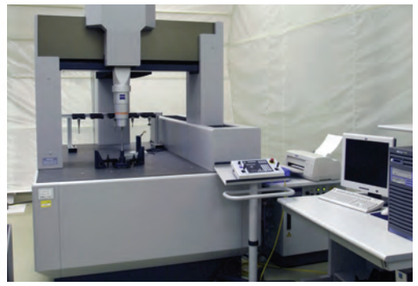
[I•K KAN]
Our research and development annex features advanced, high-precision processing equipment that helps us to achieve our goal of 10 times greater precision than ever before.

Cutting and Processing Technologies Based on Unrivalled Expertise

The Hotaka Plant is located in the town of Azumino-shi in the picturesque Japan Alps, where pristine waters flow into the valleys from the heights of such peaks as Mt. Jounen-dake.



Hotaka Plant
Total site area: 66,544.23m^2
Total ground area of buildings: 14,053.77m^2
Total floor area of buildings: 21,465.07m^2



The Joy of Making Things Arises from Art, Culture, and Human Interaction

All engineers, whether involved in production or pursuing new technologies, look to the future with enthusiasm for making new things and developing original ideas. Harmonic Drive Systems Inc. has been cultivating that enthusiasm and sensibility in every employee through various cultural activities.

One such activity is the Harmonic Concert Series, which was launched to commemorate the company's tenth anniversary. Proceeds from these concerts are donated to local elementary and middle schools. Another is our series of international symposiums for engineers from around the world who are dedicated to the pursuit of cutting-edge technologies. In addition, we invite guest speakers to give lectures in our Harmonic Lecture Series, as an expression of our appreciation for the generous support of the citizens of Azumino-shi, where our plant is located.

In these and other ways, we continue to nurture an enthusiasm for innovation through the cultivation of art, culture, and human interaction.

Nurturing the Passion and Sensibility Necessary for Innovation

● Harmonic Lecture Series

Harmonic Drive Systems is proud to sponsor this lecture series to express our appreciation to the people for Azumino-shi for their generous support. Proceeds from the series are donated to local elementary and middle schools for the purchase of books.

1. Teru Miyamoto (Writer)
   "What You Get from Travel"
2. Jun'ichi Nishizawa (Former president of Tohoku University)
   "What Creative Technology Means"
3. Fumihiko Maki (Former professor of the University of Tokyo, present principal of Maki and Associates)
   "Presenting Space and Landscaping"
4. Keiichi Kodaira (Director-General of the National Astronomical Observatory of Japan)
   "Initiation of Observations by the 'Subaru' Astronomical Telescope"
5. Teru Miyamoto (Writer)
   (In commemoration of Harmonic Drive Systems' 30th anniversary)
   "A 6,700km Silk Road Journey"
6. Hajime Karatsu (Professor, Tokai University)
   "Innovative Manufacturing—The Only Key to Japan's Future"
7. Hiroyuki Agawa (Writer)
   "Humor and the Japanese"
8. Kazuhide Uekusa (Professor, The Okuma School of Public Management, Waseda University)
   "Rebuilding the Japanese Economy"
9. Eiin Yasuda (Chief priest of Yakushi-ji Temple)
   "In Quest for Ideal Land"
10. Yoshiko Sakurai (Journalist)
    "Education Opens the Path to the Future"
11. Shumon Miura (Writer)
    "Japan in Asia"
12. Tsuyoshi Watanabe (Doctor of science·Emeritus Professor Tohoku University)
    "Courage to study and which it is pleased with and tells"
13. Noriko Hama (Professer of Doshisha Business School)
    "Deployment next to a global jungle "
14. Gerald L. Curtis (Professor, Department of Political Science, Columbia University)
    "Upheaval Japan - U.S. relation in Asia"
15. C.W.Nicol (Author, Naturalist)
    "Harmony of human and nature"
16. Shunji Yanai (Former Japanese ambassador to the U.S.)
    "East Asia's Transformation and Japan's Security"
17. Junichiro Koizumi (Former Prime minister)
    "Path Japan should take"
18. Keiko Kishi (Actress • Writer)
    "Les formes de l'amour"
19. Taichi Sakaiya (Writer • Economist)
    "To the next era from Showa and Heisei ~ The creation of Attractive Japan ~"
20. Sadayuki Sakakibara (Honorary Chair, Japan Business Federation)
    "The road to revitalization of the Japanese economy"
21. Mamoru Mouri (Astronaut)
    "The post Covid-19 society seen from the universe"

(Titles in parentheses were applicable at the time of the presentation.)

● Harmonic Drive International Symposium Series

To mark the company's 20th anniversary, the first Harmonic Drive International Symposium was held in 1991 with the intention of further symposia being organized every five years. Under the overall theme of "Motion Control," these symposia provide customers and researchers from universities and institutions both in Japan and abroad with the opportunity to exchange opinions on the latest technical trends and to share their application results in the motion control field. We also use this series as a forum to publish our own R&D results.

● Harmonic Concert Series

The Harmonic Concert Series was inaugurated to commemorate the 10th anniversary of our founding. Proceeds from the concerts are donated to Azumino-shi for the purchase of books for the town's elementary and middle schools.

1. Yoko Nakayama (mezzo-soprano), Yoshio Tsukada (piano) Concert
2. Yuko Fujimura Piano Recital
3. Koji Toyoda (violin), Motoko Toyoda (piano) Concert
4. Mitsuko Shirai (mezzo-soprano), Hartmut Höll (piano) Duo Concert
5. Hiroyuki Iwaki Percussion Instrument
   Concert in commemoration of 15th anniversary
6. Mitsuko Shirai (mezzo-soprano), Hartmut Höll (piano) Duo Concert
7. Yuko Fujimura Piano Recital
8. Tadao Yoshie (baritone), Michael Gees (piano) Concert
9. Toru Yasunaga (violin), Ayumi Ichino (piano) Concert
10. Mitsuko Shirai (mezzo-soprano), Hartmut Höll (piano), Tabea Zimmermann (viola), Eduard Brunner (clarinet)
    Concert in commemoration of 20th anniversary
11. Tadao Yoshie (baritone), Misao Minemura (piano) Concert
12. Yuko Fujimura Piano Concert
13. Mitsuko Shirai (mezzo-soprano), Hartmut Höll (piano) Duo
    Concert in commemoration of 25th anniversary
14. Soichirou Ohno (horn), Tsugio Tokunaga (violin), Kei Itoh (piano) Concert
15. Teruji Karashima (piano), Keiko Urushihara (violin), Hirofumi Kanno (cello) Concert
16. Tsugio Tokunaga (violin), Shigeo Neriki (piano) Concert
17. Yuko Fujimura Piano Concert
18. Mitsuko Shirai (mezzo-soprano), Christoph Prégardien (tenor), Hartmut Höll (piano)
    Concert in commemoration of 30th anniversary
19. Teruji Karashima (piano), Souichiro Ohno (horn), Tomoyuki Hirota (oboe), Tomomi Takahashi (clarinet), Kohji Okazaki (faggotto) Concert
20. Tsugio Tokunaga (violin), Noboru Kamimura (cello), Shigeo Neriki (piano) Concert
21. Mitsuko Shirai (mezzo-soprano), Christoph Prégardien (tenor), Hartmut Höll (piano) Concert
    (Sponsored jointly with the Hugo Wolf Society of Stuttgart, Germany in commemoration of the 100th anniversary of the death of Hugo Wolf)
22. Teruji Karashima (piano), Hiroaki Kanda (flute), Tomoyuki Hirota (oboe), Shuuhei Isobe (clarinet), Kohji Okazaki (bassoon), Souichiro Ohno (horn) Concert
23. Yuko Fujimura Piano Recital
    Concert in commemoration of 35th anniversary
24. Tsugio Tokunaga (violin), Hiroko Komoriya (piano) Concert
25. Soichiro Ohno (horn), Reiko Honjo (piano), Daishin Kashimoto (violin) Concert
26. Jörg Demus (piano), Tadao Yoshie (baritone) Concert
27. Tsugio Tokunaga (violin), Eri Hayashi (piano) Concert
28. Mistuko Shirai (mezzo-soprano), Hartmut Höll (piano) Concert
29. Momoo Kishibe (violin), Hiroyuki Abe (piano) Concert
30. Tsugio Tokunaga (violin), Eri Hayashi (piano) Concert
31. Japan Concert by the Chamber Ensemble of the Frankfurt Radio Symphony Orchestra
    Susanne Stoodt (1st. violin), Gerhard Miesen (2nd. violin), Gerd Grötzschel (viola), Peter Wolf (cello), Soichiro Ohno (1st. horn), Thomas Sonnen (2nd. horn)
32. Yuko Fujimura Piano Recital
33. Tsugio Tokunaga (violin), Eri Hayashi (piano) Concert
34. Teruji Karashima (piano), Momoo Kishibe (violin), Fumiaki Kono (cello) Concert
35. Soichiro Ohno (horn), Yasuo Watanabe (piano) Concert
36. Fumiaki Miura (violin), Maika Miura (piano) Concert

● Forum

Established in 1990 to commemorate the 20th anniversary of the founding of the company, our in-house Forum provides employees with the opportunity to freely consider and make proposals about the company's future through a frank exchange of opinion.

"WERK-GREEN"
1966
Copper plate, a wooden color board
560 x 460 x 60mm

"SCREEN-CANYON"
1983
Lead, colored nylon rope
3,200 x 6,400 x 1,460mm

● IIDA • KAN

Our pursuit of the ultimate precision and development of an environment for this purpose would be merely the pursuit of skills if it ended there. We have come to realize that, when we pursue the true technologies that lie beyond this, strong determination and deep feelings are essential. IIDA•KAN has been born through our desire to create a place where those involved in technological development can encounter this strong determination and deep feeling.

Harmonic Drive Systems Inc.

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TOTAL
MOTION
CONTROL

HarmonicDrive® ハーモニックドライブ®
HarmonicPlanetary® ハーモニックプラネタリ
Harmonicsyn® ハーモニックシン
HarmonicLinear® ハーモニックリニア
AccuDrive® アキュドライブ®
BEAM SERVO® ビームサーボ

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July, 2022